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**Exploring the concerns, attitudes and
experiences of health professionals
regarding a vegan diet during pregnancy
and early life; a mixed-method study**

A thesis presented in the partial fulfilment of the
requirements for the degree of

Master of Science
In
Human Nutrition

Massey University, Albany
New Zealand

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2022

Abstract

Background: There is an increasing trend in vegan diet consumption globally and in New Zealand. A restrictive and unplanned vegan diet may have negative health implications, especially during pregnancy and early life, when nutrient needs are elevated. Health professionals who interact with individuals following a vegan diet must be knowledgeable about the nutritional risks of poorly-planned vegan diets, and have access to appropriate educational resources

Aim: Explore concerns, attitudes, and experiences with regards to a vegan diet during pregnancy and early life, among health professionals in New Zealand

Methods: Healthcare professionals who work with pregnant, breastfeeding women and young children, as well as specialists who provide dietary advice, were invited to participate in this mixed-method study. An online questionnaire was first used to collect quantitative data on knowledge and attitude. Subsequently, qualitative data from semi-structured interviews provided descriptions of experiences, concerns, and perspectives about the adoption of vegan diets during pregnancy and early life.

Results: A total of 14 health professionals completed both the quantitative and qualitative phases of the study. All health professionals showed positive attitudes towards the adoption of vegan diets during pregnancy but some exhibited greater concern about the restrictive nature of vegan diets during early childhood. In particular, health professionals were concerned about iron and vitamin B12. Health professionals discussed the insufficiency of educational resources on vegan diets and the limited availability of dietitians. The lack of evidence-based consensus and updated government guidelines were reasons impacting confidence levels among health professionals in providing nutritional advice on vegan diets.

Conclusion: Healthcare providers support individuals and families in nutrition care. Knowledge must thus be aligned with changing diet trends. Continual professional education and updated evidence-based resources may improve knowledge and confidence in providing guidance on vegan diets.

Acknowledgments

I would like to first thank all the health professionals who have volunteered their time to make this research study possible. Your insights have provided valuable information and new knowledge about vegan diets during pregnancy and early life. I would like to thank you for completing the questionnaires and openly sharing your experiences and perspectives during the interviews.

I am in gratitude to all three of my academic supervisors, Cathryn Conlon, Pamela von Hurst, and Rachel Batty for their invaluable guidance throughout the research project. Your expertise and advice have aided in the development and completion of all aspects of the thesis, and I have truly gained so much wisdom through your teachings. Thank you for believing in my ability and supporting me in my academic pursuits.

I would like to thank my husband, Cyril for being such a supportive role in my academic journey, and for always believing that I can pursue my dreams even when it feels impossible. I am indebted to the Vegan Study research team at Massey University. Rebecca and Hajar, thank you for all those opportunities where we discussed research designs and for your unyielding encouragement over the past six months. Lastly, I would like to thank my family and friends in Singapore who have always been rooting for me and been as equally excited about my academic journey.

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List of Abbreviations and Symbols

Abbreviation or Symbol	Definition
AI	Adequate Intake
ALA	Alpha-linolenic acid
APA-JARS	American Psychological Association - Journal Article Reporting Standards
ANZ	Australian and New Zealand
BDA	British Dietetic Association
BMI	Body-mass index
BMD	Bone mineral density
BMC	Bio Med Central
BW	Body weight
CI	Confidence interval
DHA	Docosahexaenoic acid
DPA	Docosapentaenoic acid
EPA	Eicosapentaenoic acid
EAA	Essential amino acid
ESPGHAN	European Society for Paediatric Gastroenterology, Hepatology and Nutrition
FAO	Food and Agriculture Organisation of the United Nations (FAO)
g	Gram
GDM	Gestational diabetes mellitus
GFHGNP	Groupe Francophone d'Hépatologie-Gastroentérologie et Nutrition Pédiatriques
GP	General practitioner
HDL-C	High density lipoprotein cholesterol
HG	Hyperemesis gravidarum
HP	Health professional
IQ	Intelligent Quotient
IU	International unit
kg	Kilogram
kJ	Kilojoule
L	Litre
LA	Linolenic acid
LC-PUFA	Long chain polyunsaturated fatty acids
LDL-C	Low density lipoprotein cholesterol
LMC	Lead maternity carer
MDPI	Multidisciplinary Digital Publishing Institute
MCV	Mean corpuscular volume
mg	Milligram
ml	Millilitre
MOH	Ministry of Health
MVM	Multi-vitamin/mineral
NB	Nota bene
NCF	Nutrition competency framework
NHMRC	National Health and Medical Research Council
NIH	National Institute of Health
nmol	Nanomole
NZWFFQ	New Zealand Women's Food Frequency Questionnaire
PBB	Plant-based beverages
PEN	Practice-based evidence in nutrition
PubMed	Medline Public Publisher
QR	Quick response
RANZCOG	Royal Australian and New Zealand College of Obstetricians and Gynaecologists
RCT	Randomised controlled trial
RDI	Recommended dietary intake
SGA	Small for gestational age
SSI	Semi-structured interview
TC	Total cholesterol
TEI	Total energy intake
UVB	Ultraviolet B
UIC	Urinary iodine concentration
UNU	United Nations University
WHO	World Health Organisation
25-OHD	25-hydroxyvitamin D
µg	Microgram
<	Less than
>	Greater than
≤	Less than or equal to
±	Plus-minus
=	Equal
/	Per
%	Percent

Chapter 1 : Introduction

1.1 Background

A vegan diet is strictly plant-derived (Modlinska et al., 2020) and includes only fruits, vegetables, grains, legumes, nuts, seeds, herbs, and spices. It differs from a lacto-ovo vegetarian diet because of the complete exclusion of all animal-derived food substances (Clarys et al., 2014; Meulenbroeks et al., 2021; Rocha et al., 2019) such as honey, dairy, and eggs (Saintila et al., 2021). Becoming a vegan may be motivated by reasons including better health outcomes, religious practices, and the desire to protect animal and environmental welfare (Lynch et al., 2018).

A vegan diet is gaining popularity globally and a similar trend may be observed in New Zealand (Vegan Society, 2021; Health Navigator, 2022; Kantar Insights New Zealand Ltd, 2022). Data from 47,000 respondents in the 2018 New Zealand Attitudes and Values Study showed that 5.8% of New Zealanders identified themselves as veg*ns, a category that includes vegetarians, vegans, and whole-food or plant-based vegans, but this quantity was not compared in relation to data from previous years (Milfont et al., 2021). Clear representations from wider population studies to reflect the prevalence of vegan diets in New Zealand are required.

Trends show that women may be more likely than men, to adopt a diet centred around plants (Browarnik, 2012; Rudy, 2012; Trocchia & Janda, 2003). Dietary habits are unlikely to change during pregnancy (Crozier et al., 2009; Sebastiani et al., 2019), suggesting that vegan women may continue this diet during pregnancy and lactation, and provide their infants or children with a vegan diet. Pregnancy and early life, categorised as between the ages of zero to two years of age (Ministry of Health, 2021) are significant growth phases. While it is clear that a diet high in plant foods confer several health benefits, an inappropriately planned vegan diet, especially during these phases may cause health risks if nutrient needs are not met. Plant foods have absent or limited amounts of nutrients such as vitamin B12 (Pawlak, 2015). The bioavailability of minerals like iron and zinc is also reduced (Gibson et al., 2014). Vegans should thus be aware of these health considerations to minimise nutrient deficiencies.

Healthcare professionals providing primary support for pregnant women are likely to be important figures in monitoring nutritional statuses during the antenatal and post-natal periods (Baroni, Goggi, Battaglino, et al., 2018). They must therefore be knowledgeable about the benefits of a vegan diet and its associated health risks. Only then can they be well-informed about providing the whānau with accurate and confident advice to plan a balanced vegan diet (Costa-Rodrigues et al., 2018), and be alert to signs of nutrient deficiencies.

Quantitative methods provide a means to measure existing knowledge and attitudes of health professionals towards vegan diets. Qualitative studies could provide opportunities to examine participants' experiences and uncover a deeper understanding of perspectives that may be shaped by life circumstances (Doyle et al., 2016). To this end, a mixed-method study serves to triangulate data and corroborate findings from both quantitative and qualitative aspects of the research (Doyle et al., 2016), motivating subsequent intervention strategies to resolve concerns and knowledge discrepancies in the area of vegan nutrition.

Overall results from past quantitative studies on healthcare professionals showed a collective deficit in knowledge of vegan and/or vegetarian nutrition (Bettinelli et al., 2019; Elias & Green, 2007; Hanna et al., 2021; Krause & Williams Sr, 2019; McHugh et al., 2019; Meulenbroeks et al., 2021; Saintila et al., 2021; Sanne & Bjørke-Monsen, 2020). Some questionnaires from these studies have low response rates and small sample sizes (Elias & Green, 2007; Saintila et al., 2021; Sanne & Bjørke-Monsen, 2020) and are unvalidated (Elias & Green, 2007; Krause & Williams Sr, 2019; McHugh et al., 2019; Meulenbroeks et al., 2021; Sanne & Bjørke-Monsen, 2020). This limits the generalisation of results and comparisons to past studies (Zeldman & Andrade, 2020). Furthermore, levels of nutritional knowledge and concerns may be inadequately interpreted because of insufficient questionnaire items on vegan nutrition, unclear discernment of a vegan diet from other plant-based diets, and the tendency to collate results from vegan populations with vegetarians.

Qualitative findings examining aspects of nutritional knowledge, experiences, and beliefs of health professionals are evident (Arrish et al., 2017; Lee et al., 2018; McHugh et al., 2019), but these were limited in exploring knowledge involving vegan or vegetarian diets. Some had only examined insights from midwives (Arrish et al., 2016; Lee et al., 2018; Othman et al., 2020b). There is currently a lack of in-depth study on the perspectives of New Zealand's antenatal and postnatal caregivers, within the realm of vegan diets during pregnancy and

early life which are phases of the life cycle highly impacted by the choice of a restrictive and poorly-planned vegan diet.

Firstly, more studies are needed to uncover if health professionals are aware of potential nutrients of concern in a vegan diet. Secondly, it is important to elicit feedback on the availability of educational resources that may assist them in providing nutrition care. Lastly, key reasons why health professionals may or may not support a vegan diet during pregnancy and early life should be explored. Insights from such a study will contribute to our understanding of health professionals' experience of vegan diets, their concerns, and determine if educational interventions or updated resources are necessary.

For the purposes of this study, the mention of 'plant-based' diet refers to diets that are predominantly high in plants and include vegetarian and vegan diets. The use of 'vegan' or 'strict plant-based diets' refers to the complete exclusion of all animal-derived food sources. In this study, nutritional knowledge refers to the level of understanding that health professionals have about plant-based foods and nutrients (minerals and vitamins), especially those that are impacted in vegan diets. Attitude refers to health professionals' perspectives and potential concerns about vegan diets during pregnancy and early life, and their opinions on the availability of resources on vegan nutrition. This may be influenced by health professionals' professional experiences.

1.2 Aim of Study

To explore knowledge, areas of concern, attitudes and experiences with regards to a vegan diet during pregnancy and early life, among health professionals in New Zealand.

1.2.1 Objectives

1. To explore the nutritional knowledge and attitudes of health professionals on vegan nutrition during pregnancy, lactation and early life (0-2 years)
2. To ascertain experiences, concerns and perspectives of health professionals regarding vegan diets during pregnancy, lactation and early life (0-2 years)

N.B. A mixed method explanatory sequential design will be utilised to answer the above objectives.

1.3 Thesis Structure

The thesis is divided into six chapters and the structure is guided by the APA Style Journal Article Reporting Standards (JARS) included in **Appendix 1**. **Chapter one** is an introduction to the background, aims, and objectives of the study. **Chapter two** focuses on providing a narrative review of the current literature surrounding vegan diets during pregnancy and early life. Literature discussing the impact of vegan diets in New Zealand and around the world is presented in this section. **Chapter three** is a presentation of the methodology used to design the mixed-method study. **Chapter four** presents both the quantitative and qualitative results of the study while **Chapter five** is the discussion that collates and interprets both the quantitative and qualitative results and the comparison of these findings to the existing literature. **Chapter six** establishes the conclusion of the study. This encompasses a summary of the findings, addresses how the research question has been answered, discusses potential contributions and requirements for future research, as well as evaluates the strengths and limitations of the study.

1.4 Researcher Contributions

Table 1.1 Researchers' contributions to this study

Author	Contribution to Thesis
Soh Bi Xue Patricia MSc Nutrition candidate	Primary author of the thesis and responsible for all study components including leading the research, applying for ethics, designing the questionnaire and interview schedule, literature review, conducting interviews and disseminating the questionnaire, collection, analysis and interpretation of results, finalising and submitting the thesis chapters and manuscripts.
Associate Professor Cathryn Conlon Academic Supervisor	Academic supervisor, assisted and checked ethics application, part of the team of experts who reviewed the questionnaire and interview schedule. Advised and assisted with recruitment and data analysis, advised on thesis structure, revised and approved thesis chapters and final manuscript.
Professor Pamela von Hurst Academic Supervisor	Academic supervisor, assisted and checked ethics application, part of the team of experts who reviewed the questionnaire and interview schedule. Advised and assisted with recruitment and data analysis, advised on thesis structure, revised and approved thesis chapters and final manuscript.
Dr. Rachel J. Batty Academic Supervisor	Academic supervisor, guided and advised on qualitative data analysis such as the coding process, provided resources for qualitative data interpretation, advised on thesis structure, revised and approved thesis chapters and final manuscript.

Chapter 2 : Literature Review

2.1 Introduction

This chapter reviews the current literature about the nutrition of vegan diets during pregnancy and early life. The search strategy is shown in **Figure 2.1**. Manual searching of references from highly relevant articles were conducted.

Figure 2.1 Search strategy

Date searched: March 2022 – November 2022

Search terms

Vegan OR vegetarian OR plant-based

AND pregnan* OR lactation OR breastfeeding OR complementary feeding OR early life OR children OR infants OR paediatric

AND benefits OR advantages OR risks OR dangers

AND Nutrition* knowledge OR questionnaire Or survey Or interview Or mixed-method

AND Attitude OR confidence

Health professionals OR midwives OR obstetricians OR OBGYN OR gynaecologists

Electronic databases: MEDLINE/PubMed, Elsevier, The American Journal of Clinical Nutrition, Oxford Academic, BMC Nutritional Journal, MDPI Journals, Dietitians Association of Australia, SAGE Journals, Google Scholar, Massey Discover

2.2 Benefits and Risks of a Vegan Diet

2.2.1 Health Benefits of a Vegan Diet during Pregnancy and Early Life

A vegan diet focused on whole plant sources may provide positive maternal outcomes. For example, higher intake of folate may be associated with reduced risks of neural tube defects in contexts of vitamin B12 sufficiency (Koebnick et al., 2001). High intake of plant foods could lower risks of preeclampsia (Costa-Rodrigues et al., 2018; Piccoli et al., 2015). Gestational diabetes mellitus (GDM) is often associated with oxidative stress (Ozler et al., 2019), so the intake of fibres, nitrates, and antioxidants from plant foods (Schiattarella et al., 2021) could reduce reactive oxygen species, inflammation, and homocysteine levels (Kerley, 2018) to minimise adverse health implications during pregnancy.

Health benefits were also evident among children on vegan diets. In a Finnish cross-sectional study on 40 vegan children (Hovinen et al., 2021) who followed the diet from birth, low total cholesterol and low plasma low-density lipoprotein cholesterol (LDL-C) were observed. However low levels were similarly observed in beneficial high-density lipoprotein cholesterol (HDL-C). Differences in these lipid biomarkers may be contributed from different bile acid metabolism in vegans as compared to lacto-ovo vegetarians and omnivorous children, and are likely associated with a high fibre diet that is low in saturated fats (Hovinen et al., 2021). Vegan diets that are low in energy density and saturated fat but high in complex carbohydrates, fibre and water may promote satiety and minimise excessive energy intake (Newby, 2009; Sabate & Wien, 2010). Promoting such healthy eating habits from a young age could reduce the prevalence of childhood obesity and prevent the subsequent development of non-communicable diseases (Sabate & Wien, 2010).

2.2.2 Position Statements about a Vegan Diet during Pregnancy and Early Life

A vegan diet is generally supported by international organisations. The Academy of Nutrition and Dietetics, and the Dietitians of Canada (Kiely 2021; Melina et al., 2016) have stated that appropriately-planned vegetarian diets including vegan diets, can provide sufficient nutrition and confer health benefits. These diets are suitable for all stages of the life cycle, including pregnancy, lactation, and infancy. However, dietary requirements for protein, iron, zinc, calcium, iodine, vitamin B12, vitamin D, and essential fatty acids must be met. Reliable sources of B12 must come through fortified foods and supplements. Similar concerns for vitamin B12 were stated by The German Nutrition Society (Richter et al., 2016).

The Spanish Paediatric Association advised that children on these diets must continue to show normal growth and development during paediatric assessments (Redecillas-Ferreiro et al., 2020). Caution is not without reason because there are currently insufficient longitudinal studies to describe the energy and protein intakes, and the impact of these diets on growth patterns and nutrient markers among vegan children of more than three years of age (Amit et al., 2010; Desmond et al., 2021). The French-speaking Paediatric Hepatology, Gastroenterology and Nutrition Group (GFHGNP) (Lemale et al., 2019) stated that the complete exclusion of all animal products may likely cause the development of nutritional deficiencies which can negatively affect children throughout their lives.

The importance of receiving education and healthcare support is highlighted by various European organisations. The Nutrition Committee of the European Society for Paediatric Gastroenterology, Hepatology and Nutrition (ESPGHAN) and the Italian Nutrition Society have both suggested the importance of seeking dietary and medical advice should vegan diets be adopted in children (Agnoli et al., 2017; Fewtrell et al., 2017). This ensures that nutrient levels are monitored and existing deficiencies treated promptly (Baldassarre et al., 2020; Penney & Miller, 2008) to avoid irreversible growth and developmental impairment.

2.2.3 Health Risks of a Vegan Diet during Pregnancy and Early Life

Risks are defined here as negative health indicators and nutritional insufficiencies due to a vegan diet (Piccoli et al., 2015). Elevated risks of deficiencies in vitamin B12, vitamin A, vitamin D, iodine, zinc, selenium, iron and omega-three fatty acids were observed (Davey et al., 2003; Elorinne et al., 2016; Saunders et al., 2013; Schüpbach et al., 2017) in vegans, likely due to the restriction of all animal foods.

Highly restrictive vegan diets among young children could result in faltering growth, nutritional rickets, and developmental impairment (Farella et al., 2020; Guez et al., 2012; Lemoine et al., 2020). The VeChi diet study from Germany (Weder et al., 2019) that compared macronutrient intakes between omnivorous (n=164), vegetarian (n=127), and vegan (n=139) children of one to three years of age found that despite similar total energy intakes and dietary energy density, more outliers for weight-for-height, height-for-age, and weight-for-age were present for the vegan children. In this study, it was identified that 3.6% of vegan children had wasting or stunted growth, as compared to 2.4% in vegetarian children and 0% in omnivorous children, although differences were not significant. Stunting could be related to inadequate dietary intake and micronutrient deficiencies (Prendergast & Humphrey, 2014) but may also be related to utilising World Health Organisation (WHO) growth standards that raised the prevalence of stunting and wasting (Weder et al., 2019). The VeChi study found significantly lower protein intake for vegan and vegetarian children as compared to omnivorous children, but overall, protein intake was already 2.3 to 2.5-fold higher than the German reference values of 1g of protein/kg/body weight (BW)/ day.

Among neonates born to diet-based (defined by data from food frequency questionnaire) vegetarian women in a recent cohort study in the United States (Yisahak et al., 2021), mean

birthweight and length were found to be significantly lower [adjusted birthweight = -202.02, 95% CI: -383.49, -20.56; adjusted length = -1.01, 95% CI: -1.93, -0.09] and the odds of being small for gestational age (SGA) [adjusted odds ratio = 2.51, 95% CI: 1.01, 6.21] were higher than non-vegetarian neonates. Results were however limited by a small sample size of vegetarians which made up only 2% of the sample (n=2802) studied, and were mostly Asians who could have smaller infants regardless of diet.

Severe deficiencies were observed among children on a macrobiotic vegan diet typically comprising cereals, vegetables, legumes, pulses, seaweed, soy (Agnoli et al., 2017; Baldassarre et al., 2020), fruits, seeds, fermented foods and omitting vitamin D supplements, dairy and meat (Dagnelie & van Staveren, 1994). A longitudinal study compared the dietary intake, growth, and blood chemistry between four to 18-month-old macrobiotic (n=53) and omnivorous control subjects (n=57) (Dagnelie & van Staveren, 1994). Infants were observed across three cohorts from four to 10 months old (cohort one), eight to 14 months old (cohort two), and 12 to 18 months old (cohort three). Deficiencies found for energy, protein, vitamin B12, vitamin D, calcium, and riboflavin among infants on macrobiotic diets were significantly related to poor growth, muscle and fat wasting, and reduced psychomotor movement. Macrobiotic infants had higher iron intake but significant iron deficiency was found in 15% of this group and not in controls (P=0.003). Vitamin D status was poor, as evident by low 25-hydroxyvitamin D [25-(OH)D] concentrations (<20nmol/l) in 20 out of 25 macrobiotic children. Nutritional rickets was present in 90% of 53 macrobiotic children. More longitudinal studies with larger sample sizes are required to determine the long-term impacts on growth and development in vegan children (Amit et al., 2010; Meulenbroeks et al., 2021).

Studies examining maternal health outcomes in vegan pregnant women are limited and results may be reported with other vegetarian diets. Inconsistent findings were reported in a systematic review (Piccoli et al., 2015). In examining maternity care records of 775 vegan women, lower risks of preeclampsia were found (1 out of 775 cases) as compared to the general population (3% to 5%) (Carter et al., 1987). Another study found a lower prevalence of hypertension with proteinuria among vegetarians than in omnivores (4% versus 12%), but eclampsia risks were elevated in vegetarians as compared to omnivores (2% versus 0%) (Reddy et al., 1994). These differences were not significant. Mixed findings may be a result of heterogeneity in study designs that restricted the pooling of overall outcomes (Piccoli et

al., 2015). The absence of randomised controlled trials (RCTs) limits the potential of determining if risk outcomes were a result of dietary choices. Various confounders could also influence health outcomes. However, no conclusive evidence from this review suggested adverse maternal-foetal outcomes in pregnant women following vegan-vegetarian diets (Piccoli et al., 2015). Hypertensive disorders were similarly not associated with vegetarianism in the United States cohort study (Yisahak et al., 2021).

Inconsistencies were similarly highlighted in nine papers of the review examining nutritional deficits among vegan-vegetarians in Europe, North America, and India (Piccoli et al., 2015), which were mostly limited by small cohort sizes (23 to 109 women). Vitamin B12 and iron deficiencies were high among vegan-vegetarian pregnant women (Koebnick et al., 2004; Sharma et al., 1994) while zinc (King et al., 1981) and free fatty acids (Stammers et al., 1989) were roughly similar to levels of omnivorous counterparts. Iron deficiency was also noted but not associated with anaemia among vegetarian women in the United States cohort study (Yisahak et al., 2021).

These studies had recruited pregnant women who were lacto-ovo or lactovegetarians, and none had sufficiently represented vegan women. As vegetarians consume a less restrictive diet as compared to vegans, data obtained from vegetarian participants may not be generalised to vegans. More current research studies that solely examine nutrient deficiencies among vegan pregnant women are required.

2.2.4 Nutrients of Concern

Appropriate planning is required to strategically meet nutrient intake through a balanced diet, fortified foods and supplementation (Baroni, Goggi, Battaglino, et al., 2018; Sebastiani et al., 2019; Thomas et al., 2016), especially during pregnancy and early life where nutrient needs are elevated. Many countries have specified nutrient recommendations for women during pregnancy, infancy and childhood, including New Zealand (NHMRC, 2006). Micronutrient intake must accommodate for diluted concentrations of minerals and vitamins, especially those that are water-soluble, due to the expansion of blood volume during gestation (Picciano, 2003; Sebastiani et al., 2019). Young children have higher nutrient and energy requirements relative to weight than adults for normal growth and functioning of the neural, endocrine and immunological systems (Desmond et al., 2021; Heird, 2012).

The presence of dietary fibre, phytates, and oxalates (Rudloff et al., 2019) in plant foods may reduce the bioavailability of key nutrients such as iron, zinc, selenium, and calcium, and affect the protein quantity and quality (Kiely et al., 2021). Pregnant women may seek to consume multivitamin/mineral (MVM) supplementation to improve health outcomes but MOH (2020a) has only recommended folic acid and iodine for pregnancy unless clinical deficiencies are evident. Similarly, WHO (2016) has highlighted the need for further research before recommending supplementation during pregnancy. Key nutrients of concern in vegan diets are outlined in the following section.

Protein

Essential amino acids (EAAs) from protein-rich foods provide the building blocks for the synthesis of proteins, hormones, and neurotransmitters (Kleinman, 2009). As pregnancy is marked by rapid growth and development (Joint WHO/FAO/UNU Expert Consultation, 2007), adequate intake supports conception, maternal homeostasis, foetal growth, and lactation (King, 2000b). Although concentrations of amino acids decrease during early pregnancy and remain low throughout (Elango & Ball, 2016), increased protein synthesis and reduced amino acid catabolism may help accommodate higher demands during pregnancy (Duggleby & Jackson, 2002). However, if protein intake falls below the threshold required to maintain these metabolic adaptations, risks of adverse pregnancy outcomes increase (King, 2000b).

Plant proteins are lower in quality due to composition of EAAs (Schürmann et al., 2017) and reduced digestibility of 50-70% as compared to animal proteins (Bakaloudi et al., 2021). This may be a result of high fibre content, antinutrients, food processing, and heat treatments (Baroni, Goggi, Battaglino, et al., 2018; Millward, 1999). Protein needs may thus need to be elevated by 30 to 35% for children under two years old, to account for amino acid composition and digestibility of a vegan diet, but this can be accomplished through a diverse diet with sufficient energy (Messina & Mangels, 2001). Digestibility of soy protein and gluten can reach 95% while whole cereals and pulses reach 80-90% (Agnoli et al., 2017). Consuming a wide variety of plant proteins, including soy and its analogues like tempeh and pseudograins (e.g. quinoa and amaranth) could thus promote a more complete EAA profile (Redecillas-Ferreiro et al., 2020).

A systematic review of 26 studies (Bakaloudi et al., 2021) examining 9,862 participants in total, found that vegan groups had the lowest dietary consumption of protein in three studies as compared to meat consumers. Overall, 10 studies from the review found that protein intake among vegans did not always meet recommended levels, as evidenced by a total energy intake (TEI) of 13-15% from protein. One study also found plasma concentrations of EAAs to be significantly lower ($p < 0.001$) in vegan diets as compared to lacto-ovo-vegetarian, semi-vegetarian and omnivorous diets (Šebeková et al., 2001). However, the sample size of vegans surveyed ($n=9$) limited the generalisation and conclusion of results. A recent review by Parikh et al. (2022) on children aged 0-59 months from low and middle-income countries uncovered that there was 1.44 higher odds of stunting among children who do not consume EAAs from animal sources (meat, eggs, and dairy), as compared to non-vegan children (Krasevec et al., 2017).

The Healthy Eating Guidelines for New Zealand Babies and Toddlers (0-2 years old) have specified that plant-based milk alternatives are nutritionally insufficient for the growth and development of an infant under 12 months, but unflavoured soy milk that is fortified with calcium and vitamin B12 may be given from one year of age due to its higher protein content (MOH, 2021). Infants and young children who have small stomachs may not tolerate large quantities of food and consequently, have reduced protein intake. However, consuming a wide variety of nutrient-dense plant foods in small meals throughout the day (Young & Pellett, 1994) could improve amino acid sufficiency to support growth (Parikh et al., 2022).

Long-chain polyunsaturated fatty acids (LC-PUFAs)

LC-PUFAs are essential for visual and cognitive development, growth, metabolic and immune functions during childhood (Gibson et al., 2011). Adverse outcomes from low docosahexaenoic acid (DHA) accumulation are often more evident in the nervous (Burdge et al., 2017; Lauritzen et al., 2016) and retinal functions in pre-term infants (Carlson, 1999).

Dietary sources vary in quantities of LC-PUFA. Eicosapentaenoic acid (EPA) and DHA are predominantly found in oily fish, meat, and dairy products. The body can convert some alpha-linolenic acid (ALA) from plant foods to the longer chain omega-three fatty acids, EPA, DHA, and docosapentaenoic acid (DPA) (Baroni, Goggi, Battaglino, et al., 2018; Gibson et al., 2011). After conversion, a developing foetus and infant may obtain these LC-

PUFAs via selective uptake from the mother's plasma and breastmilk respectively (Sanders, 1999). Subsequent chain elongation and desaturation occur within foetal tissues such as the brain (Sanders, 1999).

Studies have however found as low as 0.2% (Pawlosky et al., 2001) extent of conversion (Burdge et al., 2017) via the desaturation-chain elongation system in humans (Plourde & Cunnane, 2007). A high intake of omega-six fatty acids, namely linolenic acid (LA) (Sebastiani et al., 2019) competes for the D6 and D5 desaturase and elongation enzymes (Brenner & Peluffo, 1966; Stark et al., 2008), further impeding conversion. Additionally, the process is impacted by individual variations in cellular metabolism (Harris & Von Schacky, 2004), genetics, age, and overall health (Davis & Kris-Etherton, 2003).

Despite confounders that exist across multiple studies from different geographical locations, significant differences were observed between EPA and DHA status in vegan and vegetarian women compared to omnivorous counterparts (Burdge et al., 2017; Sanders, 2009, 2014). DHA status may vary depending on the type of oils consumed in regional diets. Canadian vegetarians who have higher ALA intake from canola oil may obtain higher DHA levels by conversion (Conquer & Holub, 1997), suggesting the importance of sufficient plant-based sources of omega-three. Studies from the United States had not observed lower proportions of DHA in breastmilk lipids among 30 vegetarians (Finley et al., 1985), and 12 vegetarians (Specker et al., 1987), and similarly linked this to elevated intakes of ALA from the diet.

Consuming fish rich in EPA and DHA is a more direct and efficient method to increase quantities of LC-PUFAs (Abedi & Sahari, 2014; Kris-Etherton et al., 2002). A small sample of vegan women (n=16) in the United Kingdom consumed only 20mg/day of EPA with no traces of DHA as compared to fish consumers (n=6258) who had an intake of 110 mg/day of EPA and 150 mg/day of DHA (Welch et al., 2010).

PUFA intake was found to be higher among vegetarian than omnivorous (47.06% vs 42.32% of total fatty acids) adolescents (11-15 years) in two studies conducted in Slovakia (Krajčovičová-Kudláčková et al., 1997; Krajčovičová-Kudláčková et al., 1997), but highest blood levels of omega-three, EPA and DHA were only found in those who ate fish as the only meat source (n=10), at 0.75% and 1.95% respectively. EPA and DHA levels were lowest in vegans (n=7) at 0.3% and 0.29% respectively. Generalisation of these results was however

limited due to the small sample sizes and relegation of results from one area in Europe. Cord artery phospholipid samples from South-Asian vegetarian (n=27) mothers showed lower proportions of EPA and DHA (Reddy et al., 1994) as compared to omnivores (n=27). Collectively, these studies suggest that low quantities of EPA and DHA among non-meat consumers may impact levels in foetus and remain low throughout childhood.

The desaturation and elongation of ALA to DHA is likely the best dietary strategy for vegans to obtain LC-PUFA. Omega-six and omega-three ratios should be balanced at 1:2 or 1:3 (Sebastiani et al., 2019). Tropical oils (coconut, palm), saturated fat and trans-fat can impair the DHA and EPA synthesis (Abedi & Sahari, 2014; Davis & Kris-Etherton, 2003; Harnack et al., 2009) and should be limited. While several authors have recommended an algae-based DHA supplement to provide at least 100mg per day for children above six months old (Baroni, Goggi, Battaglino, et al., 2018.), pregnant and lactating women (Baroni, Goggi, & Battino, 2018; Greenberg et al., 2008; Ryan & Symington, 2015), this is contradicted in the Eating and Activity Guidelines for New Zealand Adults (MOH, 2020a).

Iron

Iron is an essential nutrient for the development of the central nervous system, especially in the first year of life. It is required for myelination, hematopoiesis (Fisher & Nemeth, 2017), normal functioning of neurotransmitters, and hippocampal dendritogenesis (Domellöf et al., 2014). Iron requirements increase exponentially to accommodate expansion in the maternal blood volume (MOH, 2020a; WHO, 2004) and erythrocyte mass (WHO, 2004), support iron transport to the foetus (Garzon et al., 2020), and replace iron loss during delivery (Bothwell, 2000; Parisi et al., 2017). Iron stores are accumulated in the first and second trimesters to provide for greater requirements in the third trimester (MOH, 2006).

Iron is provided to infants by breastmilk in a highly bioavailable form (Brannon & Taylor, 2017). Iron stores within infants are not only dependent on gestational age at birth and birth weight, but also the iron status of the mother (Brannon & Taylor, 2017). Hence, infants born to mothers with iron deficiency anaemia are at higher risks of iron store depletion (Lönnerdal, 2017). When maternal haemoglobin concentration falls below 90g/L, the mineral is prioritised to the infant's red blood cells over the brain, consequentially increasing the risks of long-term neurodevelopmental impairment (Georgieff, 2017).

In a position statement by the American Dietetic Association, pregnant women and children who are vegan can obtain substantial quantities of iron that is comparable to omnivorous diets (Craig & Mangels, 2009). This is evident in a cross-sectional survey (Clarys et al., 2014) on men and women, where nutrient intake was compared among vegans (n=104; 7.1%), vegetarians (n=573; 38.8%), semi-vegetarians (n=573; 38.8%), pesco-vegetarians (n=145; 9.8%) and omnivores (n=155; 10.5%). Iron intake was highest in vegans compared to omnivores and vegetarians. Authors however noted the overrepresentation of women in the vegan sample (70% females) who may have practised dietary habits to consciously increase iron intake, as compared to men.

Moreover, higher iron intake does not necessarily equate to improved status as iron obtained from plant foods is non-haem with reduced absorbability (1-15%), as compared to haem iron (20-40%) (Hunt, 2003; Lönnerdal, 2009). Phytic acid and polyphenols in the form of tannic acid or chlorogenic acid from vegetables, fruits, tea, coffee, red wine, cereals, and legumes inhibit iron absorption (Hallberg, 1981). Calcium (Craig & Mangels, 2009) and fibre (Coudray et al., 1997) have such inhibitory effects to a slight extent.

Low iron bioavailability may be a contributing factor to iron deficiency among long-term vegans (Bakaloudi et al., 2021). Ferritin values were observed to be lower (under 30µg/L) among vegans than non-vegans [OR 2.25, 95% CI: 1.12 – 4.5] but when comparing markers for ongoing iron deficiency (haemoglobin, ferritin), the difference in risk was not significant between vegans and non-vegans [OR 1.71, (0.62 – 4.66)] (Selinger et al., 2019). In a cross-sectional study by Desmond et al. (2021) on five to 10-year-old children, the prevalence of depleted iron stores evident by serum ferritin of <15µg/L was 30.2% in vegans (n=46) compared to 12.8% and 18.3% in omnivores (n=61) and vegetarians respectively (n=29). Mean red blood cells, haemoglobin and heamatocrit levels were also lower among vegans. Overall, despite lower ferritin levels, the prevalence of iron-deficiency anaemia may not be greater in vegans compared to non-vegans (Bakaloudi et al., 2021). The presence of dietary enhancers and inhibitors (Gallego-Narbón et al., 2019), physical activity, and menstruation among female participants may also serve as confounders that impact levels of iron status.

Food preparation techniques such as soaking and sprouting seeds, grains, and beans, as well as leavening bread (Agnoli et al., 2017; Collings et al., 2013) may reduce inhibitory phytates (Manary et al., 2002; Sandberg et al., 1999). Consuming fermented soy products such as miso

and tempeh, (Craig & Mangels, 2009) and adding vitamin C, organic acids, carotene and retinol to iron-rich or fortified plant foods may compensate for lower iron bioavailability (Collings et al., 2013; Hunt & Roughead, 2000; Kristensen et al., 2015)

Vitamin D

Vitamin D is essential for skeletal development and regulation of calcium homeostasis (Hollis & Wagner, 2004a, 2022). Increased risks of high bone turnover, osteomalacia, and hypovitaminosis D myopathy occur when mothers face deficiency (Glerup et al., 2000; Lips, 2001). Insufficient vitamin D *in utero* and in breastmilk (Wharton & Bishop, 2003) may have negative implications for calcium homeostasis among neonates, leading to increased risks of hypocalcaemia and rickets (Yu et al., 2009), as well as adversely affect lung development and induce ailments such as asthma (Hollis & Wagner, 2022).

A systematic review of 31 observational studies showed associations between insufficient 25(OH)D concentrations and adverse pregnancy and birth outcomes such as GDM, preeclampsia, SGA, low birth weight infants, and increased risks of bacterial vaginosis (Aghajafari et al., 2013). Studies from trials have demonstrated positive impacts of vitamin D supplementation on reduced preterm delivery and low birth weight, but results remain inconclusive for GDM (De-Regil et al., 2016). Moreover, heterogeneity was found among RCTs where evidence was absent to conclusively prove the protective effects of vitamin D3 supplementation against pregnancy complications (Roth et al., 2017). However, Hollis and Wagner (2022) described that well-designed RCTs should administer vitamin D early during the gestational period for best protection against preeclampsia and other birth complications. A lack of benefit is evident past the developmental phase. Administration of vitamin D should be from the first trimester and maintained throughout pregnancy, as supported by evidence from a large-scale trial of women with moderate (n=400) and severe (n=400) vitamin D deficiency (Rostami et al., 2018). Results showed reduced preeclampsia, GDM, and preterm delivery by 60%, 50% and, 40% respectively in women taking a monthly dose of 50,000IU of vitamin D3, initiated four to eight days after the first prenatal visit, with higher efficacy and benefits among participants who were severely deficient at baseline (Rostami et al., 2018).

Sunlight is the most important source of vitamin D for pregnant women (WHO, 2016) so supplementation may be considered for at-risk individuals who live in regions or experience seasons with low ultraviolet B (UVB) exposure (Braegger et al., 2013; MOH, 2020b). In New Zealand, people living south of Nelson-Marlborough from late winter (August) to early spring (October) (MOH, 2020b) are at risk of deficiency. Vegans in these regions may be more at risk because food sources for Vitamin D are limited to animal sources (oily fish, full-fat dairy, egg yolk) and are very limited in fortified plant foods (Craig & Mangels, 2009; JM, 2012).

Several studies in Scandinavia (Bakaloudi et al., 2021) revealed that vitamin D consumption in a vegan diet was lower than the intake reference value of 5µg per day (WHO, 2004; Ströhle et al., 2011) and was more inadequate when compared to other diets (Allès et al., 2017; Davey et al., 2003; Elorinne et al., 2016; Kristensen et al., 2015; Outila et al., 2000; Schüpbach et al., 2017; Ströhle et al., 2011). A Finnish study revealed that the serum concentration of total vitamin D in the form of 25 (OH) vitamin D2 and D3 were significantly lower by 34% in vegans (n=22) as compared to non-vegetarians (n=19) ($P<0.001$), with 24% of vegans as compared to 6% of non-vegetarians, having a vitamin D concentration of $\leq 50\text{nmol/L}$ (Elorinne et al., 2016). In contrast, another study had shown no significant differences between serum 25(OH)D status between these diet groups ($P=0.854$) despite a reduced intake among the vegans (Pinto et al., 2017). The efficacy of vitamin D absorption may be higher among more deficient individuals (Rostami et al., 2018) so differences in baseline vitamin D status, in addition to testing done during different seasons or at varied geographical regions may contribute to heterogeneity among studies.

Supplementation of up to 4400IU/day for pregnancy and lactation is safe, as confirmed by several studies involving cohort populations and RCTs (Dawodu et al., 2013; Hollis & Wagner, 2004a, 2004b; Wagner et al., 2006). For at-risk pregnant women in New Zealand, vitamin D supplementation with cholecalciferol oral liquid that provides 7500IU/ml or 188µg/ml may be provided, after consultation with their doctor or midwives (MOH, 2020a).

Calcium

Calcium, as regulated by vitamin D is required for bone health (Braegger et al., 2013), maintenance of biological systems, cellular homeostasis, and nerve conduction in muscles

(Tyree et al., 2012). Inadequate intake results in poorer cardiac conduction and interference with the body's acid-base balance. Risks of fracture in vegans are more likely with a calcium intake of less than 500mg/day, as determined by findings from the EPIC-Oxford cohort that compares fracture risks among meat consumers, fish consumers, vegetarians and vegans (Appleby & Key, 2016). However, when anthropometric measures were adjusted for, bone mineral density (BMD) was not statistically different between vegetarians and omnivores, apart from total lumbar spine BMD, as supported by results from the National Health and Nutrition Examination Survey (Karavasiloglou et al., 2020). The study postulated that any differences in BMD were more related to lower body mass index (BMI) and waist circumference rather than dietary compositions. This is especially so for women. In contrast, findings from children of five to 10 years old found that even after accounting for a smaller body and bone size, vegan children had lower bone mineral content associated with lower protein quality, calcium, vitamin B12, vitamin D intake and serum concentrations (Desmond et al., 2021).

The presence of oxalate and phytates may reduce the bioavailability of calcium in plant food sources (Agnoli et al., 2017; Redecillas-Ferreiro et al., 2020). A study to compare nutritional quality among restrictive plant-based diets and omnivorous diets (Clarys et al., 2014) showed that vegans who abstain from high-calcium dairy products attain only half the intake when compared to dairy-consuming vegetarians. Plant sources for vegans which have higher bioavailability (50-60%) of calcium can be contributed from tofu and dark leafy greens (Heaney & Weaver, 1990) which are low in oxalates (Craig & Mangels, 2009). These foods and other fortified sources, with physical activity, are crucial for vegan children (Redecillas-Ferreiro et al., 2020).

Results from the New Zealand Women's Food Frequency Questionnaire (NZWFFQ) and four-day weighed food record on 110 women of reproductive age (16-45 years) found a mean daily calcium intake from food, excluding supplementation to be 1255mg and 943mg respectively (Beck et al., 2020). Although a larger sample size and survey on pregnant and lactating women are required, the results suggest the likelihood of women meeting daily calcium requirements through dietary intake alone without the need for supplementation. Furthermore, a vegan diet maintains acid-base balance and calcium stocks in the body, and has positive effects on metabolic markers for bone health (Craig, 2009).

Although the calcium requirement for the foetus is high with 30g transferred from maternal calcium store over the 280-day gestation period (Lafond et al., 2001), calcium availability is met through higher maternal absorption and bone turnover during pregnancy (Cullers et al., 2019). The increase in maternal resorption of calcium in the bone due to lowered oestrogen levels is the major contributor of calcium in breastmilk (Prentice, 1994), as opposed to dietary calcium intake. This allows 260 mg/day of calcium to the nursing infant (Goulding, 1998). Subsequently, from one year of age, vegan toddlers could be provided with unflavoured soy milk that contains at least 100 mg of calcium per 100ml (MOH, 2021).

Calcium supplementation may reduce hypertensive conditions among pregnant women, particularly for those with insufficient intake from food, but larger trials are required to obtain higher-quality results (Hofmeyr et al., 2018). Supplementation should only be advised by a doctor (MOH, 2020a). Overall, the need for supplementation whilst on a vegan diet during pregnancy appears to be unnecessary as long as calcium-rich vegetables, fortified vegan milk, and fruit juices fortified with calcium citrate or malate (bioavailability of 40-50%) (Craig & Mangels, 2009) are consumed.

Vitamin B12

Vitamin B12 deficiency is a serious risk associated with vegan diets as active forms are only present in animal food sources (Agnoli et al., 2017; Melina et al., 2016). B12 deficiency may be masked by the high folate present in vegan diets. (Winckel et al., 2011). Deficiencies of B12 can cause irreversible neurological damage and induce adverse psychiatric and haematological alterations in early life (Guez et al., 2012) because B12 is involved in myelin formation and the one-carbon metabolism (Bridson, 2003; Guerra-Shinohara et al., 2004; Molloy & Weir, 2001; Porter et al., 2016; Stollhoff & Schulte, 1987). Physiological manifestations of B12 deficiency include permanent developmental delays, movement impairments, and failure to thrive. B12 is a cofactor in intracellular reactions for the synthesis of healthy red blood cells and DNA, so normal oxygen transport is only possible in B12 sufficiency (Benham et al., 2021).

Literature and clinical evidence concluded that symptoms of B12 deficiency are present in the children of vegan mothers (Bruckmann et al., 2015; Guez et al., 2012; Kühne et al., 1991; Sklar, 1986). Cases, where infants and toddlers have died due to B12 deficiency as a result of

a vegan diet, were reported (Pawlak, 2020) in France (Allen, 2011) and New Zealand. (Second Opinions; Di Genova & Tanya, 2007). This may contribute to debates and worry over the level of education parents have received before beginning a restrictive vegan diet during infancy. Due to liver stores, most adults can tolerate a B12-deficient diet without developing symptoms for years but neonates have insignificant sources of B12 hepatic reserves, which is further limited if maternal B12 status and intake are suboptimal (Dror & Allen, 2008). Another problem associated with B12 deficiency in infants is the increased risks of neural tube defects (Molloy et al., 2009; Peker et al., 2016) and preterm birth (Rogne et al., 2017) which is problematic when significant neurological impairment has already occurred by the time the deficiency is detected (Devalia et al., 2014).

A systematic review of 40 research studies (Pawlak et al., 2014) on vegan-vegetarian diets showed a 45% prevalence of B12 deficiency among infants and 17 to 39% in pregnant women. A higher frequency of deficiency is observed in vegans than vegetarians, with greater risks among non-supplemented individuals (Gilsing et al., 2010; Pawlak et al., 2014; Pawlak et al., 2013). Early studies reported that B12 is found in plant foods such as mushrooms, spirulina, and some fermented foods, but these are not reliable sources as the vitamin is an inactive analogue (Dagnelie et al., 1991; Koyyalamudi et al., 2009; Rauma et al., 1995). Hence, supplementation is likely the only method to supply B12 to vegans.

A cross-sectional study on 36 vegans and 36 omnivores has found encouraging data that similarly good B12 status can be obtained in vegans as compared to omnivores when a high rate of supplementation was provided (Weikert et al., 2020). Similarly, in a study on children from five to 10 years old (Desmond et al., 2021), vegans (n=15) who were not given supplements had significantly lower mean serum B12 concentrations, higher mean homocysteine and mean corpuscular volume (MCV) than omnivores (n=72) (all $p < 0.01$). Accessible guidelines for B12 supplementation should be made available to vegan parents and lead maternity carers (LMCs) to avoid severe health implications for this population.

Iodine

Insufficient iodine negatively impacts thyroid hormone synthesis (Zimmermann, 2008). The hormone is critical for neuronal migration and myelination of the brain in the foetus and infant, so deficiency during pregnancy can impair neural and psychomotor development with

the most severe consequence being cretinism (Zimmermann, 2012). Results from the Avon Longitudinal Study of Parents and Children (n=1040 pregnant women and children) have shown that low maternal iodine status is negatively associated with Intelligence Quotient (IQ) scores at eight years of age, reading accuracy, comprehension, and reading score at nine years of age (Bath et al., 2013). A meta-analysis of three prospective population-based cohorts has shown that mild to moderate deficiencies in iodine, especially during the third trimester were associated with lower verbal IQ scores (Levie et al., 2019). An increment of approximately 50% of iodine (160 to 220µg/day) is needed during pregnancy to accommodate for elevated maternal thyroxine levels, provide for maternal iodine transfer to the foetus and maintain iodine-replete conditions in both the mother and foetus (Brough et al., 2015; Zimmermann, 2012). Requirements are similarly increased (190 to 270µg/day) during lactation as breastmilk is a crucial source of iodine for infants (Azizi & Smyth, 2009).

A Norwegian study showed that 55% of vegans have a urinary iodine concentration (UIC) lower than 50µg/L especially if supplements were not consumed (Groufh-Jacobsen et al., 2020). However, iodine deficiency may not be specific to the vegan population (Elorinne et al., 2016) as quantities in soil and foods vary across different regions of the world. Since the re-emergence of iodine deficiency in New Zealand during the 1990s, two specific initiatives were introduced. Firstly, all bread, except organic bread are mandatorily fortified with iodised salt in 2009 (Brough, 2015). Secondly, a 150-µg iodine-only tablet is provided to all pregnant and lactating women in New Zealand (MOH, 2020a).

A pilot study of iodine intake and status among pregnant and lactating women (n=127) in Palmerston North, New Zealand (Brough et al., 2015) showed that despite an improvement in iodine status, deficiency remains an issue with median UIC of 85µg/L for pregnant women and 74µg/L for lactating women. A concurrent study among 300 New Zealand school-aged children of eight to 10 years had similarly shown mild deficiency as observed by serum thyroglobulin concentrations (Skeaff et al., 2002). These results suggest that the iodine quantity of 100–125µg in some supplements is insufficient, or that less than two slices of bread were consumed per day (Brough et al., 2015). In another longitudinal cohort study by Jin et al. (2022) to determine the iodine status of New Zealand mothers and infants recruited at three (n=87) and followed up at six (n=78) and 12 months (n=71) postpartum between 2016 to 2017, infant mean UIC at three and six months postpartum were below 125µg/L.

Overall, the study found that postpartum women were iodine-deficient, and breastfed infants had suboptimal iodine status.

Considering that iodine-rich foods are seafood, meat, eggs, and dairy (Vannoort & Thomson, 2005), vegan women should obtain iodine from fortified sources and/or supplementation. Marine algae in the form of kelp, kombu, and wakame are often not recommended due to high fluctuations of iodine content, between $16\mu\text{g/g}$ (± 2) in nori to $8165\pm 373\mu\text{g/g}$ in kelp, which could lead to excessive intake (Teas et al., 2004).

Zinc

Zinc is a key catalyst in more than 300 metalloenzymes and 2500 transcription factors (King et al., 2015). It is essential for gene expression and cell signalling, (Foster et al., 2015) through the regulation of kinase and phosphorylase activities (King et al., 2015). Physical manifestations of zinc deficiency include delayed growth, delayed sexual and bone maturation, compromised immunity, and diarrhoea (Foster et al., 2015).

Higher zinc demands are required for foetal growth and development, especially during the third trimester (Sebastiani et al., 2019; Swanson & King, 1987). There are however inconsistent outcomes of zinc deficiency during pregnancy because homeostatic adaptations such as increased intestinal absorption are likely physiological regulation for zinc and may compensate for the absence of high dietary zinc intake (King, 2000a). Breastfed infants born to vegan mothers who obtain sufficient dietary intake of zinc will likely obtain similar zinc nutritional status as infants of omnivorous mothers (Agnoli et al., 2017).

Phytate presence in unrefined cereals, pulses, and whole grains may interfere with zinc absorption in the small intestine (Agnoli et al., 2017; Foster et al., 2013; Hunt, 2003). A 50% increment in zinc consumption may be required for certain vegetarian diets to accommodate the lower bioavailability (Foster et al., 2013). Despite this, overt deficiency has not been widely documented in western vegetarians (Hunt, 2003). In a systematic review of zinc deficiency among eight studies with a total of 4525 participants (Bakaloudi, 2021), overall zinc intake was lower among vegans who had a higher risk of zinc deficiency (Allès et al., 2017; Davey et al., 2003; Kristensen et al., 2015). The EPIC-Oxford cohort study (Davey et al., 2003) compared nutrient intakes between 33,883 meat eaters and 31,546 non-meat eaters

in the United Kingdom showed that zinc intake was lowest among vegan women (n=1342), with a mean intake of 7.22mg per day, as compared to women who were meat-eaters (n=22,962) (9.16mg), fish-eaters (n=6931) (7.94mg) and vegetarians (n=12,347) (7.67mg). It was however unclear if differences in intake were statistically and clinically significant.

Appropriate preparation methods of grains such as soaking, germination, genetic modifications, enzymatic actions, and fermentation can reduce phytate interference (Gupta et al., 2015; Temple et al., 2002). The consumption of vitamin C and organic acids with a zinc-rich meal can promote intestinal absorption (Wegmüller et al., 2014). The limitation of fibre content by incorporating some refined foods in the diet or straining fruits and vegetables helps toddlers (up to 24 months) to achieve zinc sufficiency (Baroni, Goggi, & Battino, 2018). There is currently a lack of advice on zinc supplementation and methods to increase zinc bioavailability in the Eating and Activity Guidelines from MOH (2020a).

2.3 Guidelines for Vegan Diets in New Zealand

The Eating and Activity Guidelines for New Zealand Adults (MOH, 2020a) were designed based on the principles of healthy and sustainable eating by the Food and Agriculture Organisation of the United Nations (FAO) and the WHO (FAO & WHO, 2019). Information in the guidelines for vegan food options is presented in **Table 2.1**. Some guidelines for vegan diets during early life are highlighted in the updated Healthy Eating Guidelines for New Zealand Babies and Toddlers (0-2 years old) (MOH, 2021), but are limited in content. This is presented in **Table 2.2**.

Table 2.1 Ministry of Health guidelines for plant-based diets (MOH, 2020a)

Source	Guideline
Eating Statement 1	<ul style="list-style-type: none"> a. Enjoying a variety of vegetables and fruit to obtain vitamins, minerals, dietary fibre, and phytonutrients such as folate from green leafy vegetables, and pro-vitamin A (carotenoids) from yellow, orange, red and green vegetables. b. Inclusion of legumes, nuts, soy milk, and seeds to increase protein and energy needs c. Sourcing for fortified foods such as plant-based milk alternatives that are fortified with B12, vitamin D, and calcium d. Supplementation advice <ul style="list-style-type: none"> i. folic acid – only tablet (800µg) four weeks before pregnancy until twelve weeks after pregnancy ii. iodine - only tablet (150µg) from the start of pregnancy till breastfeeding ends iii. Vegan women are required to additionally consume B12 supplements during pregnancy and breastfeeding, even if no deficiency status is presented. This should be provided by their LMC. B12 is the main nutrient of concern highlighted in the guidelines for vegan pregnant and breastfeeding women. iv. Supplementation for other micronutrients is not recommended, unless clinically implicated or approved by LMC which may include her midwife, doctor, or dietitian
Appendix 3: Serving size examples (for vegan alternatives)	<ul style="list-style-type: none"> a. A standard serve of 500 – 600kJ of milk or milk products is equivalent to 1 cup (250ml) of calcium-fortified (100mg of calcium per 100 ml) plant-based milk such as soy, rice, almond, oat milk b. A standard serve of 500 – 600kJ of plant protein is equivalent to 1 cup (150g) of cooked or canned beans, lentils, chickpeas, or split peas, 170g of tofu, or 30g of nuts, seeds, peanut, almond butter, tahini or other nut or seed paste.

Table 2.2 Ministry of Health guidelines for plant-based diets in children (MOH, 2021)

Source	Guidelines
Eating Statement 3	a. Babies and toddlers who follow a vegan diet should be breastfed for two years and more. b. Parents of vegan babies and toddlers must be provided with a vitamin B12 supplement.
Eating Statement 5	a. Unflavoured soy milk that is fortified with calcium (of at least 100mg per 100ml) and vitamin B12 is the only plant-based milk alternative for babies over 12 months old and who are not breastfed. Homemade soy milk is not recommended as there is an absence of calcium.

Other brief guidelines on plant-based diets are obtained from the New Zealand Nutrition Foundation (2022) and the New Zealand Heart Foundation (2022). A more elaborate guideline titled ‘Eating for Healthy Vegetarians’, last revised in 2012, is available on HealthEd (2011) and provides more information about nutrients of concern such as B12, (e.g. ‘there is no natural animal source of vitamin B12’) and methods to improve iron absorption. However, this resource does not provide information tailored to vegan diets for pregnancy, breastfeeding, and early life.

The British Dietetic Association (BDA) (BDA, 2017) and the Vegan Society (2022) have produced documents to support healthy growth and development for vegan individuals, including elaborate information for vegan diets during pregnancy and early life, but evidence-based guidelines that are based on the nutritional needs and the geographical context of the New Zealand population are required. These may benefit LMCs who work independently or have limited access to dietitians.

2.4 Current Findings about Health Professionals' Knowledge and Attitude on Vegan Diets

2.4.1 Summary of Studies

Appendix 2 summarises the 12 studies in this section of the literature review that examines past studies assessing knowledge and/or attitude among health professionals on vegan diets. Due to the lack of studies examining only vegan diets, those that examined nutrients in vegetarian or plant-based diets that were relevant to pregnancy and early life were included.

2.4.2 Outcome Findings

Overall nutritional knowledge

Because convenience sampling was utilised in most of these studies, participants may already possess higher baseline knowledge and have more positive attitudes towards vegan and/or vegetarian diets. Scores may be overestimated, limiting the extent of data generalisation to a wide population of health professionals. Furthermore, as the difficulty of questionnaire items was not evaluated, the knowledge levels may not be distinguished between health professionals of higher education and that of the general population. Regardless of the limitations, the collective finding from most articles revealed that health professionals did not have extensive knowledge about nutrient deficiencies associated with vegan and/or vegetarian diets (Arrish et al., 2016; Lee et al., 2017; Bettinelli et al., 2019; McHugh et al., 2019; Sanne & Bjørke-Monsen, 2020; Landau et al., 2020; Othman et al., 2020a; Meulenbroeks et al., 2021; Hanna et al., 2021).

A cross-sectional questionnaire on health professionals in the maternal-child ward of two tertiary-level hospitals in Milan (n=418) (Bettinelli et al., 2019) reported that specific questions about protein bioavailability, sources of calcium, zinc, and vitamin D, as well as the adequacy of long-chain omega-three fatty acids were answered correctly by less than half of the participants. More than 55% of participants answered questions about iron and B12 correctly. At least four items in this questionnaire included alternative terms of vegetarian/vegan diets (e.g., Question 8: 'The vegetarian/vegan mother is at greater risk of deficiency in...'; Question 15: 'The supplemental nutrient that should not be missing for a

vegetarian/vegan child is...'). Responses may be subsumed under either diet classification but scores may not be reflective of accurate knowledge because nutrient risks and supplementation requirements are higher in vegan diets than in vegetarian diets.

A mixed methods approach with a cross-sectional questionnaire (n=202) and semi-structured interviews (n=31) with Australian pregnant women and clinicians (midwives and obstetricians) (Lee et al., 2018) found that while clinicians had an overall significantly higher knowledge score than pregnant women ($p < 0.001$), only one clinician had attained a score of more than 80% on the nutritional knowledge questionnaire and less than 50% of clinicians had correct responses to questions about iodine. While pregnant women have the poorest knowledge about iodine, less than 50% of clinicians provided correct responses for three questions on iodine ('Need for iodine supplementation': 45%; 'Iodine is recommended during pregnancy and breastfeeding': 29%; 'Food sources of iodine': 27%). In a similar cross-sectional survey (Arrish et al., 2016) on members of the Australian College of Midwives (n=329), 79.9% of midwives provided incorrect responses for iodine requirements per day for pregnant women, and only 9.1% could correctly identify all sources of iron.

Norwegian medical students showed similarly poor knowledge about vitamin B12, with 33% stating that plant foods were adequate sources (Sanne & Bjørke-Monsen, 2020). Folate deficiency was mistakenly identified to be present in a vegan diet by 53% of students. Findings from a survey of pharmacists in Belfast (Hanna et al., 2021) concluded the absence of knowledge on the type of foods that provide specific vitamins. For instance, not all participants could identify that B12 deficiency was common in vegan diets (65.2% correct).

One study using a cross-sectional questionnaire on registered midwives in New Zealand (n=370) concluded that the participants were generally knowledgeable of nutrition issues related to pregnancy, but poor knowledge on nutrition related to vegetarian and vegan diets was observed (Elias & Green, 2007). With regard to spirulina, 64.6% of midwives incorrectly identified that it is a good source of iron for vegetarians but 93.8% of midwives (n=347) were knowledgeable about the impacts of vitamin C and tea on iron absorption. Not all midwives were aware that spirulina is a poor source of vitamin B12; 58.1% (n=215) provided the correct response. Only 32.2% of participants (n=119) could correctly identify that breastmilk was a poor source of vitamin D. While this study provided the first examination of knowledge among New Zealand midwives on pregnancy nutrition, it was severely limited by

a low response rate of 27.6% (370 of 1340). As far as this researcher is aware, no further studies have surveyed maternity care professionals on knowledge or concerns about vegan diets in New Zealand, justifying the necessity for current investigations.

Evidence from a pre- and post-intervention study on 44 Australian midwives (Othman et al., 2020a) showed significantly improved knowledge scores from baseline to immediately after the intervention ($p < 0.001$) and six to eight weeks post-intervention ($p < 0.01$). In particular, improved knowledge was observed for nutrients of concern in a vegetarian diet, such as vitamin C, D, and B12 (baseline: 60.5%, $n=26$; immediate: 93.1%, $n=27$; post: 94.7%, $n=18$), recommended iodine intake during pregnancy (baseline: 27.3%, $n=12$; immediate: 93.1%, $n=27$; post: 84.2%, $n=16$), and recommended vitamin D requirement during pregnancy (baseline: 11.4%, $n=5$; immediate: 79.3%, $n=23$; post: 47.4%, $n=9$).

Hence, continuous training in nutrition may be the key to improving knowledge, attitudes, and confidence in health professionals. Australian midwives found that those who received nutrition information during midwifery education scored higher knowledge scores (mean=13.96) than those who did not (mean=13.30) (Arrish et al., 2016), but whether this was a significant difference was unclear due to a lack of either parametric or non-parametric statistics. In a systematic review (Othman et al., 2018), a few articles ($n=4$) compared pre- and post-intervention nutritional knowledge scores, with all reporting statistically significant improvement in scores among midwives after the educational intervention. This is further supported by an emerging theme from clinicians' interviews (Lee et al., 2017) that insufficient training, education, and knowledge were factors impeding the provision of nutrition advice. However, an absence of randomised trials increases the difficulty in relating knowledge change to educational interventions. Knowledge scores may also be impacted by questionnaire items that were based on nutrient guidelines that differ among countries. This increases the difficulty in collating and generalising nutritional knowledge globally.

Health professionals appear to refer women on restrictive diets to dietitians (Elias & Green, 2007; Schaller & James, 2005) who may be perceived as experts on food and nutrition. However, knowledge of vegan diets among dietitians is not always sufficient. Among Dutch dietitians ($n=111$) (Meulenbroeks et al., 2021), 96.4% stated that formal nutrition training had not covered strict plant-based diets during pregnancy, with only 7.2% taking on an additional course to learn about them. Only 38.7% of dietitians claimed confidence in offering counsel

for strict plant-based diets during pregnancy. Among Peruvian dietitians (Saintila et al., 2021), less than 50% provided accurate answers to questions on iron, calcium, zinc, and fatty acids. The evidence thus suggests that even dietitians may not have an exhaustive knowledge of all aspects of a vegan diet, rendering continuing education a necessity. Common barriers to dietitian referral, as determined by the Australian midwives, included a high demand for their services, insufficient time allocations, limited funds, and availability, particularly in remote regions (Arrish et al., 2016).

Factors impacting knowledge

Some studies found that the personal dietary habits of health professionals may be related to higher nutritional knowledge. A cross-sectional questionnaire among paediatricians in Israel (n=270) (Landau et al., 2020) found that vegetarians / semi-vegetarians had significantly higher mean scores for knowledge at 48.4%, as compared to non-vegetarians, at 36.2% (95%CI 6.8-17.6, $P<0.001$). Among Norwegian medical students (Sanne & Bjørke-Monsen, 2020), significantly more vegetarians (83%) than omnivores (65%) correctly considered meat to be a good source of vitamin B12 ($P=0.003$). Significantly more Peruvian vegetarian dietitians (77.8% of 179) had correct responses for the nutrients needed by an infant during complementary feeding than non-vegetarians (63.6%) ($P=0.043$) (Saintila et al., 2021). Higher scores from the vegetarian health professionals were postulated to be a result of a significantly higher proportion of them receiving training in vegetarian nutrition in the last five years as compared to non-vegetarians ($P<0.001$) (Saintila et al., 2021). A positive attitude among vegetarians could be associated with increased interest in seeking self-education about their diet. (Corrin & Papadopoulos, 2017).

Findings of higher knowledge in vegetarians as compared to non-vegetarians were however not always consistent. On whether a vegan mother can breastfeed without supplementation (Bettileni et al., 2019), both omnivores and vegetarians had the same percentage of correct answers. For the question of whether the nutritional demands for the first 1000 days of life can be provided by a plant-based diet, vegetarians had lower scores than omnivores (Bettileni et al., 2019). More omnivorous Norwegian medical students were aware of the deficiencies of fatty acids, selenium, zinc, and vitamin A in a vegan diet ($P\leq 0.05$) (Sanne & Bjørke-Monsen, 2020).

Without more research with larger sample sizes, it cannot be concluded that individuals who are vegan or vegetarian have more accurate knowledge than meat consumers. Importantly, there is an absence of knowledge comparisons between vegan and non-vegan participants. Health professionals who are vegans may be rare, or these individuals were categorised under ‘vegetarians’ during analysis.

Confidence and attitude

Overall, most health professionals had lower levels of confidence in discussing or providing nutritional advice for vegetarian and vegan diets. This was the case for 71.8% of Australian midwives (Arrish et al., 2016). The more current study on Australian midwives (Othman et al., 2020a) showed that at baseline, more than half reported being ‘not confident at all’ or only ‘slightly confident’ in providing education for vegetarians and vegans. It is of note that after the administration of an educational workshop, mean confidence scores significantly increased from a baseline (n=44) score of 22.05 ± 6.87 to 31.48 ± 7.47 immediately after education (n=29), and to 30.89 ± 7.19 (n=19), ($P < 0.05$) six to eight weeks post education. This suggests that educational interventions could be associated with greater knowledge and thus, improved confidence. A positive correlation between knowledge and confidence scores over the three time periods supports this (Othman et al., 2020a). More research is however needed to determine the retention of knowledge over time and if changing national guidelines can subsequently impact knowledge and confidence.

Overall attitudes towards vegetarian and vegan diets may be related to personal dietary habits. Significantly more vegetarian (44%) than omnivorous students (13%) considered vegetarian diets to be healthier than omnivorous diets ($P < 0.001$) and significantly more vegetarians (16%) than omnivorous students (2%) considered vegan diets to be healthier than vegetarian diets ($P < 0.001$) (Sanne & Bjørke-Monsen, 2020). Similarly, among Israeli pediatricians (Landau et al., 2020), vegetarians had significantly higher mean attitude scores of 53.1% than non-vegetarians who had a mean score of 35.7% (95% CI 10.5-24.4, $P < 0.001$). Participants who have reaped benefits from plant-based diets may display more positive views and have increased motivation in providing dietary advice. It is therefore critical that they have accurate knowledge about nutrient concerns in these restrictive diets.

Some evidence shows the presence of negative attitudes among health professionals toward vegetarian and vegan diets. Focus group interviews reported that Dutch pregnant women had received negative attitudes from their obstetric care providers on their strict plant-based (vegan) diets and felt that there was a challenge in obtaining accurate information about veganism during pregnancy (Meulenbroeks et al., 2021). A strict plant-based diet was considered by 80.2% of midwives (n=121) and 93.9% of obstetricians (n=54) to be a significant risk factor for nutrient deficiency during pregnancy. Additionally, the perspective on who should be responsible for providing education to pregnant women on strict plant-based diets was somewhat divided (Meulenbroeks et al., 2021; Lee et al., 2017). A portion of midwives (20.3%) and obstetricians (41.9%) considered dietitians to be responsible, while a portion of obstetricians thought that the patient (45.8%) and the Dutch National Nutrition Centre (45.8%) should provide this information. Clinicians in Australia similarly perceived that patients should be responsible for obtaining knowledge (Lee et al., 2017).

A study on health professionals in Gisborne, New Zealand (n=41) found some mixed reviews on plant-based diets (McHugh et al., 2019). Generally, these diets were viewed to benefit health and lead to improved quality of life. A proportion (56%) agreed that vegan diets were beneficial. However, the difficulty in preparing a well-balanced vegan meal, especially for large families, was a perceived barrier. Cost, accessibility and traditional attitudes to foods were also thought to be inhibiting factors. A doctor-focus group within this study commented on the difficulty in maintaining plant-based diets in a culture centred around meat consumption in New Zealand. Attitudes towards the best sources of calcium and iron were still geared towards dairy and meat sources respectively.

Similar mixed attitudes were observed among medical providers of Rush University Medical Centre (n=106) (Krause & Williams Sr, 2019). While the majority perceived plant-based diets to be safe and healthy, the recommendation of a plant-based diet was indicated by only 33%. Major limitations in both studies (Krause & Williams Sr, 2019; McHugh et al., 2019) included the lack of comparative statistics to elucidate quantitative data, small sample sizes, and unvalidated questionnaires. It is apparent from the study by Krause and Williams Sr (2019) that even highly-educated health professionals do not have thorough knowledge of all aspects of a vegan diet (e.g., the definition of the diet, protein, iron, omega-three sources, B12 deficiencies). Inadequate knowledge may be linked to less positive attitudes toward recommending vegan diets to patients, but an absence of measures indicating such

correlations means that conclusions cannot be ascertained. Opportunities should be made accessible for medical providers to learn about the benefits of these diets (Krause & Williams Sr, 2019). Improving knowledge could potentially be the best way to alter attitudes and promote supportive care. (Fraser, 2009; Kiely, 2021; Tuso et al., 2013).

Overall, health professionals were willing to pursue further education to improve their knowledge and confidence status about vegan diets. In the Dutch study, 95.5% of dietitians were keen to learn more by attending conferences, and courses and receiving clear national guidelines, while 86.8% of midwives and 88.6% of obstetricians expressed interest in learning via short online courses (Meulenbroeks et al., 2021). Supportive views were also obtained by program directors of dietetics programmes in the United States to teach vegetarian and vegan nutrition to their students (Hawkins et al., 2019). With an expected increase in the adoption of vegan diets among women and the simultaneous risks of deficiencies from poorly planned meals, the effort is urgently needed to introduce and update vegan nutrition education for all healthcare professionals.

2.5 Concluding Statements

As described in the Maternity Report from MOH (2021), continuous care and monitoring of maternal and infant health is a fundamental step to monitoring the health of the population. A range of health professionals, including LMCs, doctors and dietitians are likely to look after women preconceptionally, during pregnancy, infancy and childhood. This reasonably suggests that women and their babies will receive communication about health and nutrition from these professionals who must provide respectful and supportive care for families on vegan diets. This cannot happen if there is little awareness of nutrient deficiency risks. Negative attitudes and a lack of clarity on the roles and responsibilities in providing nutrition care could have adverse impacts on a woman's satisfaction with the birth experience. Quality maternity care and services are contributing factors to her self-esteem and relationship with the newborn (Goodman et al., 2004). Investigating the perspectives and concerns of health professionals about vegan diets in New Zealand is the first step to bridging knowledge gaps and promoting positive attitudes in vegan nutrition care.

Chapter 3 : Methodology

3.1 Introduction

A mixed-method study design allows the collection of quantitative data and subsequent interpretation of such objective data through a qualitative approach that examines human experiences within a variety of contexts (Doyle et al., 2009). The current study comprises a two-stage process. First, a pre-interview nutritional knowledge and attitude questionnaire (quantitative), was designed to determine knowledge and attitude about vegan diets. Second, a qualitative semi-structured interview (SSI), was designed to explore the experiences and perspectives of health professionals regarding vegan diets during pregnancy and early life. This is the first study in New Zealand to uncover such insights. Hence, the triangulation of data from both quantitative and qualitative approaches, in an explanatory sequential design increases validity, offsets limitations of each study design and allows the research aims to be met comprehensively (Doyle et al., 2009). This research project was evaluated by the Massey University Human Research Ethics Committee and judged as low risk.

3.2 Questionnaire Design

Concepts surrounding the adoption of a vegan diet during pregnancy, lactation, and complementary feeding were included in the questionnaire (Uribe & Olson, 2020). Items about nutrient requirements in a vegan diet were crafted using national guidelines from the Eating and Activity Guidelines for New Zealand Adults (MOH, 2020a), the Healthy Eating Guidelines for New Zealand Babies and Toddlers (0-2 years old) (MOH, 2021), and recent peer-reviewed publications with questionnaire items assessing vegan and/or vegetarian knowledge and attitude among healthcare professionals (Meulenbroeks et al., 2021; Bettleni et al., 2019; Saintilia et al., 2021).

An unvalidated questionnaire (**Appendix 3**) consisting of 21 questions in total and subdivided into three sections was provided to the participants via a secure link or Quick Response (QR) code. Participants were instructed to complete the questionnaire before their interview with the researcher. Section A included ten questions asking for information about the sociodemographic (e.g. age range, gender, ethnicity) and professional (job title and experience) profile of the health professionals. The last question in this section asked about the current diet followed by the health professional. Section B consisted of nine questions

comprising nutritional knowledge of vegan diets during pregnancy, breastfeeding, and early life. Questions included the risks of nutrient deficiencies, sources of key micronutrients of concern (e.g. B12 and iron), supplementation, and alternative vegan milk sources for young children. The Likert scale was used in one question, with a series of statements asking about health professionals' attitudes towards the adoption of vegan diets, and the role they play in supporting their patients or clients who are on these diets. Questions were also asked to identify the sources of information and preferred mode of training to increase knowledge on vegan diets. Questionnaires were conducted and disseminated online via a secure link, through Qualtrics (Qualtrics, Provo, UT, 2022). Section C consisted of two questions that asked for feedback on the length of the questionnaire.

3.3 Quantitative Analysis

Questionnaires responses were exported from Qualtrics to Microsoft Excel for tabulation and analysis. Responses for each question were presented as a proportion of the total number of respondents.

3.4 Interview Design

The interview schedule (**Appendix 4**) was guided by the research aims. The SSI schedule was developed following the general interview guide approach (Butina, 2015). Questions that addressed pertinent topics of the research were constructed, with additional questions able to be spontaneously added (Butina, 2015). For example, specific questions about breastfeeding and infant nutrition were added when interviewing lactation consultants and paediatric specialists. The choice of terminology for each question was attained through preliminary brainstorming between the researcher and academic supervisors, and motivated by discussed concepts in the literature (Bettieni, 2019; Krueger & Casey, 2015; Meulenbroeks et al., 2020). Interview questions were open-ended and crafted to allow free expression of opinions and ideas (Arrish et al., 2017; Hennink, 2014).

3.5 Recruitment

Inclusion criteria were all health professionals that have regular or potential interactions with pregnant, lactating women, and children in early life (0-2 years). A sample which included midwives, Plunket nurses, Tamariki Ora nurses, Karitāne nurses, and general practitioners

(GPs) were recruited. Health professionals who provide dietary or nutritional advice such as dietitians and nutritionists were also included.

Purposive sampling was conducted where participants with relevant experiences in providing nutrition care during pregnancy and early life were recruited (Etikan et al., 2016). Health professionals affiliated with the College of Health, at Massey University were contacted. The study was advertised to the participants of the Massey University Early Life Nutrition symposia series who indicated consent to participate in relevant research studies. To grow the sample size, participants who had completed the study were asked for contacts who fit the inclusion criteria and were willing to participate. Sampling was performed to the point of data saturation where no new information was generated (Butina, 2015).

Potential participants were recruited with a formal invite through email, with an attached information sheet (**Appendix 5**) which described the aims of the study, their involvement, and how the collected data will be used and safeguarded. Participants were advised that they were free to leave the discussion at any time and that they may choose to decline to answer any questions. A personalised confirmation letter (**Appendix 6**) and consent form (**Appendix 7**) were sent to participants via email who expressed interest and met the inclusion criteria.

3.6 Interview Proceedings

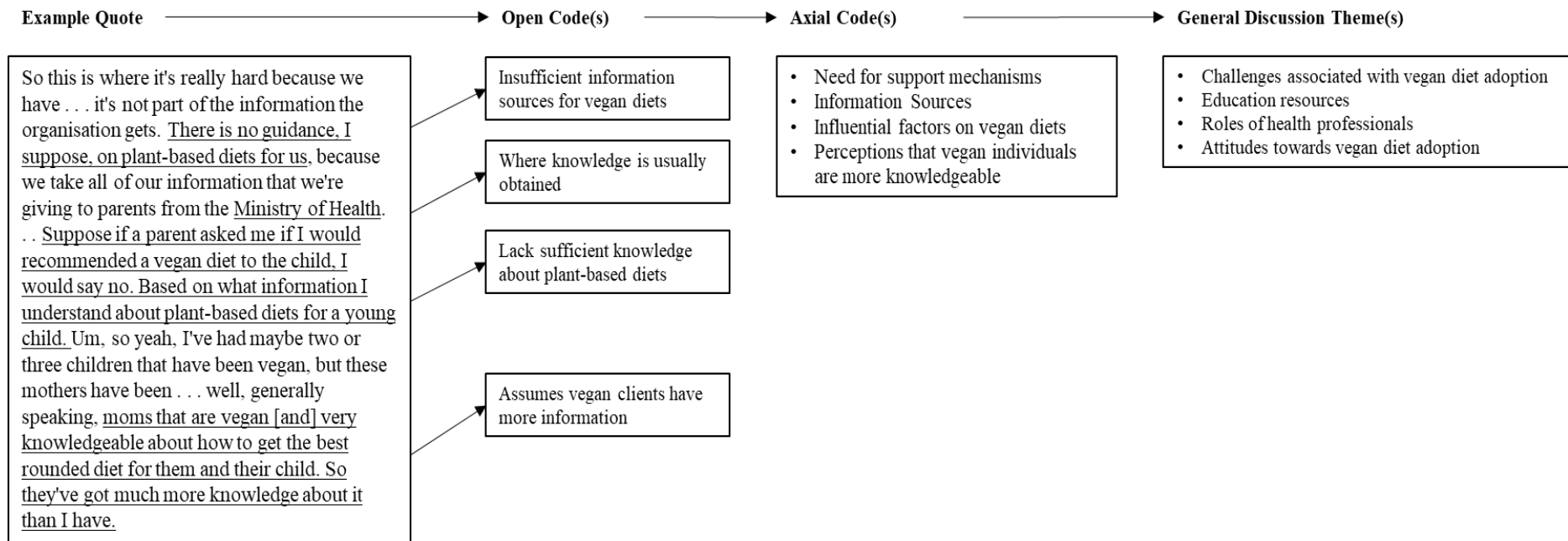
Before the interview, written and verbal consent were attained before the recording of conversations. Participants were required to attend one interview session and were interviewed individually. The venue of the SSI was conducted securely via the online meeting platform, Zoom (Zoom, 2022), and recorded with consent provided. Each SSI ranged from 30 to 45 minutes. Although the names of participants were used during the interviews, these were removed from the transcript and finalised report to protect their identities and ensure anonymity. Names were replaced with a customised code: HP (Health Professional), followed by the number of the interview. For example: HP1. The auto-transcription function in Zoom (Zoom, 2022) was enabled, with the generated transcript subsequently checked and edited for accuracy. All audio files and transcripts were downloaded to the researcher's password-protected computer for safekeeping.

3.7 Qualitative Analysis

The interview transcripts served as material for qualitative analysis. While the use of qualitative data analysis software, such as NVivo was considered, a manual analysis process was considered appropriate due to the relatively small number of interviews. The manual qualitative analysis process incorporated a standard three-step process of open, axial, and reflective coding, and followed the guidelines in the literature (Butina, 2015; Clarke et al., 2015; Krueger & Casey, 2015; Schmidt, 2004).

In the open coding process, each transcript was read and quotes were highlighted according to emerging themes (Gournelos et al., 2019; Krueger & Casey, 2015). Open codes were subsequently categorised into axial codes by identifying commonalities and linking similar concepts. Finally, during the reflective process, axial codes were further condensed into the major overarching themes that reflected the research aims. **Figure 3.1.** provides an example of the coding process.

Figure 3.1 Sample coding process (from HP5)



Chapter 4 : Results

A total of 14 participants returned signed consent forms and completed the questionnaire and SSI. All participants were healthcare professionals who either had experiences in pregnancy and early life, or provided dietary advice to patients. All respondents had experiences with restrictive diets, including allergy-free diets, diet intolerances, as well as vegetarian and/or vegan diets. Detailed professional experiences are presented in **Appendix 8**.

4.1 Questionnaire Findings

The majority of the health professionals surveyed in this study were female, of New Zealand European or European ethnicity, and most had omnivorous diets. Participant demographics and professional characteristics are presented in **Tables 4.1** and **4.2** respectively.

Table 4.1 Demographic characteristics of health professionals.

Demographic Category	Characteristics	Total n (%)
Participants		14 (100%)
Gender	Female	13
	Male	1
Age (years)^a	< 30	3
	31 – 40	1
	> 40	3
Ethnicity	New Zealand European / European	11
	Māori	1
	Asian	1
	Indo-Fijian	1
Personal diet	Omnivorous	11
	Pescatarian	1
	Vegetarian	1
	Vegan	1

^a Missing data as not all participants provided age, so percentage does not total up to 100%.

Table 4.2 Professional characteristics of health professionals

Characteristic	Categories	Total n (%)
Participants		14 (100%)
Highest qualification	Undergraduate	4 (28.6)
	Postgraduate	10 (71.4)
Professional role	Dietitian	4 (28.6)
	Nutritionist	1 (7.1)
	General Practitioner	1 (7.1)
	Plunket Nurse	2 (14.3)
	Tamariki Ora Nurse ^b	1 (7.1)
	Karitāne Nurse ^c	1 (7.1)
	Paediatric Registrar	1 (7.1)
	Midwife	3 (21.4)
Work experience (years)	1-3	3 (21.4)
	4-5	3 (21.4)
	6-10	5 (35.7)
	>10	3 (21.4)
Type of patients / clients^a	Women in pregnancy and/ or lactation	7 (50.0)
	Infants or babies (0-12 months)	8 (57.1)
	Toddlers (1-3 years)	6 (42.9)
	Pre-schoolers (3-5 years)	4 (28.6)
	Children (5-12 years)	2 (14.3)
	Adolescents (12-18 years)	3 (21.4)
	Adults (18-64 years)	2 (14.3)
	Older adults > 60 years	2 (14.3)
	All of the above	3 (21.4)
Experience with individuals on restrictive diets	Yes, with pregnant, breastfeeding women or young children (<2 years)	12 (85.7)
	Yes, with other groups	1 (7.1)
	No	0 (0.0)
	Unsure	1 (7.1)

^a Participants allowed to choose more than one type of patient/client.

^b Nurses trained to support the growth and health of a child from six weeks up to 5 years of age (Ministry of Health, 2018)

^c Provide support to families with children under five and provide information on parenting issues (Wintec, 2022)

Nutritional knowledge scores were tabulated in **Table 4.3**. The majority of health professionals perceived that pregnant and vegan women were likely to have the highest risks of iron and vitamin B12 deficiencies. Knowledge about nutrient deficiencies for protein, omega-three fatty acids, iodine, zinc, and vitamin D were raised by ≤50% of health professionals. Less than 50% of health professionals were aware that plant foods do not provide sufficient quantities of B12. Plant sources of iron were well answered by respondents with the majority selecting beans, lentils, and nuts (71.4%) and green leafy vegetables

(85.7%) as sources. Almost all health professionals (92.9%) correctly identified that consuming vitamin C with an iron supplement will increase iron absorption. Only 57.1% correctly identified fortified soy milk as the only appropriate vegan milk alternative for children above one year of age.

Table 4.3 Nutritional knowledge scores of health professionals

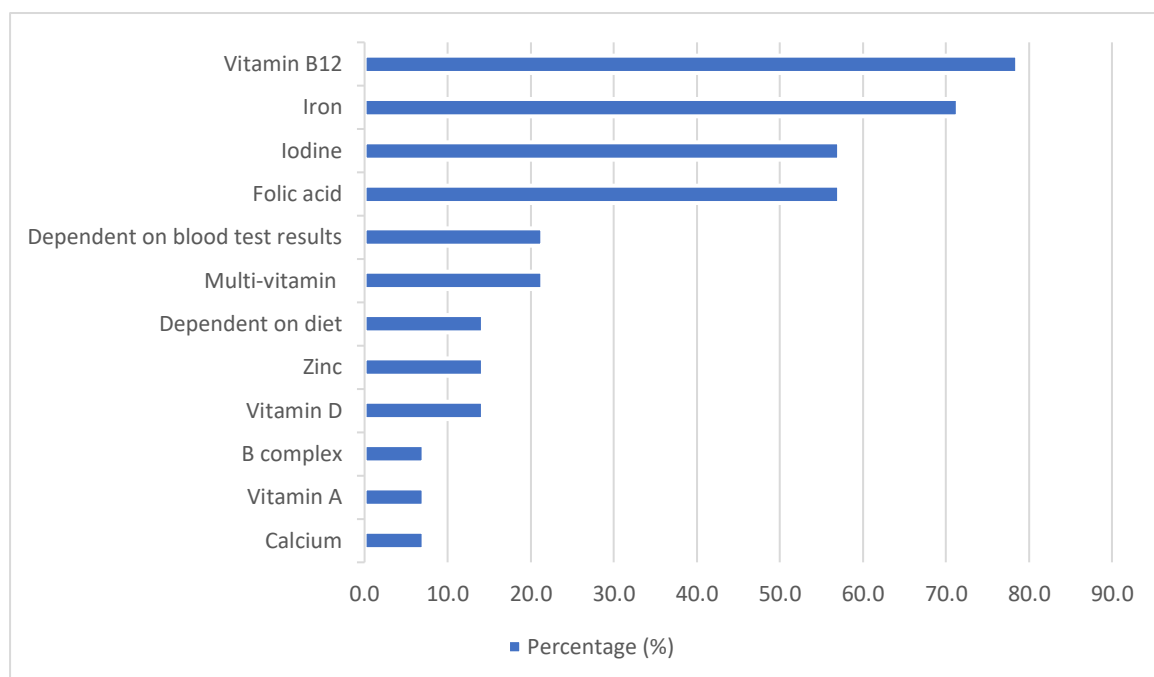
Nutritional Knowledge	Categories	n (%)
1. A pregnant woman on a vegan diet has increased deficiencies in the following nutrients	Protein	6 (42.9)
	Omega-three fatty acids	7 (50.0)
	Calcium	8 (57.1)
	Iron	13 (92.9)
	Iodine	4 (28.6)
	Zinc	5 (35.7)
	Vitamin A	5 (35.7)
	Vitamin B12	13 (92.9)
	Vitamin D	3 (21.4)
2. A pregnant woman on a vegan diet can obtain sufficient vitamin B 12 from the following plant foods	Algae	2 (14.3)
	Mushrooms	1 (7.1)
	Spirulina	2 (14.3)
	Nutritional yeast	4 (28.6)
	Beans, lentils and nuts	1 (7.1)
	None of the above	5 (35.7)
	All of the above	0 (0.0)
	Unsure	4 (28.6)
	Prefer not to answer	1 (7.1)
3. Plant sources of iron are:	Beans, lentils and nuts	10 (71.4)
	Green leafy vegetables	12 (85.7)
	Fruits	1 (7.1)
	Mushrooms	2 (14.3)
	Nuts	7 (50.0)
	Seeds	6 (42.9)
	Unsure	1 (7.1)
	All of the above	2 (14.3)
	4. Eating an orange while consuming an iron-rich vegan meal increases iron absorption in the body	True
False		0 (0.0)
Prefer not to answer		1 (7.1)
5. The most recommended option as a fortified vegan alternative to cow's milk for toddlers aged 1-3 years old is	Nut milk	2 (14.3)
	Soy milk	8 (57.1)
	Rice milk	0 (0.0)
	Oat milk	0 (0.0)
	Unsure	3 (21.4)
	Prefer not to answer	1 (7.1)

Questions 1-3: Participants were allowed to choose more than one option, thus the values do not total up to 100%.

The majority (71.4%) indicated the importance of continuing professional development to support them in providing nutritional advice. More than 60% of respondents indicated the use of New Zealand dietary guidelines, Ministry of Health websites, and other health professionals for information. The least number of participants (7.1%) utilised media such as television, newspaper, magazines, and social media platforms for information. The majority of health professionals (71.4%) preferred self-directed learning and online lectures or symposiums (64.3%) to increase knowledge on vegan diets. None of the respondents chose the option of ‘do not wish to learn more’.

Vitamin B12 and iron were the two supplements most selected by health professionals that should be consumed by a pregnant or breastfeeding woman who is vegan, with 78.6% choosing B12 and 71.4% choosing iron. These results aligned with the most selected nutrients of concern (iron and B12). The selection of supplements is presented in **Figure 4.1**.

Figure 4.1 Supplement a vegan pregnant woman should consume



Participants were allowed to choose more than one supplement, hence results do not add up to 100.

The Likert Scale was utilised to measure the attitude and opinion scores of health professionals with regard to aspects of vegan diet adoption during pregnancy, breastfeeding, and early life (**Table 4.4**). While most health professionals believe a well-planned vegan diet with B12 supplementation is nutritionally adequate for pregnancy and breastfeeding, more were unsure if this diet was suitable for early life. The majority of health professionals

believe that vegan pregnant women and infants should be checked for nutritional deficiencies. Most respondents viewed veganism positively but the majority believe that planning is important. More respondents disagreed that resources were adequate but a higher proportion of respondents were confident about discussing vegan diets.

All participants selected the option of 'just right' in the question asking about the length of the questionnaire, suggesting that an appropriate number of questions were utilised to collect information on knowledge and attitude without incurring participant burden.

Table 4.4 Attitude and opinion scores of health professionals

Statements	Strongly Agree	Agree	Neutral or Unsure	Disagree	Strongly Disagree
	n(%)	n(%)	n(%)	n(%)	n(%)
A well-planned vegan diet with B12 supplementation is nutritionally adequate for pregnancy / breastfeeding	2(14.3)	10(71.4)	1(7.1)	1(7.1)	0(0.0)
A well-planned vegan diet with B12 supplementation is nutritionally adequate for infants aged 0 to 2 years	1(7.1)	4(28.6)	6(42.9)	3(21.4)	0(0.0)
A vegan diet during pregnancy can promote positive health outcomes.	2(14.3)	4(28.6)	7(50.0)	1(7.1)	0(0.0)
A pregnant woman cannot get enough quality protein from a vegan diet.	0(0.0)	2(14.3)	2(14.3)	6(42.9)	4(28.6)
A pregnant woman or infant should be checked for nutritional deficiencies if they are on a vegan diet.	6(42.9)	5(35.7)	2(14.3)	1(7.1)	0(0.0)
Veganism is a trend and is not sustainable for individuals on a long-term basis.	1(7.1)	0(0.0)	1(7.1)	8(57.1)	4(28.6)
Planning is important in a vegan diet.	11(78.6)	2(14.3)	0(0.0)	1(7.1)	0(0.0)
Health professionals are responsible for providing information and supporting individuals who choose to follow a vegan diet.	3(21.4)	9(64.3)	0(0.0)	2(14.3)	0(0.0)
There is sufficient information about vegan diets for pregnancy, breastfeeding and early life (infants 0 to 2 years).	3(21.4)	1(7.1)	2(14.3)	6(42.9)	2(14.3)
I am confident in discussing vegan diets with my patients or clients.	2(14.3)	6(42.9)	1(7.1)	4(28.6)	1(7.1)

4.2 Interview Findings

A total of 14 participants completed the interviews. Six emerging themes were identified through the interview transcript coding process:

- Definition of a plant-based diet
- Attitudes toward the adoption of a vegan diet
- Nutritional adequacy of vegan diets during pregnancy and early life
- Education about vegan diets
- Roles of health professionals
- Challenges associated with vegan diet adoption

These themes are discussed in detail below.

4.2.1 Definition of a 'Plant-Based' Diet

Inconsistencies were observed among health professionals in the understanding of the term, 'plant-based' diet. A small number described the term as being equivalent to a vegan diet. For example, one respondent noted the term to have 'no dairy, as well as no meat, fish, or chicken' (HP1). In contrast, a few others described a 'plant-based' diet as one where the majority of protein is from plant sources, but that does not exclude meat. For example, one respondent commented that 'plant-based doesn't necessarily mean vegan or vegetarian, it just means eating more plants or having a diet full of a good variety of fruits and veggies and legumes and lentils' (HP5). A small number of health professionals perceived a plant-based diet as a healthy and unprocessed form of eating.

Among other respondents, a plant-based diet comprised mostly foods from plant sources, but depending on the restrictiveness, vegan and vegetarian diets were considered to be types of a plant-based diet. One respondent (HP3) has provided an explanation of this.

We assume that they're excluding animal proteins coming into the diet, depending on the restrictive nature. They may also be avoiding dairy products. So of course, the vegan diet typically, we don't have eggs and dairy, compared to some plant-based diets that actually do include these two. Vegan, vegetarian diets are examples of plant-based diet.

4.2.2 Attitudes towards the Adoption of Vegan Diets

Influential factors impacting perspectives about vegan diets

None of the health professionals showed strong objection to a pregnant woman or child following a vegan diet and expressed willingness to be respectful and provide as much support as needed. This was the stance despite concerns over nutrient inadequacy. For instance, one respondent commented on the importance of ‘supporting someone to the best of your knowledge and skills, even if they don't align with your own choices, but working through the best results for them’ (HP3).

Positive and negative experiences with vegan families could impact the perspectives of vegan diets among health professionals. For example, one respondent mentioned that ‘the vegan diet comes with a really huge personal internal bias as well because of the cases I have seen’ (HP8). In contrast, another respondent (HP13) reflected on the positivity of vegan diets, upon witnessing families who had a low intake of quality vegetables due to poverty.

I see very high levels of poverty where access to good food is hard. They have poor quality vegetables, or no vegetables, and a high fat, high sugar diet. So, that is more of a concern to me, people living in poverty who have low access to good foods whereas people who have a vegan diet tend to be able to afford a very healthy diet, eat more of fruits, vegetables, nuts, and seeds. So, certainly I have no concerns.

A small number of health professionals would not intervene unless there is evidence that a vegan child was not thriving. For example, one respondent stated, ‘I wouldn't have asked why, if it was a personal choice, because to me that wouldn't matter, except in the case where they were really young infants being given non-nutritionally complete milks, given the age’ (HP4).

A few health professionals noted the occasional challenge of going against parental decisions. For example, one respondent mentioned, ‘they’ve already very clearly made up their minds, and they’re normally quite convinced and forceful in their opinions about that, and that it’s the right thing for the child’ (HP5).

Some health professionals specified the importance of respecting individual dietary decisions. This was described by one respondent (HP1).

If someone believes ethically, in regards to animals and the environment, then I would be really hesitant to ever criticize... I do feel very hesitant about very young children, but I could also see how saying that statement to someone vegan would be highly offensive, I would never say that... I don't like judging other people's food choices.

Health professionals following or have once followed a vegetarian or vegan lifestyle could relate better to the experience of adopting vegan diets and share similar philosophies, as described by one respondent (HP7).

I understand some of the trials and tribulations of doing that. And I try not to be biased, so I'm not saying to people you must become vegetarian, but I'm more aware of some of the health benefits of reduced meat.

Respondents were adept at maintaining the balance between their philosophies and professional practice. There was an inclination to rely on evidence-based knowledge and government consensus to inform the advice they provide to vegan patients. For example, one respondent mentioned the need to 'follow the guidelines, even if you have different thoughts in your head, but you don't say' (HP9). Another respondent noted that 'We're always affected by how we perceive the world, that just shapes how we practice...I guess it affects me, my work to some extent, but I try not to let my philosophy dominate' (HP7).

Benefits and disadvantages of a vegan diet

Many health professionals confirmed the benefits of a vegan diet, including the belief that vegan diets are healthy. For example, one respondent mentioned it is likely to be 'closer to the 5+ a day[®] than non-vegan... getting at least enough fibre and that's always a positive' (HP6). Another respondent discussed the increased likelihood of higher opportunities for children accepting vegetables and commented that 'introducing green leafy vegetables as first foods really set the roadmap' (HP13).

However, a few health professionals believed that there are disadvantages to adopting a vegan diet. Vegan alternatives can be expensive (HP1) and must be supported by sufficient

income, especially if feeding a large family (HP8). A vegan diet is more nutritionally complex, so vegan families must be knowledgeable and have appropriate planning, especially during the growth phases of life. As one respondent commented, ‘just leaving meat out of your diet will not make you feel good. It’s eating everything that brings in the nutrients’ (HP14), suggesting that balance and variety are important aspects of healthy eating for vegans. The consequence of the lack of planning may lead to becoming a ‘junk food vegan’ who consumes less nutritionally adequate foods such as hot chips (HP6).

4.2.3 Nutritional Adequacy of Vegan Diets during Pregnancy and Early life

Nutrient adequacy and availability from plant foods

All health professionals expressed concern about the high nutritional risks associated with the adoption of vegan diets during pregnancy and early life because plant foods provide less bioavailable sources of nutrients, and a high amount must be consumed to compensate for reduced nutrient quantity and quality. The nutrients that were of greatest concern were vitamin B12 and iron. Other less frequently mentioned nutrients included calcium, protein, omega-three, vitamin D, vitamin A, and zinc. Some health professionals believed that adequate sources of plant proteins are available. Other worthwhile discussions about omega-three included that ‘omega-three is associated with fish’ (HP4 and HP6) and that ‘if they have removed a lot of the junk food from their diet, then supplementing the omega-three might not be as essential’ (HP7), suggesting that diet quality may impact on sufficiency of omega-three within the body.

There were also concerns about the potential of plant foods meeting elevated growth needs during pregnancy and early life. One health professional noted that ‘the requirements of the growing foetus are really high and a lot of time, it can actually become iron deficient for women’ (HP3). One respondent highlighted the concerns about the absorbability of nutrients in fortified foods, ‘so fortified foods, is it still in an absorbable form, you know the calcium?’ (HP7).

Some health professionals commented on the popularity of plant sources speculated to contain iodine and B12. This included algae which are not frequently found in the diets of

New Zealanders (HP3). One health professional was concerned about misconceptions regarding vitamin B12 from plant sources. ‘There are a lot of myths around mushrooms and spirulina having B12, but this is not evidence-based’ (HP8).

Many health professionals knew about enhancers and inhibitors of iron absorption. For example, one respondent said ‘iron pills (taken with) with orange juice. I think everyone knows that, we’ve known it for a long time. And you don’t drink tea.’ (HP14). When asked how this knowledge came about, several health professionals noted it was likely accumulated over time in their profession or ‘handed down through the generations’ (HP10). One respondent commented that the ‘knowledge about iron being bioavailable in vegetarian diets is something we definitely got taught in med school’ (HP4). As discussed by one respondent (HP14), adequate iron status is crucial for all pregnant women, regardless of their diet.

If their iron stores are low, a bleed has more consequences, so for example, if your haemoglobin is 130, if you had a blood loss of 500ml, then you can cope with it. But if your haemoglobin is too low, then, the consequences of losing 500ml is way worse.

Appendix 9 provides an elaborate overview of the perspectives shared by all participants for each nutrient of concern.

Dietary behaviours affecting nutrient acquisition

As highlighted by one respondent (HP3), women during pregnancy may experience hyperemesis and be less inclined to eat large quantities of food.

During pregnancy, of course a lot of people do experience nausea, and they're not eating as much as what they typically would be, so by saying okay you need to have a whole heap of broccoli... a whole heap of those, sometimes it just doesn't work.

Young children may exhibit fussy eating and poor digestibility during complementary feeding. One respondent commented that ‘once you get to that solid stage, a lot of children may not be happy to eat what their parents put in front of them’ (HP2). Some health professionals were thus concerned that these dietary behaviours and smaller appetites mean a challenge in meeting daily nutrient requirements through food alone, especially from plant

sources that are high in fibre and antinutrients. Another respondent has concerns over ‘baby-led weaning and if they were really getting everything they need.’ (HP14).

Vegan diets in early life

Many health professionals were concerned about the developmental progress among young children on vegan diets. One commented on the potential disadvantage for the child who is ‘missing out on different tastes and different textures’ (HP1) as a result of a diet that is low in variety. Another discussed the possibility that ‘a child may appear healthy and growing but they could actually be lacking...iron levels could actually be quite low. And the parent may or may not pick out what that looks like’ (HP5). Detrimental impacts can ensue if parents do not have adequate health literacy and ensure their child gets the required health checks.

A small number of health professionals had experiences with children on vegan diets who had not thrived and seen the vast improvement in growth and energy when the child obtained B12 supplementation, thus asserting the non-negotiable requirement of B12 for optimal health.

A few health professionals were concerned about subjecting young children to many intensive measures to check nutrient levels. However, most noted the importance of these assessments to detect risks of deficiencies. For instance, one health professional commented ‘I feel sorry for the children having to have blood tests, but it’s a necessity as well, they need it’ (HP12).

Another respondent (HP1) also discussed the difficulty of ensuring nutrient sufficiency in very young children.

For infants and toddlers, key nutrients like iron and zinc can be so difficult to get into infants from six to 12 months of age anyway, adding vegan on top of that? And then, thinking about how supplementation would work...intensive and restrictive dietary choice to put on a very young child.

Concerns were noted by one respondent (HP4) for infants on alternative milk options.

The main source of nutrition for young kids is milk-based, young infants on milk alternatives which are not adequate... I wouldn't know what to do if we were to recommend milk-based nutrition to someone who was opposed to giving milk-based things.

Some health professionals commented that soy formula was the only recommended plant-based milk alternative. Due to poorer nutrient content in plant-based beverages such as oat and almond milk, some health professionals felt that these should only be offered as complementary to solids, and 'not the main ingredient in their diet' (HP12) and may only be provided 'if the kid has multiple food allergies' (HP8).

Another respondent raised the importance of food over milk in weaning children. 'Babies who have big volumes of milk have a low appetite for food. They need to be eating food, otherwise, they don't develop taste for good food' (HP13).

A small number of health professionals raised concerns over soy milk and the possibility of 'carcinogens' (HP13) and 'oestrogens' (HP14). One respondent (HP13) highlighted that while '(soy formula) is available for before six months, it's not recommended and there are long-term developmental concerns for a six-month-old on a soy-based formula' (HP13). A few respondents commented that breastfeeding should be the priority for vegan mums, and in the cases they have seen, 'they tend to breastfeed, or breastfeed and supplement with soy formula' (HP13).

A few health professionals commented that nutritional status among non-vegans is not always necessarily better than vegans. One respondent commented that 'under two-year-olds particularly are at risk of low iron, so regardless of your diet, some people who are meat eaters still have poor meat choices and are not necessarily getting iron alongside vitamins and minerals' (HP13).

Perspectives on supplementation

The majority of health professionals discussed the importance of supplementation to fill nutrient gaps, with the most important supplement being vitamin B12. For instance, one respondent commented that ‘So B12 from my understanding, unless you take a supplement, you can’t get from plants’ (HP5). Most respondents believed that a vegan diet during pregnancy and breastfeeding is reasonable ‘as long as they are having supplements’ (HP12). Another respondent (HP8) highlighted how adequate supplementation is required for ‘kids who aren’t going to be eating huge amounts of nuts and seeds’.

Some health professionals perceived that supplementation is generally safe for vegans. For example, one respondent commented that ‘typically the nutrients that are involved are water soluble so they’re not the fat-soluble vitamins. So if the body doesn’t need them, they are going to excrete them.’ (HP3). However, it was noted that analysing the diet history and having appropriate nutritional analysis are important steps to identify, fulfil nutrient gaps and prevent overdose.

One respondent noted the dangers of pregnant women jumping on the bandwagon of supplementation and ‘suddenly they’ve got six different forms of selenium or zinc’ (HP7). Another respondent (HP6) discussed the appropriate measure of providing supplements safely to ensure there is no overlap and excessively high intake of certain micronutrients.

Generally multivitamins are probably a good idea and should be recommended. I know that the Ministry of Health guidelines don’t currently recommend one. But certainly, I don’t see any harm in recommending a multivitamin in pregnancy. Because, in a multivitamin, all of the micronutrients are going to be below the RDI. I would check that the multivitamin that they were having didn’t have high iodine and folate, because all pregnant women should have that separately.

Some health professionals raised challenges associated with supplementation. For instance, one health professional commented that, ‘my experience with vegan patients was that they like to be as natural as possible. So they weren’t always open to supplementation’ (HP1). Two respondents suggested less invasive options were available for children in the form of ‘B12 drops’ (HP1 and HP12).

Most health professionals were knowledgeable about the compulsory supplementation of iodine and folate during pregnancy and breastfeeding. In particular, one respondent mentioned that ‘a breastfeeding woman is recommended to take iodine, regardless of what kind of diet’ (HP5).

Nutrient quality of breastmilk

With regard to the nutrient adequacy of breastmilk for infants, health professionals noted that mothers need to have optimal nutritional status. One respondent discussed the finding that ‘a significant amount of iron deficiency is found in some young children if they’ve been breastfed for quite a long time, which I suspect is a reflection of maternal iron intake too’ (HP2).

Another respondent (HP8) noted that a mother’s diet is a crucial factor in determining the nutrient quality of breastmilk.

It would depend on the mother’s nutrient status, so mum has to be on supplements, mum has to be on vitamin D and omega-three supplements, keeping up with fluid intake, eating tofu and beans every single day, twice a day to have really optimum nutrition status, so then that’s passed on to the kid.

Another health professional (HP12) noted the difficulty of an infant receiving adequate nutrients, just from breastmilk alone.

When asking how they are getting the B12, then the mum says, ‘from me’, and I’m like ‘how are you getting your B12?’, and she’s like ‘I take a supplement’, and I’m just, I don’t know if the transfer from mum’s milk to the baby is actually going to be enough.

4.2.4 Education about Vegan Diets

Current information sources used by health professionals

A variety of information sources were used by health professionals in this study to obtain knowledge on nutrition and vegan diets. This is presented in **Table 4.5**.

Table 4.5 List of education resources mentioned by health professionals

Education Sources	n (%)
Heart Foundation	2 (14.3)
Health Navigator	2 (14.3)
Vegan Society	2 (14.3)
Scientific journals	7 (50.0)
Government published resources e.g. Ministry of Health Eating and Activity Guidelines	4 (28.6)
Organisational handouts e.g. New Zealand Beef and Lamb, 5+ A Day®	5 (35.7)
Continual competency courses	1 (7.1)
Textbooks	1 (7.1)
Practice-based Evidence in Nutrition (PEN)	2 (14.3)
National Institute of Health (NIH)	1 (7.1)
Professional experience	1 (7.1)

Participants were allowed to select more than one option.

Some health professionals frequently provided printed nutrition information sources for parents. For example, one respondent commented that resources would be ‘easily digestible’ and ‘something from a government organisation’ (HP4).

Most health professionals prioritised the use of credible resources to provide dietary advice on vegetarian diets. For example, one respondent noted that ‘the Ministry of Health has a booklet on healthy eating for vegetarians, but it’s also got information on a vegan diet. When you go on the Vegan Society websites, you know they’re accredited’ (HP8). Another health professional (HP2) noted guidelines that have provided focus on vegan diets.

Vegan society seems to go into further detail. The NIH one is pretty good, it sort of lays out B12, calcium, and vitamin D and says, these are, you know, the foods that you should eat. Vegan Society also talks about caffeine reducing your absorption. The Vegan Society I notice, has a really detailed PDF information on vegan diets, pregnancy, lactation, etc.

Some participants have access to platforms that they can use to obtain more specific information and provide individualised nutrition care. For example, one respondent commented on ‘using my tools of FoodWorks and doing that full nutritional analysis, because when I have that exact data, I know exactly what type of foods I need to be recommending to that client’ (HP3).

4.2.5 Roles of Health Professionals

A few respondents felt that only dietitians can put someone on a restrictive diet, but, in general, most agreed that health professionals should be equipped with basic nutrition knowledge, provide suitable reading material, and redirect patients to medical professionals for blood tests, supplementation and further dietetic advice. Health professionals should recognise ‘there is a multidisciplinary team, so everyone needs to be involved for the patient to have the most optimal outcome’ (HP3).

Some respondents raised the concern that apart from dietitians, other health professionals may not have adequate knowledge and time to discuss the in-depth nutritional requirements of vegan diets. Hence, referring vegan patients onwards to dietitians is strategic for health, especially during phases of life where growth and development are prioritised. One respondent commented that dietitians could have ‘an hour for an initial appointment and half an hour for follow up’ (HP3). Thus, more content can be covered within this longer duration as compared to doctors who ‘have about ten minutes maximum’ (HP3).

One respondent (HP1) highlighted that dietitians may need to have updated knowledge of vegan diets as well.

It should be a dietitian or a nutritionist. The responsibility of the other health professionals would be to refer to a dietitian or nutritionist. I would only hope it's a dietitian talking about a vegan diet in depth with the patient, but unless they are vegan themselves, I don't think they would be able to have the appropriate training or understanding of the depth of it.

Dietary recall was utilised by a few respondents. One respondent provided elaborations (HP13).

I just encourage them to talk to me a little bit about what they consider a healthy choice. You know, what kind of foods, what do they have for breakfast, lunch and dinner. What do they give their babies, and just listening to them, is the way that I assess if it's a good healthy diet or if I would encourage them to look into it further.

4.2.6 Challenges Associated with Vegan Diet Adoption

Misinformation and inadequate knowledge about vegan diets

Some participants noted the presence of vegetarian guidelines coming from the Ministry of Health, but a majority agreed that updated and evidence-based guidelines for vegan diets are significantly lacking, in particular for vegan diets within contexts of different life stages and health conditions. One respondent highlighted that, ‘there are so many people on it, there needs to be a booklet on healthy eating for vegan diets, one for children and one for adults’ (HP8).

Another respondent (HP9) highlighted limitations in guidelines for plant-based milk alternatives.

The new Ministry of Health guidelines has a kind of plant-based I think or vegetarian section, doesn’t really elaborate much more than that, so it’s not that useful. I think it still very much talks about it like if you were eating meat or dairy; it’s not that specific. And formula wise, with the guidelines, it mainly just pushes blue top milk. I got asked the other day, the recommendation of how much milk you should have as an alternative milk, and I wasn’t sure the answer to that.

A small number of health professionals discussed the dangers of patients being misinformed about vegan diets. Some were concerned that a mixture of poor knowledge and inappropriate messages from unaccredited sources may lead to dangerous health consequences. This was highlighted by one respondent (HP3).

People like to follow trends in New Zealand, so the dangers of a vegan diet don’t get displayed as much, but the benefits don’t also have the full light, so I think there’s a lot of misinformation on Google. I think if someone is following a vegan diet, they need to know who to talk to, so they’re not going on social media and looking at an influencer who is fasting and following a vegan diet. That’s a really big issue in New Zealand, there are few people who say they are nutritionists and have media attention when actually they don’t have the proper credentials to make those statements.

Another health professional observed that if ‘parents are isolated, (they are) more likely to create a wall’ (HP8) and be less accepting to advice and information. Another respondent had

a similar concern that ‘they try it without any support or without monitoring through their GP’ (HP6). A small number discussed experiences where parents were unwilling to listen to advice and modify dietary habits, and this is particularly concerning if deficiency develops. However, one respondent shared the experience of persistence. ‘I have had a couple who just don’t want to hear what I have to say but I can email the info, give parents the information, so I can go around that way and go back another time’ (HP12).

A small number of respondents pointed out that health professionals should themselves be appropriately educated if they are looking to provide dietary advice or recommend vegan diets. One respondent discussed instances where “patients come in for any kind of range of issues and they like ‘you should go on a vegan diet’. That’s all very harmful.” (HP8).

A few participants thought that vegan parents may have more information or have done more detailed research about vegan diets than health professionals. This was highlighted by one respondent (HP11).

A lot of women who are vegan do plan their diets quite well, and are very conscious of good foods to eat, things to get their vitamins and minerals, and perhaps eating a bit more in pregnancy. And a lot of them often eat a healthier diet, than someone who just eats a standard diet.

Low confidence in discussing vegan diets during pregnancy

Health professionals listed a few aspects that impact their confidence levels when advising patients about vegan diets during pregnancy and early life. For example, a respondent (HP5) stated the need for a clear consensus, that is supported by sufficient scientific evidence on the appropriacy of a vegan diet during pregnancy and early life.

Lack of information and consensus I suppose around, whether it is okay for a six-month-old baby to be given a vegan diet. I suppose it's just probably a lack of knowledge and the lack of access to information that I would deem to be trustworthy. Of course, you look at stuff online and you can find multiple sources that will agree or disagree with you. But whether those are scientific medical journals, or whether they're just people's opinions about it...

One respondent (HP4) discussed that a lack of in-depth nutritional knowledge may reduce overall confidence when providing advice.

I think it's because I feel like I have a vague idea, but I don't know studies to say this is an acceptable diet to have or not, and lots of people who follow these diets have their information, so you have to be reasonably sure what you're saying is factual to advise them and I don't necessarily think I have that, you know, behind what I'm saying.

A small number of health professionals commented that low confidence may be related to the lack of sufficient experience with pregnant women and children on vegan diets. One respondent (HP3) however highlighted the importance of self-research to support these patients.

I don't see a huge number of vegan clients, so when I have a vegan client coming in, what I have to do is actually go back to all of my notes and I do a little bit of research to make sure that I'm most up-to-date. I do have those key nutrients, but it's thinking of all those different pathways and the different foods that I can recommend for a client because I think in my whole perspective it's not my most confident area, but it is an area that I feel confident in that I can provide the basic education that they need.

In contrast, health professionals with personal experiences in vegan or vegetarian diets may have increased levels of confidence in providing nutrition advice due to prior knowledge. One respondent (HP9) described that confidence will improve if there were more resources from the government.

I am more confident than other people because I have the experience, but then also nervous...don't want to kind of overstate what you say, and you don't have the evidence to back it up...feel nervous to give information because, you know you want to make sure that you're saying the right thing, that the government recommends, not just what you think.

Another reason for low confidence in providing advice on vegan diets could be associated with the absence or insufficiency of nutrition education during medical training. This was highlighted by one respondent (HP11).

We did discuss nutrition, but it was in the context of what we can prescribe for women who are deficient in iron, and different types of iron. Definitely more discussions about it, but it's mainly in those areas for iron and B12 to watch for, but not a lot else about protein targets, or different types of protein.

Challenges in referral to dietitians

While dietitians were thought to have significant roles in helping vegan patients with nutrition, a large number of health professionals commented about challenges associated with obtaining a referral. One health professional (HP6) has described the potential problems a vegan patient may face in seeking a dietitian.

In general, (dietitians are) definitely underfunded, and there are private practice dietitians but they can be quite expensive and not covered by insurance, so it's not always available to go and see a dietitian, particularly when it's just that they're vegan and pregnant. A lot of their care would come through the doctor, the GP, and their midwife, or their LMC.

However, LMCs may also not have sufficient time or be able to discuss nutrition in great detail. This was highlighted by one respondent who said that 'midwives don't really have the time or the scope, especially since the pandemic, to address nutrition in general, let alone veganism, like they just quickly touch on food safety.' (HP3).

Furthermore, the location may also be a factor that impedes the referral process. One respondent has mentioned that 'someone rural is much less likely to access medical health than someone in the main city centre' (HP3). Additionally, dietitians are in high demand and likely overwhelmed, as pointed out by one respondent (HP9).

An official referral would be really hard, it's probably quite a low priority, unless there is a medical condition because they do have a lot of people that they're trying to see so they would have to triage and take, you know, the most needy families as opposed to, people just wanting more information

The alternative in the event of failing to see a dietitian adequately would be the likelihood of self-research, as one respondent commented, 'so Google becomes the next best' (HP2).

Chapter 5 : Discussion

5.1 Introduction

This study explored the experiences, knowledge, and perspectives of health professionals toward vegan diets during pregnancy and early life in New Zealand. In this mixed-method study, the discussion seeks to reflect integrated findings from both the quantitative and qualitative sections of the study, explore the implications of these findings and compare them to existing literature.

5.2 Definitions of Plant-Based Diets

Health professionals in this study were somewhat divided on the definition of a plant-based diet. The understanding of the term is similarly mixed among literature. A larger proportion of medical providers perceived it to be similar to a vegan (43%) diet, and a smaller proportion associated it with a vegetarian (36%) or vegetarian with fish (21%) diet (Krause and Williams Sr, 2017). Among 108 New Zealand responders (Harris & Morgan, 2021), a majority (51.9%) of whom were dietitians and nutritionists, a plant-based diet was perceived by 54.6% to be flexitarian (includes meat consumption), vegan (43.5%), vegetarian (37%), and 1.9% perceived it to be a collection of these diets. The definition and utilisation of the term 'plant-based' diet was similarly varied among past nutritional knowledge surveys on health professionals (Bettileni et al., 2019; Hanna et al., 2021; Meulenbroeks et al., 2021).

The New Zealand Heart Foundation defined a plant-based diet to be rich in fruit, vegetables, legumes, whole grains, nuts, and seeds, and is a largely unprocessed diet, with smaller quantities of meat, poultry, fish, and seafood (Heart Foundation 2022). This is the accepted definition by the New Zealand Ministry of Health. Further clarity of the term is observed in other literature (Fehér et al., 2020; Harris & Morgan, 2021; Lea et al., 2006; Tuso et al., 2013). The plant-based diet focuses primarily on the inclusion of plant foods but does not necessarily eliminate animal products (Fehér et al., 2020). As such, a plant-based diet may include the Mediterranean diet (whole-food, plant-based diet with fish, and small amounts of meat and dairy), lacto and/or ovo vegetarian diet, flexitarian diet, and pescovegetarian diet (vegetarian with fish), depending on individual restrictions. The interpretation taken by a proportion of respondents in this study is aligned with the current stance in the aforementioned literature.

The definition is subjected to individual perspectives which may often be influenced by the mass media and varied usage among scientific literature. Regardless, health professionals' should effectively communicate (Adamski et al., 2018) their understanding of a plant-based diet during the provision of nutrition advice. This means stating if their interpretation accommodates the inclusion of animal products or not, and the level of restriction in processed foods (Harris & Morgan, 2021). To avoid conflicting messages, there should be avoidance of vague and contrasting words such as '**limit** or **avoid** animal products' and 'discourage **most** or **all** animal products' (Harris & Morgan, 2021).

5.3 Attitudes towards Vegan Diets

In the current study, health professionals were generally supportive of vegan diet adoption during pregnancy and early life. Questionnaire findings were aligned with interview responses. However, while Likert scale results showed that many participants believe a vegan diet during pregnancy can contribute positive attributes, a significant proportion (50%) were unsure. None of the respondents could specify the potential of vegan or plant-based diets in protecting against disease risks and morbidities, such as hypertensive disorders, GDM (Longo-Mbenza et al., 2008; Zhang et al., 2006), and infant obesity (Saintila et al., 2021). The absence of this knowledge or the lack of discussion may be attributed to insufficient evidence-based studies about the direct or indirect effects of plant-based diets on maternal and infant outcomes (Baroni et al., 2021).

The majority of respondents believed that a vegan diet can be sustainable, but almost all perceive planning to be essential. Most of the respondents also agreed that vegan pregnant women and children should be regularly checked for nutrient deficiencies. Taken together with the interview findings, health professionals' support towards vegan diets could be related to assumptions that vegan families are knowledgeable in vegan nutrition, practice good planning and are compliant with regular blood tests and supplementation requirements. Likewise, findings from Hanna et al. (2021) reflected that more health professionals disagree with the statement that 'veganism is a trend or fad; it is not sustainable for individuals on a long-term basis', but a majority of the respondents agreed (42.4%) and strongly agreed (51.1%) that planning and discipline are crucial in vegan diets. Positive attitudes were likewise portrayed among other health professionals in New Zealand (Harris & Morgan, 2021), with a substantial proportion (72.2%) agreeing that they would recommend a plant-

based diet to their patients. Similar perspectives were noted about challenges associated with cost, food access, and meal preparation for large families in a study on Gisborne health professionals (McHugh et al., 2019).

Evidence from some literature suggested that higher nutritional knowledge and attitude scores were observed among more vegan or vegetarian health professionals than meat-eating counterparts (Bettinelli et al., 2019; Hanna et al., 2021; Landau et al., 2020; Marciniak et al., 2021). In this current exploratory study, there was an insufficient number of vegan or vegetarian participants which limited the potential of determining an association between personal dietary preference and overall attitude towards vegan diet adoption.

5.4 Nutritional Concerns

All health professionals in this study acknowledged the nutritional risks involved in following a vegan diet during pregnancy and early life. A majority discussed that elevated nutrient demands during these phases of life are unlikely to be met through the diet alone due to the poor bioavailability and low quantity of certain nutrients from plant foods. In the questionnaire, almost all respondents selected vitamin B12 and iron (92.9%) as the main nutrients of concern in vegan diets (**Table 4.3**). These findings were supported by interview responses.

A high proportion of pharmacists in Ireland (Hanna et al., 2021) similarly identified iron (89.1%) and calcium (80.4%) to be the most deficient in a vegan diet. However, in contrast to findings from this study, less Irish professionals identified B12 as a nutrient of concern (65.2%). B12 was also the least frequently mentioned micronutrient deficiency among Australian midwives (Arrish et al., 2016). A few participants from this study discussed the importance of supplementing iron and B12 as these are key nutrients for growth and development, but only a small proportion (35.7%) were aware of the absence of B12 from all plant foods (unless fortified). The misunderstanding that the presence of B12 in plant foods was also evident among health professionals in other studies (Elias & Green, 2007; Sanne & Bjørke-Monsen, 2022).

If this knowledge gap is observed among a small sample group of health professionals in this study, then it becomes paramount to determine if similar misinformation exists among a more

representative sample of health practitioners in New Zealand. Myths about B12-containing plant foods such as spirulina and mushrooms (Saunders, 2014) may be plausible causes of this misconception. Only plant foods fortified with B12 will contribute quantities of the micronutrient (Zeuschner et al., 2013), so consuming these foods and supplementation are the only methods to obtain B12 for vegans (Byrnes, 2000; Saunders, 2014).

In contrast to findings from Saintila et al. (2021) where only half of the health professionals were aware of B12 as an important supplement for vegan children and vegan breastfeeding mothers, the majority of the responders in this study (over 70%) listed B12 and iron, as micronutrients most important to supplement (**Figure 4.1**). Even though reports of a vegan or vegetarian mother having maternal B12 deficiency is rare, the provision of B12 in combination with folic acid would be beneficial for mothers who do not face issues with gastrointestinal malabsorption (Gramer & Hoffmann, 2020). This position is aligned with B12 recommendations for vegan and vegetarian mothers in The Standards of Maternity Care of Australia and New Zealand (RANZCOG, 2014; Arrish et al., 2016).

Health professionals in this study were generally knowledgeable about plant sources of iron, with more than 70% selecting beans, lentils, nuts, and green leafy vegetables as key sources in the questionnaire (**Table 4.3**). In the interview, many respondents highlighted that the non-haem iron in plant sources was less absorbable and thus not sufficiently available to meet elevated demands for growth and development (**Appendix 9**). All the respondents in this present study were aware of the enhancer (e.g., orange juice) to increase gut iron absorption (**Table 4.3**).

Among midwives surveyed in New Zealand, over 90% were also aware of the enhancers and inhibitors of iron absorption (Elias & Green, 2007). This suggests the possibility that health professionals in the country may have gained this knowledge through undergraduate medical training, or from reading material such as that from Beef + Lamb New Zealand (2020), and the Ministry of Health guidelines (MOH, 2020a). Some respondents in this study have highlighted that iron deficiency is a common problem during pregnancy and breastfeeding regardless of diet. Information on methods to increase iron bioavailability could be especially important in rural regions where women have less access to dietitians and supplementation (Teweldemedhin et al., 2021).

The majority of respondents disagreed that quality protein is absent in a plant-based diet. This was aligned with findings from Krause and Williams Sr (2017) where the majority (78%) of health providers surveyed had correctly identified that sufficient protein was available through a plant-based diet and that 98% disagreed that animal protein is the only quality protein.

A smaller proportion of health professionals selected calcium (57.1%), omega-3 fatty acids (50.0%), protein (42.9%), zinc (35.7%), iodine (28.6%), vitamin D (21.4%), and vitamin A (35.7%) as nutrients of concern (**Table 4.3**). The aforementioned nutrients were similarly identified across literature to be potentially deficient in vegan diets (Arrish et al., 2016; Betteleni et al., 2019; Elias and Green, 2007; Landau et al., 2020; Hanna et al., 2021; Krause and Williams Sr, 2017; Lee et al., Meulenbroeks et al., 2021). The risks of deficiencies in these nutrients increase when animal products are completely removed from the diet (Davey et al., 2003; Elorinne et al., 2016; Schüpbach et al., 2017). It is concerning that only a handful of respondents in this study could identify all the nutrients at risks of deficiency in a vegan diet.

All health professionals should be aware of the associated deficiencies in protein, long-chain fatty acids, iron, calcium, zinc, iodine, vitamin B12, vitamin D, and possibly retinol (Landau et al., 2020) within a vegan diet. Going into pregnancy and the first 1000 days of life without adequate quantities of these nutrients may incur metabolic and neurological impairments, leading to prolonged negative health outcomes (Cusick & Georgieff, 2016).

Most health professionals in this study knew about the mandatory supplementation of iodine during pregnancy in New Zealand, regardless of diet. In contrast, knowledge about iodine was found to be lacking among antenatal care providers in Australia (Arrish et al., 2016; Lee et al., 2017). This could likely be associated with differences in publicity and awareness levels in both countries (Arrish et al., 2016; Lee et al., 2017).

Perspectives on whether pregnant women should take a multivitamin/mineral (MVM) supplement were mixed. Thoughts about diet providing first sources of nutrients before supplementation were discussed in the literature (Othman et al., 2020b). Some health professionals in this study recommended that supplements be provided only if there is a significant nutrient risk. This point was similarly raised by Lee et al. (2017), where midwives

thought that vegan and vegetarian pregnant women should be screened for nutritional issues and then referred to dietitians if found to be deficient.

While the majority of health professionals in this study perceived well-planned vegan diets to be suitable for pregnancy and breastfeeding, a higher proportion were unsure or disagreed that vegan diets, even if well-planned, were sufficient for early life. This finding was similar to results from two other studies where approximately 50% of health professionals surveyed did not agree that a plant-based diet could meet the nutritional demands of infants in the first 1000 days of life (Bettileni et al., 2019; Saintila et al., 2021).

Respondents in this study were concerned about the use of alternative milk products that should not be recommended to babies below the age of one. This concern is not without reason. A recent study analysing energy, fat, protein, amino acid and trace element content of plant-based beverages (PBBs) has shown that apart from calcium-fortified soy, none of the alternatives (oat, rice, coconut, almond, cashew) had a comparable nutritional composition to cow's milk (Smith et al., 2022).

Based on the Ministry of Health (2020) guidelines, even fortified soy formula should only be offered after the age of one when a child can obtain a proportion of the daily nutrient requirement through solids. This implies that vegan mothers have to breastfeed, with the only appropriate alternative being cow's milk formula. Having said that, the nutrient quality of breastmilk is dependent on the mother's nutrition status (Karcz & Królak-Olejniak, 2021). Therefore, health professionals who work closely with breastfeeding mothers and infants, in particular, Plunket nurses and lactation consultants need to work closely with doctors to assess a vegan mother's health status and provide suitable alternatives to supplement breastmilk, especially if there is difficulty lactating.

5.5 Information Sources

Health professionals in this study utilised a large range of resources to educate themselves on nutrition and vegan diets. Questionnaire results showed that the majority utilised scientific literature and government guidelines. These findings corresponded to those from Australian midwives (Arrish et al., 2017) who similarly relied on government guidelines and resources, including brochures, booklets, and websites that were specific to the state and territory they worked in. A few midwives referred to national sources such as the National Health and

Medical Research Council (NHMRC, 2006) and international guidelines such as the National Institute of Health (Arrish et al., 2017). While NHMRC is a resource utilised by the Ministry of Health guidelines in New Zealand, none of the participants in this study had referred to it. Only a few respondents (<20%) included social media or the Internet as information sources. Interview findings supported this finding; participants in this study practiced care when researching, to ensure that information was based on scientific facts and not opinionated. Among other health providers in New Zealand (Harris & Morgan, 2021), the majority (74.1%) selected scientific research, and over 50% obtained information from tertiary education and other healthcare professionals. The least proportion of responders (23-30%) obtained information from family, friends, and social media. These results implied that health professionals in New Zealand are capable of selecting credible resources for self-education and information.

A few health professionals in this study noted inadequacies in the depth of knowledge for vegan diets in the named resources. Even within updated government guidelines, participants noted small sections presented for vegan diets, and an existing lack of information about vegan diets during pregnancy, lactation, and early life. A lack of detailed resources may be related to the lack of demand as it may still be relatively uncommon to find women who are pregnant and vegan in New Zealand. However, as reported by some respondents in this study who have seen more vegan individuals in recent years, government guidelines must now be regularly updated to follow national dietary trends.

Insufficiency of evidence-based guidelines was similarly reported in other literature (Arrish et al., 2016; Bettleni et al., 2019; Corrin et al., 2017; 2016; Meulenbrokes et al., 2019; Othman et al., 2018). Specially tailored dietary guidelines on vegan diets can provide significant support and consistency in the provision of information, overcome the problems of inadequate nutritional knowledge and relieve the heavy burden on dietitians. Some participants from this study stated that reliable sources could improve confidence because evidence-based knowledge could back up the advice they provide to patients. However, studies that explored vegan diets may base results on vegan and vegetarian populations (Meulenbroeks et al. 2019), thus limiting evidence available for vegan populations.

5.6 Challenges in Nutrition Care for Vegan Diets

Most of the respondents in this study supported the referral of vegan pregnant women and children to a dietitian but agreed that all health professionals should be able to provide basic nutrition knowledge or at least direct patients to credible resources. Dietitians were considered to have the most prominent role in providing nutrition care to these individuals because of their specific undergraduate training, in-depth knowledge about food (Ball et al., 2014), and access to tools for nutritional analysis. The importance of dietitians was similarly noted among midwives in Australia (Othman et al., 2020b). Health professionals who have poorer knowledge may be more inclined to seek such referrals (Landau et al., 2020).

While GPs are seen as the first probable contact point in primary care (Lepre et al., 2020), New Zealand doctors consistently report a lack of time during consultation to provide nutrition advice (Ball et al., 2010). Qualitative data from a survey of Australia and New Zealand (ANZ) medical students (Lepre et al., 2020) showed that while GPs could be more involved in nutrition care given that they are most accessible by patients, barriers discussed corroborated the challenges identified by health professionals in this study. These included the lack of confidence in providing nutrition advice, lack of guidelines on plant-based diets, insufficient time and space, and low engagement with nutrition specialists. Inadequate nutritional knowledge from medical training potentially limits the ability to communicate detailed information, especially about vegan diets to affect long-term behavioural changes (Adamski et al., 2018; Kahan & Manson, 2017; Lepre et al., 2020).

Obtaining referrals to dietitians is however challenging as described by a large proportion of participants in this study. Being vegan during pregnancy does not always guarantee a successful referral and several reasons impact dietitian availability. Similar reasons were outlined by Australian midwives (Arrish et al., 2016) – high demand for dietitians' services, limited funds, low availability in remote areas, priority given to health risks, and lack of time for midwives to make referrals to dietitians.

This, therefore, implied that LMCs would have a much greater responsibility to provide nutrition care. Yet, some respondents in this study reflected that LMCs may equally lack the time and scope to provide specific vegan nutrition care. Elias and Green (2007) reported that while New Zealand midwives receive training in a wide range of nutrition topics in the

midwifery curriculum, vegan nutrition was absent as a course topic. This was confirmed by midwives in this study and in more recent studies which found a lack of nutrition education being successfully incorporated into medical training regardless of the profession (Crowley et al., 2019; Lee et al., 2018; Saintila et al., 2021; Sanne & Bjørke-Monsen, 2020). Insufficient education around vegan diets may impact knowledge and confidence, as reflected in this current study and noted in the literature (Elias & Green, 2007; Landau et al., 2020). LMCs in New Zealand follow the continuity of care model and are in a prime position to support women during and beyond the gestational period, so nutrition training should be integrated into the medical curriculum to support LMCs in providing nutrition care.

When nutrition care is absent or provided as an adjunct therapy, the alternative may be for patients to seek potentially unaccredited advice from the media or the Internet (Cash et al., 2015). Related to this, a proportion of responders in this study believed that individuals on vegan diets were likely to be better informed about veganism than them. This was similar to findings from Othman et al. (2020b). However, given that there is a presence of misleading information on the Internet, it is risky to assume that all individuals are well-educated and motivated to search for scientifically correct resources.

To overcome the difficulty in obtaining dietitian referral in New Zealand, an efficient resolution could take the form of first implementing nutrition training for different diets, during undergraduate medical training for healthcare providers. Secondly, increased funding may be provided for continual competency courses on 'hot topics' (Adamski et al., 2018) which include vegan diets. The Nutrition Competency Framework (NCF) as represented in **Table 5.1** was first developed to address the inadequacy of nutrition competencies within ANZ medical education (Lepre et al., 2020). The framework with its proposed knowledge and skills competencies could provide a model for health professional education in the context of changing dietary trends and management of nutritional needs, with the support of a multi-disciplinary team.

Among New Zealand midwives (Elias & Green, 2007), 53% indicated an interest in collaborating with other health professionals to improve nutrition education. In this current study, none of the respondents were disinterested in learning more about vegan nutrition. The majority were however more inclined towards online and self-directed learning, suggesting that providing time-efficient methods of education can support the desire to become more

educated in vegan nutrition care. Interprofessional approaches could increase engagement between maternity caregivers and nutrition specialists (Lepre et al., 2020). If LMCs may be trained by dietetic specialists and supported by best practice guidelines (Adamski et al., 2018) tailored for vegan diets, an increment in self-efficacy and confidence could be observed.

Table 5.1 The Nutrition Competency Framework (NCF) (Lepre et al., 2020)

Knowledge-based Nutrition Competencies
K1 – Sciences: Demonstrate understanding of the basic sciences in relation to nutrition
K2 – Prevention: Demonstrate knowledge of the interactive role of nutrition in health and the prevention of disease
K3 – Treatment: Demonstrate knowledge of the evidence-based dietary strategies for the prevention and treatment of disease
K4 – Food: Demonstrate awareness of food, sources of nutrients, food habits, and the cultural and social importance of food
Skill-based Nutrition Competencies
S1 – Risk: Demonstrate skills in the identification of nutritional risk, nutritional deficits, and excesses
S2 – Critical: Demonstrate ability to interpret nutrition evidence in a critical and scientific manner, and apply appropriately in clinical practice.
S3 – Application: Demonstrate ability to apply basic dietary strategies for prevention and treatment of medical conditions, disease and trauma, with recognition that many nutritional issues require specialist management by a dietitian
S4 – Ethics: Demonstrate the ability to apply principles of ethics related to nutritional management
S5 – Team: Demonstrate ability to work effectively in a team with other health professionals to deliver optimal nutrition care

Chapter 6 : Conclusions and Future Recommendations

6.1 Study Summary and Achievement of Aims and Objectives

This mixed-method study was conducted between February 2022 to November 2022, with the primary aim of utilising an explanatory sequential design to explore the perspectives and experiences of healthcare professionals, about the consumption of vegan diets during pregnancy and early life. Health professionals (n=14) who had interactions with pregnant and breastfeeding women or young children were included in this study. Nutrition and dietetic specialists who may offer in-depth insights on special diets and associated nutrient deficiencies were also included.

The first part of the study utilised an online questionnaire to collect demographic information such as age, gender, ethnicity, educational background, professional experiences, as well as personal dietary choices. Knowledge, attitude, and information sources of a vegan diet were also surveyed in the questionnaire, and scores were tabulated as percentages. The contents of the questionnaire were motivated by evidence-based studies which utilised nutritional knowledge and attitude questionnaire, as well as national and global health guidelines. The second part of the study utilised a semi-structured interview to provide health professionals with the opportunity to describe experiences with vegan diets, thoughts, and concerns about this diet during pregnancy and early life, and implore deeper explanations about their selected choices in the knowledge and attitude sections of the questionnaire.

6.2 Findings, Concluding Remarks and Impact

Overall results of the study suggested that health professionals were generally supportive of a vegan diet during pregnancy and early life, but raised more concerns with a restrictive vegan diet during early life (infants and toddlers below two years of age). While international health organisations have described vegan diets to be nutritionally adequate during early life (Melina et al., 2016), a clear consensus from the New Zealand Ministry of Health and more updated evidence-based guidelines for vegan diets may increase confidence and assurance among health professionals in supporting this diet during early life.

The majority of health professionals advocate for vegan families to have adequate knowledge and appropriate planning so that elevated nutritional requirements during these stages of life

can be met through diet, fortified foods, and supplementation. The major nutritional concerns raised by almost all respondents were iron and vitamin B12. Other nutrients such as omega-three fatty acids, protein, iodine, calcium, vitamin D, and zinc were less frequently mentioned. As all these nutrients are found in low amounts in plant foods, and are equally crucial for health, increasing health professionals' knowledge in this area would provide increased expertise. Another major finding of the study reveals that not all participants were aware that plant sources do not provide sufficient vitamin B12 sources unless fortified. Again, updated guidelines on vegan diets, greater opportunities for further professional development, and integration of such topics within the medical curriculum are probable strategies to increase knowledge and competency.

While dietitians were noted to be key figures in the provision of educational support, health professionals have raised challenges in obtaining referrals. Dietitians are likely to have the most amount of time, knowledge, resources, and experience in vegan diets, but consistent findings from the interviews showed the lack of availability in seeing vegan pregnant women without major health complications. This suggests greater responsibility on other maternity caregivers who must upskill and be adequately trained in guiding vegan diets, rather than follow the risky assumption that vegan mothers are well-researched. Quite possibly, restructuring undergraduate medical or health science training, and changes to the framework of health care may be required to engage a multi-disciplinary approach in providing nutrition care for restrictive diets.

Information from MOH (2022) showed that in 2022, 93.5% of pregnant women received care from an LMC (midwife or doctor), with 69.3% of women registered with an LMC in the first trimester of pregnancy as compared to 53.8% in 2011. Post-natal care and infant care are provided by midwives and Well Child Tamariki Ora nurses who are placed in important positions to communicate knowledge and support families. Vegan diet consumption during pregnancy and early life may become even more prevalent, so health professionals need to be well-educated in this aspect of nutrition care to support a healthy pregnancy and the first 1000 days of life.

Overall, the study has uncovered aspects of vegan diets during pregnancy and early life that were concerning and challenging to health professionals. The study has also uncovered the

importance of continuing education and having updated evidence-based guidelines that can advise methods to achieve nutrient needs in vegan diets.

6.3 Strengths and Limitations

A major strength of this study was the mixed-method design and the diverse representation of all health professionals who provide maternity, infant, and nutrition care. The quantitative evidence showed emerging trends in this area of nutrition care while the interviews probed deeply into the key issues about vegan diets that deserve further attention. Taken together, both quantitative and qualitative sections sufficiently uncovered information about existing knowledge gaps, key concerns, and challenges with regard to a vegan diet in New Zealand during the three phases of life (pregnancy, lactation, and early childhood from 0 to 2 years).

Participant burden was kept to a minimum with the simple design of the online questionnaire and the easy flow of the interview schedule. The time taken to complete the questionnaire was no more than 15 minutes, and the maximum time for the interview was 45 minutes. Questions were crafted based on past peer-reviewed literature examining plant-based diets, as well as Ministry of Health guidelines. As interviews were conducted after the questionnaire, there was a chance for the researcher to clarify unexpected results due to participant error and improve the accuracy of quantitative data.

Several limitations were present in this study. The sample size was limited due to the nature of the thesis and the timeframe available to the researcher. While the findings enabled an exploration of insights into health professionals' perspectives on vegan diets, there is limited ability to generalise findings to a wider population of health professionals. As the questionnaire was completed online, it was difficult to ensure that participants relied on individual knowledge and did not check for answers. The questionnaire items could have offered hints about the contents that will be discussed in the interview section and it may also be possible that participants have read up on vegan diets before the interview. Furthermore, as the questionnaire was unvalidated, questionnaire items may not have measured the full content of vegan nutritional knowledge, and may not distinguish the level of knowledge between health professionals and the general population. There is also a limited ability for results to be generalised and compared to past nutritional knowledge and attitude surveys (Parmenter and Wardle, 2000; Zeldman and Andrade, 2020).

While the researcher practiced reflexivity and moderated personal beliefs when conducting the interview, personal judgement may be present that could obscure the interpretation of qualitative findings. However, the coding process was supervised by an academic supervisor who was proficient in qualitative data analysis. Emerging themes were cross-checked with quantitative results, discussed, and checked by all academic supervisors. Due to the recruitment method, selection bias (Lee et al., 2018) may be present as health professionals who were affiliated with the research institute or to other participants were more likely to volunteer. Generalisation of the results to a wider population of health professionals may thus be limited.

6.4 Recommendations for Future Studies

- 1) Develop and validate an extensive nutritional knowledge and attitude questionnaire for health professionals about vegan diets, including items for the adoption of these diets during pregnancy and early life
- 2) Assess the nutritional knowledge and attitude of a larger population of health professionals, recruited over a longer duration across New Zealand using the validated questionnaire
- 3) Determine if the personal dietary habits of health professionals affect the perception of vegan diets during these growth phases of life. For example, comparing vegan/vegetarian and omnivorous participants
- 4) Investigate if vegan pregnant women are likely to seek nutritional advice about vegan diets from maternity caregivers
- 5) Develop updated evidence-based guidelines about vegan diets during different phases of the life cycle, including pregnancy and early life. These guidelines should include:
 - a) information about the positive attributes of vegan diets
 - b) potential risks of nutrient deficiencies,
 - c) lists of plant food sources for each nutrient,
 - d) food preparation and cooking methods to increase the bioavailability of nutrients
 - e) outline of easily measurable food quantities for home-cooking
 - f) discussion of fortification and supplementation strategies to avoid nutrient deficiencies.
- 6) Explore the possibility of integrating vegan diets as a ‘hot topic’ of nutrition during medical training and continual competency programmes that focus on a multi-disciplinary

team approach, e.g., round-table situational analysis involving health professionals from different industries

7) Develop online interactive tools and a self-directed learning package for vegan diets

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Appendix 1: APA Style JARS Guidelines for Mixed-Methods Study

Appendix 2: Literature Review Table

Authors (year)	Study design	Sample population	Purpose	Validated NKA questionnaire?	Relevant findings
1.Elias and Green (2007)	Cross-sectional questionnaire	New Zealand registered midwives (n=370)	<p>1. To determine the nutrition knowledge of NZ registered midwives</p> <p>2. To assess the importance midwives place on nutrition during pregnancy</p>	No but pilot-tested with several midwives	<ul style="list-style-type: none"> • Response rate of 27.6% • 37% (n=136) received formal nutrition education; 75% (n=106) received information from midwifery education • Resources obtained from MOH guidelines for pregnant women (n=346), breastfeeding women (n=329) • 98.4% indicated nutrition was important or very important; 94.9% felt they had a significant or very significant role in educating pregnant women about nutrition; 99.1% (367) provided nutrition information to women • Level of confidence for providing nutrition information for vegetarian diets were 12.4% (n=46) and 30.3% (n=112) for very confident and confident respectively; 39.5% (n=146) and 15.9% (n=59) for moderately confident and not confident respectively. • Iron: 64.6% of midwives incorrectly identified spirulina to be a good source but 96.8% (n=358) and 93.8% (n=347) were correct for question on the impact of vitamin C and tea during meals on iron absorption, B12: 45% incorrectly identified spirulina as a reliable source: Vitamin D: 32.2% (n=119) correctly agreed that breastmilk was a poor source of vitamin D, Zinc: 58.1% (n=215) correctly identified fruits and vegetables to be a poor source • No significant difference in correct answers between midwives with nutrition education and those without, with chi-square values of $P>0.05$

Authors (year)	Study design	Sample population	Purpose	Validated NKA questionnaire?	Relevant findings
2.Arrish et al. (2016)	Web-based cross-sectional survey	Members of the Australian College of Midwives (n = 329) in all eight states of Australia	To investigate the nutrition knowledge, attitudes and confidence of Australian midwives in providing nutrition education during pregnancy	No, but pilot-tested	<ul style="list-style-type: none"> • Response rate of 6.9% (329 of 4770) • 86.6% highly rated the importance of nutrition during pregnancy; 75.7% highly rated the significance of their role in nutrition education • Nutritional knowledge mean score is 13.64 out of 20 (± 2.04); 62.3% correct for the most important vitamin supplement for vegetarian pregnant women; 73.2 % incorrect for daily recommended number of serves of dairy foods; 79.9% incorrect for iodine requirements per day for a pregnant woman; Sources of iron: 59% (n=194) identified legumes, 11.2% (n=37) identified seafood and only 9.1% (n=30) selected both • Midwives who receive nutrition information or education during midwifery education (M=13.96) scored higher than those who did not (M=13.30); 81.4% (n=249) obtained information from dietitians; 75.5% (n=231) from general knowledge; 62.7% (n=192) from midwifery education • Issues with dietitians include high demand for their services, limited time and funds allocated, limited availability of dietitians in remote areas and lack of time for midwives to make referrals to dietitians. Vegetarian and vegan diets were least referred topics to dietitians. • 70.9% (n=217) had moderate level of confidence in providing ‘general-related nutrition advice’ to pregnant women but have moderate to lowest level of confidence for vegetarian and vegan diets; midwives who reported higher level of confidence (M=14.48) in providing general nutrition advice scored higher compared to those who reported moderate (M=13.70) and low levels (M=13.15) of confidence.

Authors (year)	Study design	Sample population	Purpose	Validated NKA questionnaire?	Relevant findings
3.Krause and Williams Sr. (2017)	Cross-sectional questionnaire.	Medical providers of Rush University Medical Center (n=64 questionnaires analysed) from Chicago, Illinois, USA	To determine the knowledge of the medical community about plant-based nutrition, and assess if participants were inclined to adopt or recommend the diet to their patients	No	<ul style="list-style-type: none"> Majority were knowledgeable about dietary habits of vegans (90%, n=55/61) and vegetarian (79%, n=48/61) Mixed attitudes about recommending plant-based nutrition to present and future patients; 33% said yes and 51% said maybe. Residents and fellows were more willing than physician attendings to recommend plant-based diets to future patients (39% compared to 30%), but physician attendings were more willing than residents and fellows to adopt a plant-based diet for themselves (30% compared to 22%). Majority agreed that plant-based diets were safe and healthy (83%). Knowledge of the characteristics in a plant-based diet: 90% (n=55/61) correct in definition of vegan and vegetarian diet; 36% (n=22/61) correlated plant-based diet to vegetarian diet, 43% (n=26/61) correlated it to vegan diet, 23% (n=13/61) correlated it to a vegetarian diet with fish products Correct nutritional knowledge: 78% agreed that plant-based diets can obtain enough protein; 93% agreed that dark leafy vegetables are rich iron sources; 94% agreed that nuts are high in protein; 92% disagreed that animal proteins are the only quality protein sources; 58% agreed B12 should be closely monitored; 52% agreed that omega-three fatty acids can be obtained from plant-based foods.
4.Lee et al. (2017)	Mixed methods approach with a cross-sectional questionnaire, followed by semi-structured interviews with pregnant women and	Pregnant women and clinicians from Melbourne, Australia who were midwives or obstetricians Cross-sectional questionnaire (n=202; 105 women and 97 clinicians)	Assess and compare pregnancy nutrition recommendation knowledge and the impact of knowledge on food choices in pregnant women and nutrition education	Yes	<ul style="list-style-type: none"> None of the pregnant women had a knowledge score > 80%; poor knowledge for iodine during pregnancy: 52% correct for the need of iodine supplementation, 23% correct for iodine recommended during pregnancy and breastfeeding, 5% correct for food sources of iodine; 33% of women indicated they received nutrition advice during pregnancy Inadequate knowledge about iodine among clinicians with <50% having correct responses to questions on iodine; 45% correct for the need of iodine supplementation, 29% correct for iodine recommended during pregnancy and breastfeeding, 27% correct for food sources of iodine. Only one clinician obtained a score of >80% on nutrition knowledge questionnaire; Clinicians had a significantly

Authors (year)	Study design	Sample population	Purpose	Validated NKA questionnaire?	Relevant findings
4. Lee et al. (2017) [continued]	clinicians	semi-structured interviews with women and clinicians (n=31; 19 women and 12 clinicians)	practices of antenatal care providers		<p>higher mean knowledge score (34.5±11.0), as compared to pregnant women (42.8±8.2), p<0.001 and <i>d</i>=0.85</p> <ul style="list-style-type: none"> 68% of clinicians reported providing nutrition advice to women as part of antenatal care; referral to dietitians if patients were vegan/vegetarian or deficient in iron; used sources from undergraduate training, colleagues, Australian Breastfeeding Association, academic journals, lay literature and personal experiences; challenges with lack of training/ education, knowledge, missed opportunities, lack of time, challenging patients and it being the patient's responsibility, lack of confidence, inadequate campaigning (e.g. iodine) Women reported receiving brief and general advice about nutrition, only during the first pregnancy care visit, advice to take multivitamins, consume more meat, fruit, vegetables, fibre and dairy product; women reported likelihood to change dietary behaviour if advised by clinician
5. Bettinelli et al. (2019)	Cross-sectional questionnaire	Health professionals in two tertiary level hospitals in Milan, Italy (n=418), 65.8% were nursing staff	Investigate the level of knowledge among health professionals regarding the impacts of vegetarian diets on foetal, infant and child development	No, but pilot-tested	<ul style="list-style-type: none"> Correct answers were provided in 20% of cases for knowledge on nutrients; 34.1% had correct definition of a vegetarian diet; 45% had correct responses for the risks and benefits of a vegetarian diet; 39.4% had correct responses for the adoption of a vegetarian diet throughout the life cycle No significant correlation between nutrition training in the previous 5 years, the sociodemographic, the professional characteristics of the sample, and the answers to the 23 items on the questionnaire. A significant correlation was found between the knowledge and dietary habits of the participants for seven items. In 5 out of the 7 items, participants who were classified to have a vegetarian dietary pattern gave correct answers in a higher percentage of cases than those classified as semi vegetarians or omnivores. For two other items, one had similar percentage of correct answers between omnivores and vegetarians. For the other, the percentage of correct answers provided by omnivores was higher.

Authors (year)	Study design	Sample population	Purpose	Validated NKA questionnaire?	Relevant findings
6. McHugh et al. (2019)	Mixed-methods study with questionnaire and one subsequent focus group consisting of participants who completed the survey and were HPs likely to be asked for or to be discussing nutritional advice	HPs across 3 general practices, 3 pharmacies, one hospital, osteopathic medicine clinic in the Tairāwhiti region of New Zealand (n=41). Dietitians were approached but none participated.	To investigate nutrition knowledge, attitudes to nutrition and perceptions about nutritional education	No	<ul style="list-style-type: none"> • Nutrition education and training: wide range of estimated hours, prior to (0-550h, n=22) and after graduation (0-200h, n=19); 55% had median of 7.5 hours prior to graduation, 48% had median of 20 hours post-graduation; 43% of HPs reported dissatisfaction with quantity of nutritional training; learning was reflected to be self-directed (data collected from focus group interviews); guidelines referenced by HPs were from Heart Foundation (12%), Diabetes Guidelines (10%), unspecified studies and references with low application of evidence-based nutrition guidelines (51%) • Frequency of nutritional advice provided by HPs: Average of 2.4 times per day. • Perceptions of dietary approaches: High intake of vegetables / vegetarian and vegan diet was healthy; best source of calcium was perceived to be milk and vegetables; best sources of protein and iron was perceived to be meat by 73% and 87% of respondents respectively; other common sources included vegetables and legumes; perception that a plant-based diet is complicated to follow (cited reasons include cost, access to foods, difficulty in meal prep and cultural attitudes) but will be satiating and improve quality of life.
7. Sanne and Bjørke-Monsen (2020)	Cross-sectional questionnaire	Registered medical students at the University of Bergen (UiB), Norway (N=394)	<ol style="list-style-type: none"> 1. Investigate nutritional knowledge about vegetarian diets among well-educated young people 2. Determine if there was a difference in nutritional knowledge 	No	<ul style="list-style-type: none"> • Attitude: significantly more vegetarian students (44%) than omnivore students (13%) considered vegetarian diet to be healthier than omnivore diet ($p < 0.001$) and significantly more vegetarian (16%) than omnivore students (2%) considered vegan diets to be healthier than vegetarian diet ($p < 0.001$); significantly more vegetarians (45%) than omnivores (28%) consider supplementation necessary while following a vegetarian diet ($p = 0.004$); significantly more vegetarians (61%) than omnivores (38%) considered it possible to have a well-balanced vegan diet ($P < 0.001$). • Nutritional knowledge about a vegan diet: Significantly more vegetarian students were aware of deficiencies in vitamin B12 ($P \leq 0.05$); significantly more omnivore students were aware of

Authors (year)	Study design	Sample population	Purpose	Validated NKA questionnaire?	Relevant findings
7.Sanne and Bjørke-Monsen (2020) [continued]			between students on vegetarian diet and students on an omnivore diet.		deficiencies in omega-three fatty acids, selenium, zinc and vitamin A ($P \leq 0.05$); significantly less omnivore students (65%) considered meat to be a good source of vitamin B12 as compared to vegetarian students (83%) ($P = 0.003$); significantly more omnivore students considered fruits (13%) and bread (25%) to be good sources of vitamin B12 compared to vegetarians (6% for fruit, $P=0.01$; 22% for bread, $P=0.05$); Approximately 20% of all students considered meat and plant foods to be good sources of iodine.
8.Landua et al. (2020)	Cross-sectional questionnaire	Pediatricians in Israel (n=270)	Assess knowledge of vegetarian nutrition, familiarity of guidelines and attitudes towards vegetarian diets among pediatricians	Yes (Duncan & Bergman, 1999)	<p>Nutritional knowledge:</p> <ul style="list-style-type: none"> • Overall mean score for entire cohort: 37.8% \pm 16.0% out of 100%; vegetarians/semi-vegetarians had significantly higher mean scores compared to non-vegetarians, of 48.4% vs 36.2% (95% CI 6.8-17.6, $P < 0.001$). • Correct response that soy formula is the only appropriate substitute for cow's milk was given by 35.4% of respondents in total; 33.9% had also included regular soy milk, rice milk or almond milk as appropriate substitutes. • Correct responses were significantly higher among physicians who had ever been vegetarians than those who had never been vegetarians, at 45.4% and 32.7% respectively ($P=0.08$). • Significantly lower mean knowledge scores were found for pediatricians who have less tendency to inquire about patients' eating habits than those who do inquire, 33.8% vs 38.3% (95% CI 0.3-9.7, $P = 0.038$) • Significantly lower mean scores for those who refer vegetarian children to dietitians compared to those who do not, 36.7% vs 41% (95% CI 0.1-8.6, $P=0.047$) • Significantly higher knowledge scores among pediatricians who give recommendation on vegetarian diets than those that do not, at 39.8% vs 35.6% (95% CI 0.3-9.1, $P=0.03$).

Authors (year)	Study design	Sample population	Purpose	Validated NKA questionnaire?	Relevant findings
8.Landau et al. (2020) [continued]					<p>Attitude:</p> <ul style="list-style-type: none"> • Overall mean attitude score was 38.1% ± 20.7% • Vegetarians had significantly higher mean attitude scores than non-vegetarians, of 53.1% vs35.7% (95% CI 10.5-24.2, $P<0.001$). • Knowledge scores were positively correlated with attitude scores with Pearson's correlation coefficient at 0.45 ($P<0.001$) • 44.2% do not usually provide recommendations about nutrition to parents of vegetarian or vegan children; 39.8% reported discomfort in answering questions about vegetarian diets and 69% reported referring parents of these children to dietitians • 65.0% reported higher tendency to conduct blood workup for vegetarian and vegan children (58.2% for complete blood count; 56.7% for vitamin B-12; 56.3% for iron panel; 21.5% for vitamin D); no significant difference in this response between vegetarian and non-vegetarian pediatricians
9.Othman et al. (2020a)	Pre- and post-intervention study using a questionnaire as evaluation of knowledge at 3 time points.	Australian midwives who resided in South Australia (Adelaide) were recruited. Pre-intervention questionnaire (n=44), education intervention in the form of a workshop/webinar (n=29), questionnaire immediately after	Investigate and explore the knowledge and level of confidence among midwives to support pregnant women in eating healthily by comparing results pre and post attending educational intervention	Yes	<ul style="list-style-type: none"> • 47.7% (n=21) midwives reported receiving nutrition education during undergraduate study or post-qualification; three midwives reported attending nutrition education in the last 12 months • 4 out of 12 questions about healthy eating during pregnancy were answered correctly by 50% of participating midwives in the pre-education questionnaire. Questions that were incorrect included vitamin D, iodine, calcium for vegans and sources of omega-three • Improvement was observed in the questionnaire administered immediately after the intervention with over 50% of participants giving correct answers for 10 out of 12 questions. Questions about vitamin D and omega-three improved immediately but retention of the knowledge was absent in the 6-8 weeks follow-up.

Authors (year)	Study design	Sample population	Purpose	Validated NKA questionnaire?	Relevant findings
9.Othman et al. (2020a) [continued]		intervention (n=29), 6-8 weeks questionnaire (n=19)			<ul style="list-style-type: none"> • Total knowledge scores statistically differ between questionnaires administered pre and immediately after intervention ($p < 0.001$), and between immediately after and post intervention ($p < 0.01$) • Confidence levels of midwives significantly increased from pre- (n=44) with a mean score of 22.05 ± 6.87 to immediate (n=29) with mean 31.48 ± 7.47, and post (n=19) with 30.89 ± 7.19; ($P < 0.05$). • Midwives perceived their role to be important in providing nutrition advice and education about vegan and vegetarian diets to pregnant women • Positive correlation was obtained between the knowledge and confidence scores over the three time points of the questionnaires ($p < 0.007$)
10. Meulenbroeks et al. (2021)	Cross-sectional study with a questionnaire-based online survey	Dutch midwives (n=121), obstetricians (n=54) and dietitians (n=111) from Netherlands	To evaluate the self-reported knowledge and advice given by Dutch obstetric caregivers and dietitians who treat pregnant women who are on a strict plant-based (vegan) diet.	No, but questions derived from focus groups and pretested with six individuals	<ul style="list-style-type: none"> • 66.1% of midwives and 75.4% of obstetricians reported that their education in plant-based diets was insufficient • 27.3% of midwives and 56.6% of obstetricians were unable to give advice on specific foods and supplements • 38.7% of dietitians reported having sufficient knowledge to advise women on plant-based diets; 96.4% of dietitians reported that their formal training did not cover strict plant-based diets during pregnancy; 7.2% took an additional course on strict plant-based diets • 28.9% of midwives and 10.8% of obstetricians advise clients to consume multivitamin / pregnancy supplements / consume more protein or fat during lactation. • 80.2% of midwives and 93.9% of obstetricians considered strict plant-based diet to be significant risk factor and expected nutrient deficiency during pregnancy.

Authors (year)	Study design	Sample population	Purpose	Validated NKA questionnaire?	Relevant findings
10. Meulenbroeks et al. (2021) [continued]					<ul style="list-style-type: none"> • Less obstetricians (43%) than midwives (81.6%) felt themselves responsible for providing information about breastfeeding and plant-based formula. 20.3% of midwives and 41.9% of obstetricians feel dietitians should provide information; 45.8% and 45.8% of obstetricians respectively indicate that the patient and the Dutch National Nutrition Center should provide information about nutrition. • 86.8% of midwives; 88.6% of obstetricians and 95.5% of dietitians indicated desire to learn more about strict plant-based diets during pregnancy • 59.5% of midwives and 24.1% of obstetricians asked most of the time or always about clients' dietary preferences
11.Hanna et al. (2021)	Cross-sectional questionnaire	Queen's University Belfast (QUB), Ireland 2019-2020 final year master of pharmacy students (N=92).	Investigate the knowledge and views about veganism among pharmacy students.	No, but pilot-tested	<ul style="list-style-type: none"> • Mean knowledge score: 16.59 out of 22 (\pm 2.43); similar scores between gender and vegan/non-vegan participants; general lack of knowledge about food sources of vitamins, risks of nutrient deficiencies in a vegan diet: 80.4% correct about calcium; 89.1% correct for iron; 65.2% correct for iron • 37% (n=34) had confidence discussing veganism, 40.2% (n=37) reported ability to identify vegan-friendly medicine; 4.3% had adequate training on veganism; yes/maybe group more confident discussing veganism than the no/never group • More males (74.2%) than females (51.7%) considered that vegans are too forceful with their beliefs; a greater proportion of the no/never group than the yes/maybe group viewed veganism to be an unsustainable trend (33% compared to 17.6%).

Authors (year)	Study design	Sample population	Purpose	Validated NKA questionnaire?	Relevant findings
12.Saintila et al. (2021)	Cross-sectional online survey	Peruvian and foreign dietitians in Peru (n=179)	To compare the level of knowledge between vegetarian and nonvegetarian Peruvian dietitians about vegetarianism in different stages of life	Yes	<ul style="list-style-type: none"> • Significantly higher vegetarians as compared to non-vegetarians had correct answers for definition of lacto-ovo vegetarian (94.4% vs 31.8%) and vegan diets (98.6% vs 32.7%); $P<0.001$; for risks and benefits with vegetarianism, significantly higher vegetarians had correct answers for 3 items tested than non-vegetarians (77.8% vs 57.0%; 80.6% vs 52.3%; 93.1% vs 72.9%); all $p<0.001$. • Critical nutrients (nutrient deficiencies) and vegetarian diets in different stages of life: <ul style="list-style-type: none"> i. vegetarian dietitians obtained highest number of correct answers as compared to non-vegetarians (50% vs 42%; 71.3% vs 60% respectively) but difference was not significant ($P=0.43$; $P=0.28$) ii. correct responses were $< 50\%$ for both vegetarians and non-vegetarians for questions on iron, calcium, zinc and fatty acids iii. correct responses were $>78\%$ for both vegetarians and non-vegetarians in response to whether the following nutrients (protein, vitamin D, omega-three fatty acids, vitamin B12, iron, zinc and calcium) were critical nutrients in a vegetarian diet iv. significantly higher vegetarians had correct responses for the nutrients (vitamins B12, D, iron, zinc, folic acid, omega three and six, protein and calcium) required by an infant during complementary feeding (77.8% vs 63.6%); $P=0.043$ • Significantly higher proportion of vegetarians received training in vegetarian nutrition in the last 5 years as compared to nonvegetarians (51.4% vs 24.3%); $P< 0.001$ • higher scores among vegetarian dietitians could be related to continuous education about vegetarian diets over the last 5 years; dietitians did not have complete and exhaustive knowledge about the key nutrients in a vegetarian diet.

Appendix 3: Questionnaire

Exploring health professionals' experience of vegan diets

Section A

This section of the questionnaire aims to find out about you and your work experiences. For each question, please select the most applicable response. If you choose not to answer any question, you may select the 'prefer not to answer' option or skip the question. We thank you for the time and contribution in completing the questionnaire.

1. Participant identification code:

2. What is your age?

3. What is your gender?

- Female
- Male
- Gender diverse/others
- Prefer not to answer

4. What is your ethnicity?

- New Zealand European/European
- Māori
- Pacific peoples
- Asian
- Middle Eastern / Latin American / African
- Prefer not to answer
- Other ethnicity:

5. What is your qualification?

- High School
- Undergraduate degree / equivalent
- Post-graduate education (Diploma, Master, PhD, MD etc)
- Prefer not to answer
- Other tertiary institutions or qualifications:

6. What is your current role as a health professional?

- Midwife
- Plunket nurse
- Practice nurse
- Paediatric nurse
- Tamariki Ora nurse
- General nurse
- Karitāne nurse
- Dietitian
- Nutritionist
- Paediatrician
- General Practitioner
- Obstetrician or Gynaecologist
- Prefer not to answer
- Others:

7. How many years of practice do you have in your current role as a health professional?

- 1 – 3 years
- 4 – 5 years
- 6 – 10 years
- > 10 years
- Prefer not to answer

8. What type of clients or patients do you see in your practice? (select all that apply)

- Women during pregnancy
- Women during breastfeeding
- Infants or babies (0 – 12 months)
- Toddlers (1 -3 years)
- Pre-schoolers (3 – 5 years)
- Children (5 – 12 years)
- Adolescents (12 – 18 years)
- Adults (18 – 64 years)
- Older adults (>65 years)
- All of the above
- Prefer not to answer
- Others:

9. Have you seen any pregnant, breastfeeding women or young children (below 2 years of age) who are on a special or restrictive diet?

- Yes, this diet is:

- No
- Not this particular group, but I have seen other individuals on restrictive diets.

10. What is your current diet?

- Omnivorous (Plant and animal food sources)
- Pescatarian (include only fish or seafood but no other meat sources)
- Vegetarian (include dairy and/or eggs)
- Vegan (exclude all animal products)
- Others:

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- Prefer not to answer

Section B

This section aims to find out about the current knowledge and attitude among health professionals towards vegan diets during pregnancy, lactation and early life. For each question, please select the most applicable response(s). You may provide more than one appropriate response for some selected questions. If you choose not to answer any question, you may select the 'prefer not to answer' option or skip the question. We thank you for the time and contribution in completing the questionnaire.

1. A vegan diet is one that excludes all meat, fish and sources of animal products, including dairy, eggs and honey. When following a vegan diet, a pregnant woman may have increased risks of deficiencies in the following nutrient/ nutrients:

(select all options that apply)

- Folic acid
- Vitamin B12
- Vitamin C
- Vitamin D
- Calcium
- Carbohydrates
- Iron
- Iodine
- Magnesium
- Protein
- Omega-3 fatty acids
- Zinc
- Fibre
- None of the above
- All of the above
- Unsure
- Prefer not to answer

2. Decide if you agree, disagree or are unsure about the following statements:

Statements	Strongly Agree	Agree	Neutral or Unsure	Disagree	Strongly Disagree
A well-planned vegan diet with B12 supplementation is nutritionally adequate for pregnancy / breastfeeding	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
A well-planned vegan diet with B12 supplementation is nutritionally adequate for infants aged 0 to 2 years	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
A vegan diet during pregnancy can promote positive health outcomes.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
A pregnant woman cannot get enough quality protein from a vegan diet.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
A pregnant woman or infant should be checked for nutritional deficiencies if they are on a vegan diet.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Veganism is a trend and is not sustainable for individuals on a long-term basis.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Planning is important in a vegan diet.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Health professionals are responsible for providing information and supporting individuals who choose to follow a vegan diet.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
There is sufficient information about vegan diets for pregnancy, breastfeeding and early life (infants 0 to 2 years).	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I am confident in discussing vegan diets with my patients or clients.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

3. A vegan pregnant woman can obtain sufficient vitamin B12 from the following plant food/ foods: (select all options that apply)

- Algae
- Mushrooms
- Spirulina
- Nutritional yeast
- Beans, lentils and nuts
- None of the above
- All of the above
- Unsure
- Prefer not to answer

4. Plant sources of iron are: (select all options that apply)

- Beans, lentils and nuts
- Green leafy vegetables
- Fruits
- Mushrooms
- Nuts
- Seeds
- None of the above
- All of the above
- Unsure
- Prefer not to answer

5. Eating an orange while consuming an iron-rich vegan meal increases iron absorption in the body.

- True
- False
- Unsure
- Prefer not to answer

6. What supplements do you think a pregnant or breastfeeding woman following a vegan diet should take?

7. For the following fortified vegan alternatives to cow's milk, which would be the most recommended option for toddlers (aged 1-3 years)?

- Nut milk
- Soy milk
- Rice milk
- Oat milk
- Unsure
- Prefer not to answer

8. Which information sources do you use to help you provide nutritional advice? (select all options that apply)

- Other health professionals
- Continuing professional development (CPD)
- Ministry of Health websites
- New Zealand dietary guidelines e.g. Eating and Activity Guidelines for New Zealand adults
- Scientific journals / peer - reviewed articles
- Textbooks
- Internet
- Media such as television, newspapers, magazines and social media platforms
- All of the above
- Unsure
- Prefer not to answer
- Others:

9. What is / are your preferred mode(s) of training to increase knowledge on vegan diets? (select all options that apply)

- Face to face lectures / symposiums
- Online lectures / symposiums
- Self-directed learning package (e.g inclusion of readings, videos and audio links)
- Experiential learning with case studies and interactive activities
- Not interested to learn more
- All of the above
- Unsure
- Prefer not to answer
- Others:

10. How do you find the length of the questionnaire?

- Insufficient questions
- Just right
- Too many questions

11. Do you have any additional feedback on the content or presentation of the questionnaire?

Appendix 4: Interview Schedule

Question type and aim of question	Primary question	Possible probe questions during interview	Additional questions during interview	Time assigned
<p>1. Introductory Question</p> <p><i>Aim: Increase connection of participants to the topic and start thinking about their experience; provides a surface to the topic</i></p>	<p>a. Tell me more about the type of clients you care for and whether you provide advice on diet.</p> <p>b. Tell me about the type of dietary advice you may provide for your clients in general?</p>	<p>i. Tell me more about your practice and the type of clients you see.</p> <p>ii. For participants who see pregnant women, mothers and children: tell me more about these clients and the type of dietary advice you provide for them.</p>		5 minutes
<p>2. Transition Question</p> <p><i>Aim: Provide logical links between introductory and transition sentences, and to ask for increased depth of experiences</i></p>	<p>a. The term, ‘plant-based’ diets have been used frequently over the years. What do you understand about a plant-based diet?</p>	<p>i. Is there any difference between a vegetarian and vegan diet / types of plant-based diets?</p>		10 minutes

Question type and aim of question	Primary question	Possible probe questions during interview	Additional questions during interview	Time Assigned
<p>3. Key Question <i>Aim: Answer the focus group objective and to obtain detailed information or anecdotes from participants to fulfil research aims</i></p>	<p>a. Moving forwards in this interview, we will only be discussing vegan diets which is a form of diet that is completely plant-derived and excludes all animal products such as dairy, eggs and honey. Do you see people following this diet?</p> <p><i>For yes:</i> Could you tell me more about the advice you have provided for them?</p> <p><i>For no:</i> How would you advice someone who is on a vegan diet?</p>		<p>Are you seeing more people who follow a vegan diet in your practice?</p>	<p>20 minutes</p>

Question type and aim of question	Primary question	Possible probe questions during interview	Additional questions during interview	Time Assigned
<p>3. Key Question [continued] <i>Aim: Answer the focus group objective and to obtain detailed information or anecdotes from participants to fulfil research aims</i></p>	<p>b. In your questionnaire, you mentioned that you have seen pregnant women/ young children (on vegan diets) – any of them on vegan diets?</p> <p><i>For yes:</i> What are some topics discussed with these individuals, about such restrictive diets?</p> <p><i>For no:</i> What are your perspectives about vegan diets during pregnancy / breastfeeding / early life?</p>	<p>i. What are the positive attributes of a vegan diet?</p> <p>ii. Do you have any concerns about women who is following a vegan diet during pregnancy / breastfeeding?</p> <p>iii. How about for young children who are following such diets?</p>	<p>i. You have selected the following nutrients of concern in the pre-interview questionnaire (list selected nutrients e.g. B12, iron), are you able to elaborate on why you may be concerned about these nutrients?</p> <p>ii. What is your opinion on plant-based milk alternatives?</p> <p>iii. Are there any concerns with the nutrient content of breastmilk in the mother is a vegan?</p> <p>iv. In the event that breastfeeding, is there a possibility for mothers to seek vegan alternatives?</p>	<p>20 minutes</p>

Question type and aim of question	Primary question	Possible probe questions during interview	Additional questions during interview	Time Assigned
<p>4. Ending <i>Aim: Provide closure to discussion and ensure appropriate summary of topics discussed</i></p>	<p>a. With the increase in vegan diets, what do you think could be some challenges faced by health professionals?</p>	<p>i. What do you think is your role as a HP in providing advice on vegan diets?</p>	<p>i. What are the challenges involved in referring patients to specialists such as dietitians?</p>	<p>5 minutes</p>
	<p>b. What are the current information sources about nutrition that you have used in your practice?</p>	<p>ii. Do you think that all health professionals have equal responsibility in providing advice about vegan diets / have the knowledge to provide this advice?</p>	<p>ii. What may be factors that influence your confidence in providing advice about vegan diets?</p> <p>iii. Is nutrition education incorporated in your medical training, and is it sufficient?</p>	

Appendix 5: Participant Information Sheet



MASSEY UNIVERSITY
COLLEGE OF HEALTH
TE KURA HAUORA TANGATA

Participant Information Sheet

Exploring the concerns, attitudes and experiences of health professionals regarding a vegan diet during pregnancy and early life; a mixed-method study

Researcher: Soh Bi Xue Patricia

Type of project: Student research, Master of Science in Human Nutrition

Study Site: School of Sport, Exercise and Nutrition, Massey University, Albany

Contact phone number: [REDACTED]

Email address: patricia.soh.2@uni.massey.ac.nz

Ethics committee ref: 4000026435

You are invited to take part in an exploratory study where information provided from your experience and perspectives as a health professional will support the subsequent development of a nutritional knowledge and attitude questionnaire. Whether or not you take part is your choice. If you want to take part now, but change your mind later, you can pull out of the study at any time.

This Participant Information Sheet will help you decide if you would like to take part. It describes why this study is conducted, what your participation would involve, what the benefits and risks to you might be, and what would happen after the study ends. We will go through this information with you and answer any questions that you may have. You do not have to decide today whether or not you will participate in this study. Before you decide, feel free to talk about the study with other people, such as family, whānau, friends and other healthcare providers.

This form is 7 pages. Please make sure you have read and understood all the pages.

VOLUNTARY PARTICIPATION AND WITHDRAWAL FROM THIS STUDY

Participation in this study is completely voluntary. You are under no obligation to accept this invitation. If you decide to participate, you have the right to:

- decline to answer any particular question;
- withdraw from the study at any time;
- ask any questions about the study at any time during the participation;
- provide information on the understanding that your name will not be used at all;
- be given access to a summary of the project findings when it is concluded;
- ask for the recorder to be turned off at any time during the interview.

Completion and return of the consent form implies consent. You have the right to decline to answer any particular question.

Withdrawal from the study at any time will not result in any disadvantage to you.

WHAT IS THE PURPOSE OF THE STUDY?

In New Zealand, a range of health professionals support women and their whānau during pregnancy, lactation and early life. An important aspect of their care may include advice on healthy eating. A current trend is to follow a plant-based diet and we are seeking to find out whether women following a plant-based diet are seeking advice from health professionals. For those health professionals who are providing advice, we would like to find out more about your experience. For any health professionals who do not specifically provide dietary advice, we would like to find out more about your attitudes towards plant-based diets and whether you think there is a need for more resources in this area.

Data from this exploratory study will help us examine concerns and perspectives about plant-based diets during pregnancy and early life, and identify if there is a gap in the current resources for health professionals on early life nutrition and plant-based diets.

HOW IS THE STUDY DESIGNED?

This study will involve interviewing up to 20 health professionals. Participants will also need to complete a questionnaire that asks for their demographic and professional information. This questionnaire will also include some questions about knowledge of plant-based diets during pregnancy, lactation and early life.

WHO CAN TAKE PART IN THE STUDY?

English-speaking health professionals living in New Zealand, who see pregnant, lactating women, babies and young children, or who provide nutrition and dietary advice to patients will be included. The study will be advertised to health professionals who attended the Massey University Early Life Nutrition symposia series and have indicated that they are happy to be informed about relevant research studies.

WHAT WILL MY PARTICIPATION IN THE STUDY INVOLVE?

If you decide to take part in this study, after you have read and had time to consider the information in this information sheet, you will be required to return a signed consent form prior to the interview.

You will be required to attend one semi-structured interview with only the researcher, either in person, or virtually, at a date and time that is suitable to both you and the researcher. The interview will take approximately 45 minutes to complete and will be audio-recorded. If you prefer to have the interview in person, you will be required to visit the School of Sport, Exercise and Nutrition at Massey University, Albany. If you prefer to have the interview virtually, a link will be sent to you one day before the interview. You will also be required to complete a pre-interview questionnaire which takes approximately 15 minutes to complete.

For the questionnaire, you will be asked:

- for information about you (e.g. age range, gender, ethnicity) and about your professional role (e.g. job title, experience);
- about your knowledge in nutrients of concern during pregnancy, lactation and early life;
- about your knowledge in special diets that involve plant-based foods;
- to rely on your own knowledge and not to research for the responses.

During the interview, you will be asked questions that revolve around:

- experiences you had or may potentially have with guiding patients on nutrition and diet;
- interactions you had or may potentially have with pregnant, breastfeeding women and young children who are below 2 years of age;
- perspectives about special diets such as plant-based diets, particularly for pregnant, breastfeeding women and young children who are below 2 years of age;
- knowledge and perspectives about available resources, guidelines or professional development opportunities for further education on nutrition.

Due to the fluid nature of a semi-structured interview, which is dependent on the responses of the participant, the discussion may include topics that extend beyond those listed above. You

may also be asked for perspectives on hypothetical scenarios. However, you may decline to answer any question at any point during the interview.

WHAT ARE THE POSSIBLE RISKS OF THIS STUDY?

You may experience some social or cultural discomfort if you feel that you are unsure of the questions posed in the questionnaire or interview. However, every effort will be made to ensure your comfort and the researcher will be respectful of your input throughout the process. You may also decline to answer any question that you are uncomfortable with.

WHAT ARE THE POSSIBLE BENEFITS OF THIS STUDY?

Your input will help us identify current perspectives about plant-based diets during important growth phases of life. Through this exploratory study, you will help us identify specific resources and existing knowledge gaps regarding early life nutrition and plant-based diets. Data from the research project will inform the development of future education strategies to equip health providers with resources to support individuals on plant-based diets.

WILL ANY COSTS BE REIMBURSED?

Participants may incur costs of travel if they choose to be interviewed physically. Alternatively, a free virtual session is held if participants choose not to travel.

WHAT WILL HAPPEN TO MY INFORMATION?

During the study, the researcher will record information about you such as your demographic, professional and personal details. You cannot take part in this study if you do not consent to the collection of this information.

Identifiable information

Identifiable information is any data that could identify you (e.g. your name, date of birth, or address). The following groups may have access to your identifiable information:

- Research staff (researcher and supervisors)
- Massey University Human Ethics Committee (MUHEC) who is responsible for ethics approval for this study.

De-identified (Coded) information

To keep your personal information confidential, any information that identifies you will not be included in any report generated by the researcher. Instead, you will be identified by a code when the questionnaires are checked, and the interview transcripts are analysed.

The results of the study may be published or presented, but not in a form that would reasonably be expected to identify you.

Anonymised Information

The researcher may remove the code from your de-identified information – this is called ‘anonymisation’. This makes it difficult, but not impossible to identify the information that belongs to you. The researcher may share this anonymised information with other researchers on request for the purpose of accumulating data from individual studies. The anonymous/ anonymised data is unable to be accessed, corrected or withdrawn; and return of individual results will not be possible.

Future Research Using Your Information

If you agree, your fully anonymous / anonymised information may be used for future relevant research. This is optional and you could still participate in the present study if you do not agree.

This future research may be conducted overseas. You will not be told when future research is undertaken using your information. Your information may be shared widely with other researchers. Your information may also be added to information from other studies, to form much larger sets of data.

You will not get reports or other information about any future research that is done using your information.

Your information may be used indefinitely for future research unless you withdraw your consent. However, it may be extremely difficult or impossible to access your information, or withdraw consent for its use, once your information has been shared for future research.

Security and Storage of Your Information

Audio recording will be electronically transcribed. Your identifiable information, all audio recording, transcript and questionnaire responses will be stored in a secure drive and password-protected computer. Only the research team has access to your identifiable information and any identifiable information about you will be destroyed at the end of the study.

Risks

Although every effort will be made to protect your privacy, absolute confidentiality of your information cannot be guaranteed. Even with coded and anonymised information, there is no guarantee that you cannot be identified. The risk of people accessing and misusing your information (e.g. making it harder for you to get or keep a job or health insurance) is currently very small but may increase in the future as people find new ways of tracing information.

Rights to Access Your Information

You have the right to request access to your information held by the research team. You also have the right to request that any information you disagree with is corrected.

If you have any questions about the collection and use of information about you, you should ask the study researchers.

Rights to Withdraw Your Information

You may withdraw your consent for the collection and use of your information at any time, by informing the study researchers.

If you withdraw your consent, your study participation will end, and the study team will stop collecting information from you.

Information collected up until your withdrawal from the study will continue to be used and included in the study. This is to protect the quality of the study.

WHAT HAPPENS AFTER THE STUDY OR IF I CHANGE MY MIND?

Please inform the researcher if you wish to withdraw from the study. Information and data collected up until your withdrawal from the study will continue to be used and included in the study. This is to protect the quality of the study.

The data will be used for the purposes of this study, and fully anonymised, selected outcomes may be shared with other researchers on request for the purpose of accumulating data from individual studies. Only investigators and administrators of the study will have access to personal information, and this will be kept secure and strictly confidential. Participants will be identified only by a study identification number. Results of this project may be published or presented at conferences or seminars. No individuals will be able to be identified.

At the end of this study the list of participants and their study identification number will be disposed of. Any raw data on which the results of the project depend on will be retained in secure storage for 10 years, after which it will be destroyed.

CAN I FIND OUT THE RESULTS OF THE STUDY?

All participants will have access to a summary of the findings from the interview and questionnaire when the project is completed. However, findings of any future research conducted using fully anonymised data collected in this project will not be made available to participants.

WHO IS FUNDING THE STUDY?

The School of Sports, Exercise and Nutrition at Massey University, Albany is funding the study.

WHO HAS APPROVED THE STUDY?

“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 above are responsible for the ethical conduct of this research.

If you have any concerns about the conduct of this research that you wish to raise with someone other than the researcher(s), please contact Prof Craig Johnson, Director, Research Ethics, telephone 06 356 9099 x 85271, email humanethics@massey.ac.nz”.

WHO DO I CONTACT FOR MORE INFORMATION OR IF I HAVE CONCERNS?

If you have any questions, concerns or complaints about the study at any stage, you can contact:

Soh Bi Xue Patricia, MSc student and researcher
Email: patricia.soh.2@uni.massey.ac.nz

Associate Professor Cathryn Conlon
College of Health, Massey University
Email: C.Conlon@massey.ac.nz

Professor Pamela von Hurst
College of Health, Massey University
Email: P.R.vonHurst@massey.ac.nz

Appendix 6: Personalised Confirmation Letter (Example)

Dear (Participant name)

Thank you so much for your consent and confirmation.

Could I ask you to provide some possible dates and times next week to schedule our interview? I will send through the Zoom link when we confirm.

Prior to the interview, would you please be able to complete the pre-interview questionnaire? It takes roughly 10-15 minutes. The link and QR code is below. The first question will ask for your participant code which is **HP013**.

https://qfreeaccountssjc1.az1.qualtrics.com/jfe/form/SV_bj8ssbnYT5ctDM2



Appendix 7: Participant Consent Form

Exploring the concerns, attitudes and experiences of health professionals regarding a vegan diet during pregnancy and early life; a mixed-method study

Please indicate your consent to the following

	YES	NO
I have read and I understand the Participant Information Sheet.	<input type="checkbox"/>	<input type="checkbox"/>
I have been given sufficient time to consider whether or not to participate in this study.	<input type="checkbox"/>	<input type="checkbox"/>
I have had the opportunity to use a legal representative, whānau/ family support or a friend to help me ask questions and understand the study.	<input type="checkbox"/>	<input type="checkbox"/>
I am satisfied with the answers I have been given regarding the study and I have a copy of this consent form and information sheet.	<input type="checkbox"/>	<input type="checkbox"/>
I understand that taking part in this study is voluntary (my choice) and that I may withdraw from the study at any time.	<input type="checkbox"/>	<input type="checkbox"/>
I consent to the research staff collecting and processing my information.	<input type="checkbox"/>	<input type="checkbox"/>
I consent to the interview being sound recorded.	<input type="checkbox"/>	<input type="checkbox"/>
I wish to be given a copy of my recordings.	<input type="checkbox"/>	<input type="checkbox"/>
I agree to participate in this study under the conditions set out in the Information Sheet.	<input type="checkbox"/>	<input type="checkbox"/>
I consent to my fully anonymous / anonymised information being shared with other researchers on request for future research and the purpose of accumulating data from individual studies, and the results of future studies using my anonymous / anonymised information will not be made available to me.	<input type="checkbox"/>	<input type="checkbox"/>
If I decide to withdraw from the study, I agree that the information collected about me up to the point when I withdraw may continue to be processed.	<input type="checkbox"/>	<input type="checkbox"/>
I agree to an approved auditor appointed by the New Zealand Health and Disability Ethics Committees, or any relevant regulatory authority or their approved representative reviewing my relevant	<input type="checkbox"/>	<input type="checkbox"/>

medical records for the sole purpose of checking the accuracy of the information recorded for the study.

I understand that my participation in this study is confidential and that no material, which could identify me personally, will be used in any reports on this study.	<input type="checkbox"/>	<input type="checkbox"/>
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I know who to contact if I have any questions about the study in general.	<input type="checkbox"/>	<input type="checkbox"/>
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I understand my responsibilities as a study participant.	<input type="checkbox"/>	<input type="checkbox"/>
--	--------------------------	--------------------------

I wish to receive a summary of the results from the study.	<input type="checkbox"/>	<input type="checkbox"/>
--	--------------------------	--------------------------

Declaration by participant:

I hereby consent to take part in this study.

Participant's name: _____

Signature: _____ Date: _____

Declaration by member of research team:

I have given a verbal explanation of the research project to the participant and have answered the participant's questions about it.

I believe that the participant understands the study and has given informed consent to participate.

Researcher's name: _____

Signature: _____ Date: _____

Appendix 8: Professional Experiences of Health Professionals

Professional role	Work experiences	Experiences with restrictive diets
Dietitian 1	Gastrointestinal disorders Malnourishment Non-diet intervention for healthy eating behaviours	Low FODMAP
Dietitian 2	Involved with providing dietetic advice and education in paediatric cases and pregnancy	Allergy and intolerances which can sometimes lead to vegan diet adoption
Dietitian 3	Providing support with supplement and involved with nutritional status analysis	Elimination diet Tube-feeding
Paediatric dietitian	Experiences with children on vegan diets	Children and families on vegan, egg-free diets and multiple food restrictions due to allergies
Nutritionist	Experiences with mothers and their children considering the adoption of vegan diets	Mothers and families considering vegan diets, food intolerances, gluten-free and dairy-free diets
General Practitioner	Patients include young mothers with young children, women at reproductive age, couples looking to get pregnant and seeking advice	Allergy avoidance diets
Paediatric Registrar	Patients include children of all ages and their families, pregnant women Provide occasional nutritional advice when medically relevant	Children on plant-based beverages

Professional Experiences of health professionals [continued]

Professional role	Work experiences	Experiences with restrictive diets
Plunket Nurse	Babies and children	Dairy-free, gluten-free, egg-free diets
Tamariki Ora Nurse	Children under five, discuss developmental milestones and introducing solids	Vegetarian diets
Karitāne Nurse	Experiences with children from 6 weeks till 5 years old, under the Well Child Services Referred by nurses to provide support with sleep, development behaviour and nutrition	Children on milk protein intolerances and families with children on vegan diets
Plunket Nurse and Lactation Consultant	As a plunket nurse, discussion of development, nutrition, family health, social health, well-being, smoking cessation, sleep, maternal mental health, dental and nutrition; As a lactation consultant, help mothers who have trouble with lactation, pain, damage and supply issues and provide care for early infant, sleep, feeding and development	Dairy-free, soy-free, egg-free and other allergy (e.g. peanuts) avoidance diets
Midwife	Hospital midwife who cares for mothers postnatally.	Women who have hyperemesis and gestational diabetes, on vegetarian diets
Midwife	Midwife in private practice who cares for women of middle income background, throughout pregnancy, birth and postnatally	Vegan and vegetarian diets
Midwife	Provide care to women throughout pregnancy, birth and postnatally in the hospital and through the private practice	Vegan and vegetarian, dairy-free, gluten-free and diabetic diet

Appendix 9: Health Professionals' Remarks on Nutrients of Concern

Nutrient	Health professionals' remarks
<i>Protein</i>	<ol style="list-style-type: none"> 1. Sufficient plant-based protein can be obtained, such as soy-based protein including, beans, pulses, tofu and tempeh (HPs 2, 3, 4, 7, 8, 9) 2. Difficulty getting sufficient protein from plant foods (HP 6) 3. Unsure about amino-acid profile (HP 4) 4. Alternative plant-based beverages do not have sufficient protein apart from soy formula (HPs 6, 8, 9) 5. Protein for babies are mostly from milk (HP 6) 6. Unnecessary to have protein supplement for children with small appetites (HP 8) 7. Some restrictive diet (e.g. FODMAP) avoids plant-based protein (HP 1) 8. Inability to tolerate or digest plant-based proteins (HPs 7, 8) 9. Difficulty getting all essential amino acids – supplement may be essential (HP 1)
<i>Omega-three</i>	<ol style="list-style-type: none"> 1. Associated with fish consumption (HPs 4, 6) 2. Uncertain if there are sufficient plant-based alternatives (HP 4) 3. Should be supplemented in vegan diets (HPs 6, 8) 4. Removal of junk food may mean less need to supplement omega-three (HP 7) 5. Important for brain development (HP 12)
<i>Calcium</i>	<ol style="list-style-type: none"> 1. New Zealand main source of calcium is dairy products (HP 3) 2. Exclusion of dairy (HP 3) 3. Exclusion of fish with bones (HP 3) 4. Small quantity of calcium in vegetables and require large intake to meet daily requirement (HP 3) 5. Nausea in pregnancy limits food intake (HP 3) 6. Decision to provide calcium supplementation is complex such as overdosage (HP 3) 7. Calcium supplementation may be necessary if dairy is removed from diet (HP 13) 8. Difficulty in absorption of calcium through diet (HP 2) 9. Calcium intake of pregnancy is high to support usage by the foetus (HP 6) 10. Calcium intake is important for growing children (HPs 9, 12) 11. Concern if calcium in fortified foods are in absorbable or sufficient quantities (HPs 3, 7) 12. Calcium important for bone health (HPs 9, 13)
<i>Iron</i>	<ol style="list-style-type: none"> 1. Difficulty for infants to obtain iron in an unrestrictive diet, due to smaller appetite, let alone a vegan diet (HP 1) 2. Absence of heme iron in a vegan diet (HP 3) 3. Non-heme iron / iron from plant sources is insufficient / not as bioavailable and absorbable (HPs 2, 4, 5, 12) 4. Requirements for iron by the developing foetus in the final trimester of pregnancy is high (HPs 3, 12) 5. Blood loss during birth and association with low iron status is a concern (HPs 3, 14) 6. Fatigue during breastfeeding (HP 3) 7. Iron status in infants is a result of maternal iron intake and status (HPs 2, 7) 8. Comments on how iron absorption is increased with vitamin C (HPs 2, 4, 5, 14) 9. Importance of iron for energy and oxygenation in infant (HP 9) 10. Potential for iron to be low during pregnancy and breastfeeding, even if not on vegan diet (HPs 13, 14) 11. Checking of iron status during pregnancy, regardless of diet (HP 14) 12. Under two year olds may be particularly at risk of low iron (HP 13)
<i>Iodine</i>	<ol style="list-style-type: none"> 1. Insufficient iodine from seaweeds; not easily sourced and require supplementation (HPs 1, 2) 2. Iodine must be supplemented during pregnancy and breastfeeding (HPs 3, 4, 5, 6, 7, 8) 3. Perception that iodine can be obtained via dietary means such as iodised salt and seaweed (HP 7)
<i>Zinc</i>	<ol style="list-style-type: none"> 1. Food sources are mostly from dairy and meat (HP 8)
<i>Vitamin A</i>	<ol style="list-style-type: none"> 1. Due to an increasingly restrictive diet which spirals due to lack of knowledge (HP 3) 2. If body is able to convert vitamin A to usable forms such as retinol (HP 7)
<i>Vitamin B12</i>	<ol style="list-style-type: none"> 1. Inability to obtain sufficient amount from plant sources (HPs 1, 4, 5, 14) 2. Some foods like algae and nutritional yeast have B12 but unlikely to consume these foods in large quantities and is inadequate (HPs 3, 5, 9, 12) 3. Myths on mushrooms and spirulina having B12 and is not supported by evidence (HP 8) 4. Algae is not popular or common food source in New Zealand food culture (HP 3) 5. Importance of supplementation (HPs 1, 4, 5, 8, 12) 6. Mainly found in dairy products and eggs and difficult to obtain in a vegan diet (HP 4) 7. Status needs to be consistently monitored as levels can deplete over a prolonged time (HP 6) 8. B12 is more important for a growing baby and is essential for nervous system development (HP 12) 9. Potential for B12 to be checked even if not on a vegan diet (HP 13)
<i>Vitamin D</i>	<ol style="list-style-type: none"> 1. Different forms available; only from animal products (HP 5) 2. Attainment from food sources is not as applicable in New Zealand and prescription may only be required for at-risk individuals or during winter months (HP 2) 3. Formula for infants should have vitamin D fortification (HP 8) 4. Supplementation required for vegan mothers (HP 8)