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Dietary intake and adherence to dietary guidelines and nutrient recommendations among New Zealand pregnant women

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Abstract

National dietary guidelines are created to support maternal and fetal health during pregnancy, when nutrient requirements increase for both the mother and the baby. This study aimed to assess the adherence to the 2020 New Zealand Eating and Activity Guidelines (EAG) for pregnant women and selected Nutrient Reference Values (NRVs) for Australia and New Zealand across pregnancy. This study is a secondary analysis of data from the Koru Study, a longitudinal observational study conducted in New Zealand between 2019 and 2022. Healthy pregnant women aged 18–45 years (n = 23) with naturally conceived singleton pregnancies were recruited for this study. Participants completed a 4-day diet diary at up to 3 time points (trimesters 1, 2, and 3) to estimate daily food group servings and nutrient intakes. The current study found that the overall adherence to food group recommendations was low. More than half of participants (52%) met only one to two food group recommendations, while 45% met none; no participant met all five food group guidelines. Adherence was lowest for grain foods and fruit, with fewer than 10% meeting recommendations. Vegetable intake was suboptimal, with fewer than 1 in 5 participants meeting the guideline. Adherence to milk and milk products was the highest among food groups, although fewer than one in five women met the recommended Intake. Protein-rich food recommendations were met by 16.7% of participants. The macronutrient distribution showed high adherence to the Acceptable Macronutrient Distribution Range (AMDR) for protein (73.8%. Moderate adherence was seen for carbohydrate (50%), and very low adherence for total fat (4.8%) and saturated fat (14.3%). Adequate fibre intake was achieved by 40.5% of participants. The mean protein intake exceeded the EAR of 49 g/day across all trimesters, with mean intake of 89.5 g/day in Trimester 1, 92.5 g/day in Trimester 2, and 78.8 g/day in Trimester 3, suggesting that most women were likely to have met the protein requirement. The majority of participants did not meet the EAR for iodine (76.2%) or iron (90.5%), or the Adequate Intake for vitamin D (73.8%) or folate (59.5%). Vitamin C showed the highest overall adherence (88.1%). Significant positive correlations were observed between milk and milk product intake and calcium intake ($\rho = 0.683$, $p < 0.001$). There was a positive association found between fruit intake and fibre intake ($\rho = 0.402$, $p = 0.008$) and vitamin C intake ($\rho = 0.351$, $p = 0.022$). Vegetable intake is positively associated with fibre intake ($\rho = 0.535$, $p = <0.001$), folate intake ($\rho = 0.44$, $p = 0.004$), iron intake ($\rho = 0.392$, $p = 0.010$), and iodine intake ($\rho = 0.327$, $p = 0.035$). Protein-rich food intake was positively associated with total protein intake ($\rho = 0.593$, $p = <0.001$), selenium intake ($\rho = 0.354$, $p = 0.021$), and iodine ($\rho = 0.369$, $p = 0.016$). In this current study, the adherence to food group recommendations during pregnancy was suboptimal, with multiple micronutrient inadequacies.

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List of Abbreviations

AI	Adequate intake
AMDR	Acceptable Macronutrient Distribution Range
AGHE	Australian Guide to Healthy Eating
ADG	Australian Dietary Guidelines
DQI	Diet Quality Index for Pregnancy
EAG	Eating and Activity Guidelines for New Zealand Adults
EAR	Estimated Average Requirement
FFQ	Food frequency questionnaire
GERD	Gastroesophageal reflux disease
GUiNZ	The Growing up in New Zealand Study
KJ	Kilojoules
MoH	Ministry of Health
MATO-2	Māori and Pacific Maternal and Child Health
NAHANES	National Health and Nutrition Examination Survey
NRV	Nutrient Reference Values
RDI	Recommended Dietary Intake
SD	Standard Deviation
UL	Upper Limit
4DDD	4 Day-Diet-Diary

1 Introduction

1.1 Background:

Adequate nutrient intake during pregnancy contributes to optimal fetal growth, placental function, and long-term child development. Conversely, insufficient intake of macro- and micronutrients during pregnancy can have significant short- and long-term health implications, as well as adverse pregnancy outcomes (1-5). Pregnancy outcomes, such as gestational age at birth, low birthweight, fetal growth restriction, and the risk of congenital disabilities, are linked to maternal nutrition (4-6). Reduced bone mass in infants born to mothers who did not receive appropriate nutrition during pregnancy has been associated with a risk of fractures later in life, as well (7-9). Additionally, a mother's diet shapes her child's early food preferences, which can have a long-lasting impact on the child's eating patterns later in life (7).

A woman's nutritional intake during pregnancy also has an important implication for her own health. These can include the risk of gestational diabetes, gestational hypertension, and (10). Other factors, such as gestational weight gain and postpartum retained weight, are also strongly associated with women's nutritional status (11).

Adequate intake of macronutrients and micronutrients is essential to meet the physiological demands of pregnancy. Carbohydrate provides the primary source of energy for both the mother and the infant, while protein supports tissue growth and repair (9). Insufficient protein intake in late pregnancy has been linked to reduced placental and fetal growth (12). Insulin resistance is also observed in women with high-fat diets. A diet high in added sugars and saturated fat has been linked to gestational diabetes mellitus and hypertensive disorders of pregnancy (13-15). In contrast, adherence to healthy dietary patterns characterised by higher fruit, vegetable, and whole-grain consumption has been shown to improve metabolic outcomes and reduce the risk of gestational hypertension and excessive gestational weight gain (16).

Micronutrients are equally critical; globally, pregnant women are at risk of inadequate intake or deficiency of nutrients such as folate, iodine, iron, calcium, vitamin C, zinc, selenium, and Vitamin D (17-24).

Folate is important for fetal growth and development, particularly for DNA synthesis and cell division during pregnancy. Folate Deficiency during pregnancy can lead to megaloblastic anaemia in the mother and severe congenital abnormalities in the fetus (25, 26). Neural tube

defects are one of the most well-established consequences of inadequate folate intake. Evidence from an American cohort study also found that women with low dietary folate intake, defined as less than 240 micrograms per day, had approximately twice the risk of preterm delivery and delivering a low birthweight infant, even after adjusting for maternal characteristics, energy intake, and other nutrients. Lower serum folate concentrations at 28 weeks' gestation were similarly associated with an increased risk of preterm birth and low birthweight (26).

Iodine is essential for maintaining normal maternal thyroid hormone production and for supplying these hormones to the infant, particularly during the first trimester, when the fetal thyroid gland is not yet fully functional (27). Iodine requirements increase during pregnancy due to greater renal clearance, making pregnant and breastfeeding women especially vulnerable to iodine deficiency (27, 28). This mineral is critical for fetal neurological development, including neuron migration and brain myelination. When intake is insufficient, maternal hypothyroxinaemia can occur, increasing the risk of irreversible damage to the developing fetal brain(28). During pregnancy, an iodine-deficient diet can impair fetal thyroid hormone production and disrupt brain development, potentially leading to long-term cognitive impairment, hypotonia, and, in severe cases, intellectual disability (29). A New Zealand study of pregnant and non-pregnant women found that about 55% of daily urinary excretions were less than 50 µg/d, indicating moderate I deficiency. The median iodine concentrations were 38 and 33 mg/L in pregnant and non-pregnant women, respectively (30). A more recent study in New Zealand examined iodine status in 170 women living across the country and found that the median urinary iodine concentration (UIC) was 38 µg/L, which is below the adequate iodine status range of 150-249 µg/L during pregnancy. The study also found that only two women had a UIC > 150 µg/L (31).

Iron is a key mineral required for oxygen transport. It also functions as a cofactor for several enzymes involved in lipid metabolism. Iron also contributes to the proper functioning of the immune system(32, 33). Evidence shows that iron deficiency during pregnancy can lead to neuronal alterations in the infant, with effects that may persist into adulthood even when supplementation is provided later. These neurological impairments tend to occur early in life because the developing brain has a high demand for iron, as do other rapidly developing organs such as the liver (34).

Calcium is crucial for bone growth and maintenance and is a key marker of maternal and fetal bone health. Inadequate calcium intake during pregnancy can impair fetal skeletal development,

restrict intrauterine growth, and contribute to low birth weight. Long-term consequences of calcium deficiency have also been linked to adverse physical and cognitive outcomes, including an increased risk of bone weakness later in life (35). Furthermore, adequate calcium intake has been associated with a decreased risk of hypertensive disorders in pregnancy, particularly pre-eclampsia(10, 36). Pre-eclampsia is a serious condition that can lead to miscarriage, medically induced preterm birth, and increased risk of newborn morbidity and mortality (37).

Vitamin C is a water-soluble vitamin that functions as an electron donor in several metabolic and antioxidant reactions. Its role in preventing oxidative stress is particularly relevant during pregnancy (38). Animal studies have shown that vitamin C deficiency before and after birth can result in long-lasting reductions in hippocampal volume, suggesting potential impacts on cognitive development. In humans, vitamin C deficiency has been observed in women with preeclampsia, and this condition has been associated with poorer cognitive performance in their children compared with those born from healthy pregnancies(39-42). A double-blind study comparing high-risk pregnant women supplemented with vitamin C and vitamin E to 2 matching placebos found that supplementation improved biochemical markers of oxidative stress, indicating a potential protective effect against the development of preeclampsia (43).

Zinc is an essential trace mineral, with most of the body's zinc stored in the bones and skeletal muscles. Zinc plays a key role in cellular growth, immune function, and tissue integrity (44). Zinc deficiency in early life is associated with reduced barrier function of the skin and mucous membranes, which can impair immune responses and increase susceptibility to infections of the skin, lungs, and gastrointestinal tract (44, 45). More broadly, zinc deficiency is linked to increased morbidity and mortality at birth, greater severity of infectious diseases, impaired growth, and several physiological disturbances such as anorexia, hypogonadism, reduced taste sensation, dermatitis, and neuropsychological impairment(46). Deficiency has also been associated with diarrhoea and increased risk of fever and convulsions in infants. During pregnancy, inadequate zinc intake has also been associated with adverse outcomes, such as low birthweight and hypertensive disorders of pregnancy (47).

Selenium is an essential micronutrient with important antioxidant functions and roles in immune regulation, growth, and development. It also contributes to the prevention of chronic diseases, such as cardiovascular disease and certain cancers (48, 49). Low selenium concentrations in newborns, particularly in premature infants, increase vulnerability to oxidative stress, which is

associated with a higher risk of conditions such as retinopathy, bronchopulmonary dysplasia, and other respiratory disorders(50). Adequate selenium intake during pregnancy is crucial because deficiency has been linked to complications that affect both maternal and fetal health. These include an increased risk of pre-eclampsia, impaired glucose tolerance, altered lipid profiles, and potential delays in mental and psychomotor development (51, 52).

Vitamin D is a fat-soluble vitamin. Vitamin D plays an important role in regulating calcium and promoting bone metabolism in both children and adults (53). Adequate maternal vitamin D status is crucial during pregnancy, as deficiency has been associated with several adverse outcomes. These include preeclampsia, low birthweight, neonatal hypocalcaemia, impaired postnatal growth, and increased bone fragility(53, 54). Low vitamin D levels in early life have also been linked to a higher risk of autoimmune diseases, underscoring the importance of maintaining sufficient vitamin D levels throughout pregnancy and infancy (53, 55).

In New Zealand, two key sets of nutrition recommendations guide optimal dietary intake: the Eating and Activity Guidelines (EAGs)(57) and the Nutrient Reference Values (NRVs) (58). The NRVs, developed in collaboration with Australia, specifically recommend nutrient intakes for maintaining health and preventing nutrient deficiencies (58). These are aimed at health professionals and scientists. The EAGs are food-based dietary guidelines that provide evidence-based recommendations to support healthy eating and active living among New Zealanders. These public guidelines aim to promote overall health and reduce the risk of developing non-communicable diseases (56, 57).

Table 1 Recommended Daily Servings and Standard Serving Size Examples for Key Food Groups for Pregnant Women, as defined in the Ministry of Health, 2020.

Food Groups	Serving Size	A standard serving example
Vegetables	5 serving	75 g or 1 medium tomato, ½ cup cooked vegetables (e.g., carrot, broccoli, bok choy, taro leaves), ½ cup canned vegetables (e.g., beetroot, sweet corn), 1 cup green leafy vegetables or raw salad vegetables, ½ medium potato or similar-sized kumara

Fruit	2 serving	150 g or 1 medium apple, banana, orange, or pear, 2 small apricots, kiwifruit, or plums, 1 cup frozen fruit, e.g., mango, berries, 1 cup diced or canned fruit (drained and with no added sugar)
Grains-rich foods	8.5 serving	120 g cooked porridge, 40 g wholegrain bread, 75–120g cooked rice, pasta, ¼ cup (30 g) muesli or 1 slice (40 g) wholegrain bread
Protein-rich foods	3.5 serving	150g cooked or canned lentils, 30 g nuts, seeds, 170 g tofu, 100 g cooked fish fillet, 2 large eggs, 80 g cooked lean chicken, 65 g beef, lamb, pork, veal
Milk and milk products	2.5 serving	250ml milk, 40g of cheese, 200g yoghurt

Table 1 Outlines recommended serving sizes for various food groups and examples of what constitutes a standard serving. The categories covered are vegetables, fruit, grains, legumes/nuts/seeds/protein-rich foods, and dairy products, focusing on their energy content measured in kilojoules (kJ) (57).

The 2020 EAGs emphasise a balanced diet through five key food groups: vegetables, fruits, grain foods, milk and milk products, and protein-rich foods such as legumes, nuts, seeds, fish, eggs, poultry, or lean meat with fats removed. (56, 57). Meeting these food group recommendations helps ensure individuals meet their nutrient requirements and maintain optimal health. However, few studies have examined how well pregnant women in New Zealand adhere to these updated guidelines, yet these have limitations. The Growing up in New Zealand (GUiNZ) birth cohort study, which recruited pregnant women in 2010, found that only 27% of pregnant women consumed four or more servings of vegetables daily, and just 25% met the recommended intake of six or more servings of fruits and vegetables at the time, defined as at least four servings of vegetables and two servings of fruit per day. This recommendation differs slightly from the current Ministry of Health (2020) guidelines presented in Table 1, which specify updated daily serving targets and standard serving size definitions. Adherence to dairy and protein-rich foods was also below recommended levels. On average, 58% consumed three servings of milk or milk products daily, while women from Pacific and Asian backgrounds were less likely to drink the recommended amount of dairy. Only one in five pregnant women met the recommendation of at least 2 servings

of lean meat, meat substitutes, or eggs. (59). This data is now 15 years old, but more importantly, the dietary recommendations were updated in 2020.

The 2020 EAGs introduced important updates compared to the 2015 version. This includes increased recommendations for vegetable intake (from 3 to 5 servings per day) and more specific serving guidance for different age and gender groups. However, there is limited evidence on how well pregnant women in New Zealand adhere to these updated recommendations. Therefore, it is important to investigate dietary adherence to the updated EAGs and NRVs to understand current maternal nutrition and identify potential areas for improvement to support optimal pregnancy outcomes.

Despite the well-established importance of maternal nutrition, there is limited data on how well pregnant women in New Zealand adhere to the current national dietary guidelines and recommended nutrient intakes. This lack of up-to-date evidence creates a gap in understanding the dietary adequacy of pregnant women in New Zealand, limiting the ability to develop effective antenatal nutrition strategies.

1.2 Purpose of the study

This study aims to examine the adherence to the updated 2020 Eating and Activity Guidelines and the nutrient recommendations from the 2006 New Zealand/Australia Nutrient Reference Values (NRVs) among 23 pregnant women. The findings of this study will provide valuable insights to inform future dietary interventions and policy initiatives to improve maternal nutrition, ultimately benefiting maternal and infant health outcomes in New Zealand. The findings will also provide insight into NZ women's current dietary habits and whether they are adhering to the updated guidelines.

1.3 Aim:

To investigate dietary intake and adherence to the updated 2020 Eating and Activity Guidelines for New Zealand Adults (EAG) among pregnant women, and to examine how these intakes align with selected nutrient recommendations from the 2006 New Zealand/Australia Nutrient Reference Values (NRVs).

1.3.1 Objectives:

- To determine the dietary intake of pregnant women and assess their adherence to the food group recommendations of the Eating and Activity Guidelines for New Zealand Adults (EAGs).
- To investigate the intakes of macronutrients (carbohydrate, fibre, protein, and fat) and some micronutrients (vitamin C, calcium, folate, Iron, Vitamin D, Zinc, Selenium, and Iodine) compared to the New Zealand/Australia Nutrient Reference Values (NRVs)
- To investigate how the intake of food groups (Fruits, Vegetables, Grains, protein-rich foods, Milk, and Milk products) contributes to the intakes of macro and micronutrients.

1.3.2 Hypothesis:

We hypothesise that pregnant women in New Zealand do not fully adhere to the national dietary and nutrient guidelines set out in the EAGs and NRVs, with significant variation in dietary intake across food groups, particularly vegetables, fruits, dairy, and protein-rich foods. We hypothesise that pregnant women who adhere more closely to the Eating and Activity Guidelines will be more likely to meet the Nutrient Reference Values. We further hypothesise that adherence to food group recommendations is associated with adherence to corresponding nutrient recommendations. For example, participants who meet the recommended servings of fruits and vegetables are more likely to achieve the dietary fibre requirement.

1.3.2 Thesis Structure:

This thesis is organised into four chapters. Chapter one provides an overview of the study, outlining the background, purpose, aims, objectives, and hypothesis. Chapter two presents a narrative view of the existing literature, examining the importance of key nutrients during pregnancy and summarising international research on adherence to food-based dietary guidelines. Chapter three, structured in manuscript format, details the study's methodology, results, and discussion. Finally, Chapter Four summarises the main findings and offers a conclusion and recommendations.

1.4 Researcher contributions

Research topic and study design	A/Prof Louise Brough Dr Janet Weber

Data collection and entry	Ciara Funnel, Katrina Bewley
Data handling: Checking all diet diaries entered to FoodWorks to ensure accuracy and consistency, food group coding, data entry, statistical analysis, and interpretation Research tasks: Literature synthesis, methodological justification, results interpretation, and preparation of tables/figures Thesis writing: Drafting all chapters, formatting, referencing, and integrating supervisor feedback	Kiristika Piratheepan
Thesis writing	Kiristika Piratheepan
Reviewing and Editing	A/Prof Louise Brough

2 Literature review

2.1 Outline

The New Zealand Ministry of Health uses two main nutrition frameworks: the Eating and Activity Guidelines for New Zealand Adults (EAGs) (57) and the Australia and New Zealand Nutrient Reference Values (NRVs) (60). Both sets of recommendations are informed by current scientific evidence and tailored according to sex, age, and life stage (61). The EAGs provide food-based guidance that reflects the New Zealand context, including local lifestyles and cultural eating patterns. In contrast, the NRVs specify recommended intake levels for individual nutrients and are based on established scientific evidence (60).

2.2 Eating and Activity Guidelines for New Zealand Adults

In New Zealand, national dietary guidance is provided by the Ministry of Health's *Eating and Activity Guidelines for New Zealand Adults* (EAGs) (57). These guidelines provide food-based and activity-based recommendations for adults aged 19–64 years, informed by comprehensive international evidence reviews, major reports, expert consensus, and the Australian diet guidelines (60). The development process of the guidelines involved consultation with the Eating and Activity Guidelines Technical Advisory Group, which includes experts in nutrition and physical activity, and the Māori and Pacific Maternal and Child Health (MATO-2) advisory group, which brings additional expertise in maternal and infant nutrition. This was intended to ensure that the guidelines are scientifically robust, relevant, and aligned with national public health guidelines. However, like most guidelines from high-income countries, they are primarily derived from evidence in general adult populations and may not fully account for the specific physiological and social contexts of pregnancy (57).

An update to the EAGs was released in December 2020. The update introduced specific recommendations for pregnant and breastfeeding women while leaving the core adult statements unchanged (57). This update replaced the previous *Food and Nutrition Guidelines for Healthy Pregnant and Breastfeeding Women*. It places renewed emphasis on a nutrient-dense dietary pattern, appropriate gestational weight gain, and increased requirements for key micronutrients, such as folic acid and iodine. The update also highlights the importance of food safety during pregnancy, given the increased susceptibility to foodborne illnesses. It also

underscored the need for environments that support breastfeeding women in maintaining adequate dietary intake and overall well-being (62). Although this update represents a step towards more targeted guidance, it remains food-based and does not fully address factors such as food insecurity, cost, or access to cultural foods, all of which can constrain one's ability to follow these recommendations. Within the updated framework, pregnancy-specific serving recommendations are provided for key food groups (57).

2.3 Nutrient Reference Values

The present thesis also draws on the Australia and New Zealand Nutrient Reference Values (NRVs), which remain the primary framework for assessing nutrient adequacy in New Zealand (60). The NRVs define reference intake values for essential nutrients that are considered sufficient to meet the known nutritional requirements of almost all healthy individuals, while also indicating levels at which excessive intake may pose a risk of adverse effects (60).

The NRVs include several key reference values. The Estimated Average Requirement (EAR) represents the daily nutrient intake estimated to meet the requirements of 50% of healthy individuals within a specific life stage and sex group (60). The Recommended Dietary Intake (RDI) is the average daily intake level needed to meet the nutrient requirements of 97–98% healthy individuals in a particular population group (60). When insufficient evidence exists to establish an RDI, an Adequate Intake (AI) is set; this reflects the average daily intake level based on observed or experimentally determined estimates assumed to be adequate for a group of healthy individuals (60). The Upper Level of Intake (UL) refers to the highest average daily nutrient intake unlikely to pose adverse health effects for almost all individuals, with the risk of harm increasing as intake exceeds this level (60).

Importantly, NRV values are life-stage specific, with higher requirements set for pregnant women to reflect the increased physiological demands of pregnancy (60). Pregnancy substantially increases the need for several micronutrients, including folate, iron, iodine, calcium, vitamin D, and others, which are critical for maternal health and fetal development. Accordingly, this study aims to assess whether pregnant women are meeting the NRV reference values established for pregnancy (60).

Together, the Eating and Activity Guidelines and the NRVs aim to promote balanced dietary patterns and ensure that women meet adequate nutrient intakes during pregnancy. It is assumed that adherence to food-based dietary guidelines should support the achievement of nutrient

reference values. However, meeting recommended food group servings does not necessarily guarantee that physiological requirements for individual nutrients are met. Therefore, this study investigates both adherence to food group recommendations and compliance with NRV benchmarks to examine the extent to which these frameworks align in practice among pregnant women.

2.4 Dietary intake in pregnant women and adherence to dietary guidelines

Pregnant women are often advised to follow a balanced diet that provides the nutrients needed to support maternal health and fetal development. However, national and international evidence shows that dietary intake during pregnancy falls short of recommendations, leading to micronutrient deficiencies and poor adherence to food groups. Commonly reported inadequacies during pregnancy are iron, iodine, folate, calcium, and vitamin D. These nutrients are critical for fetal growth, neurodevelopment, and the prevention of negative pregnancy outcomes. Despite differences in dietary guidelines across countries, a consistent pattern emerges. Most pregnant women do not meet the recommended intakes for food groups, and many fail to meet their micronutrient requirements.

A large longitudinal Australian study by Blumfield et al. (2011) examined adherence to national food group recommendations and nutrient adequacy among women aged 25–30 years who were pregnant, trying to conceive, or recently postpartum (63). Using cross-sectional dietary data collected within the Australian Longitudinal Study on Women's Health (ALSWH), the study found that no women met all the recommendations of the Australian Guide to Healthy Eating (AGHE). The highest adherence was observed for meat (85%), followed by fruit (44%) and dairy (35%), while less than 14% of the participants met the recommendations for the remaining food groups. Pregnant women in the study reported significantly higher median daily intakes of both fruit (308 g/day vs 248 g/day) and dairy foods (407 g/day vs 360 g/day) compared to other women. This difference corresponds to approximately an additional half serving of fruit and one-third of a serving of dairy per day. Despite this higher intake, 82% of pregnant women still failed to meet the AGHE fruit recommendations for pregnancy (63).

Importantly, the study identified two dietary profiles among participants who met selected NRVs (EARs for folate, iron, calcium, zinc, and AI for fibre). The *High-Extras Diet* met micronutrient targets but consumed excessive non-core "extra" foods (5.9–7.1 servings/day). This resulted in

high energy and saturated fat intake. The *Optimal Diet* met NRVs with lower discretionary food intake and balanced macronutrients, but no pregnant women fell into this category. This study's findings suggest that achieving micronutrient adequacy often occurs alongside high consumption of energy-dense foods (63). A limitation of the Blumfield study is its reliance on a food frequency questionnaire (FFQ), which may overestimate the consumption of socially desirable foods and underestimate the consumption of discretionary foods. Additionally, AGHE recommendations differ from New Zealand's EAGs, and data were collected in 2003, which may limit their relevance to contemporary diets.

A more recent Australian study by Malek et al. (2013) examined adherence to the Australian Dietary Guidelines (ADG) during pregnancy among 857 pregnant women aged 18–49 years. The study used a cross-sectional food frequency questionnaire at 13–34 weeks of gestation. Recruitment for the study was conducted through a South Australian cohort, in which members of the research team approached women attending routine antenatal appointments at the Women's and Children's Hospital in Adelaide. Some women were recruited via word of mouth, and study posters were displayed within the hospital. The study aimed to improve understanding of dietary behaviours in pregnancy by assessing adherence to the ADG Five Food Group recommendations and identifying predictors of adherence (64).

The study found that 63% of women made changes to their usual pre-pregnancy diet specifically because they were pregnant. Among those who made the changes, over half (55%) reported doing so immediately after confirming their pregnancy. Among women who did not make any dietary changes, the most common reason was the belief that their existing diet was already healthy and balanced (61%). Additionally, 33% of women felt that no changes were necessary, while smaller proportions reported that dietary changes were too difficult (8%) or that they did not know what changes were required (7%). As pregnancy progressed, half of the women reported becoming more concerned about healthy eating, 41% reported no change in concern, and 9% reported being less concerned (64).

The study also found that adherence to the Australian Dietary Guidelines was generally low. Among the Five Food Groups, the highest adherence was observed for fruit and dairy, with 56% and 29% of women meeting the minimum recommended serving amounts during pregnancy, respectively. Fewer than 10% of women met the recommendations for any of the remaining food groups. Overall, 37% did not meet any of the Five Food Group recommendations, 35% met one,

21% met two, 6% met three, and only 1% met four; no women met all five recommendations. Food choices provided further insight into dietary behaviours in the study(64). Among the women who consumed bread, 70% typically selected high-fibre varieties such as wholemeal, wholegrain, multigrain, or rye, compared with 30% who chose white bread. Approximately half of the women who consumed milk and yoghurt selected reduced-fat options (51% and 49%, respectively), whereas only one-third chose reduced-fat cheese (33%). Similar patterns were seen across cohorts (64).

This study provided valuable insight into behavioural motivations for dietary change in women. However, its reliance on self-reported online data may have introduced selection bias, favouring more educated or health-conscious participants. Its findings, however, align closely with those of Blumfield et al., further reinforcing the pattern of poor adherence to dietary guidelines for pregnancy in Australia (63).

New Zealand evidence is more limited, but the Growing Up in New Zealand (GUiNZ) cohort provides the most comprehensive assessment to date. Morton et al. (2014) examined adherence to national nutritional guidelines during pregnancy using data from Growing Up in New Zealand, the country's contemporary pre-birth cohort study (59). The cohort was designed to be generalisable to all current New Zealand births. Pregnant women were eligible to participate if they had an estimated delivery date between 25 April 2009 and 25 March 2010 and lived in the Auckland, Counties Manukau, or Waikato District Health Board regions, where approximately one-third of the national population lives. No additional exclusion criteria were applied. A total of 6,822 women consented and completed the antenatal interview. Of the 5,664 respondents included in the dietary analysis, expected due date information was available for 5,584 women, with a mean gestational age at the time of the interview of 31 weeks. Most participants were interviewed during the third trimester, and the cohort was born between March 2009 and May 2010. The median age was 31 years (range 15–47 years(59). Dietary intake was assessed using a semi-quantitative, 44-item food frequency questionnaire (FFQ) administered via face-to-face computer-assisted interview. The study aimed to describe overall dietary intake relative to New Zealand's recommended food and nutrition guidelines (57) and to identify maternal characteristics associated with adherence during pregnancy.

The study found that the overall adherence to recommended serving sizes was low among the women. Only 25% of women met the combined vegetable and fruit recommendation (≥6

servings/day), and just 27% met the vegetable recommendation. Adherence to other food groups was similar: 26% met the bread and cereals recommendation, 58% met the milk and milk products recommendation, and 21% met the lean meats or eggs recommendation. Nearly a quarter (24%) met none of the serving recommendations, and only 3% met all four (59). The study also identified significant sociodemographic predictors of adherence. Older maternal age (30–39 years) was the strongest independent predictor of meeting the vegetable and fruit guidelines, whereas adherence to breads and cereals, as well as meat and eggs,/eggs varied by ethnicity, income, education, and parity. The study also found that Māori and Pacific women showed higher adherence to protein and grain-rich foods and a lower adherence to milk and milk products. (59).

Although GUiNZ provides robust population-level data, its assessment tool is a short, semi-quantitative 44-item FFQ, which limits the precision of nutrient-level estimations and may underestimate intakes of certain foods. Importantly, the study assessed adherence to older Food and Nutrition Guidelines rather than the updated 2020 pregnancy-specific EAG recommendations used in the present thesis (65).

While FFQs are useful in large populations due to their lower participant burden and cost-effectiveness, they rely on self-report and memory, making them susceptible to recall bias, social desirability bias, and misreporting, particularly for foods perceived as "healthy" such as fruits and vegetables (66). In contrast, food diaries provide more detailed, real-time data that capture actual intake over a defined period, allowing more accurate estimation of portion sizes, food types, and nutrient intake. This makes them valuable in smaller-scale studies that require precision. However, food diaries are time-intensive and place a higher cognitive and practical burden on participants. Given that the participants in this study are pregnant women, this burden may be especially pronounced, driven by fatigue, nausea and time constraints, potentially reducing compliance and data quality. Therefore, while FFQs are appropriate for assessing population-level dietary patterns and general adherence to guidelines in large cohort studies, food diaries may provide more precise but less feasible measures of intake in this population. These methodological differences should be considered when interpreting findings, as FFQs may overestimate usual intake compared to more detailed dietary assessment methods, potentially contributing to discrepancies in reported adherence to fruit and vegetable intake recommendations (66-68).

Similar suboptimal dietary patterns observed in Australia and New Zealand are also evident in other Western countries. A cross-sectional analysis of 1,003 healthy pregnant women aged 20-40 years from the 2001-2014 National Health and Nutrition Examination Survey (NAHANES) in the United States examined the usual nutrient intake from both foods and dietary supplements, using 24-hour dietary recalls to assess adherence to the Dietary Reference Intake (DRI) set by the National Academies of Science, Engineering, and Medicine (56). Despite supplement use (approximately 70% of participants), a significant proportion of women failed to meet the Estimated Average Requirement (EARs) for multiple essential nutrients. In particular, over one-third of participants had inadequate intakes of magnesium (47.5%), vitamin D (46.4%), vitamin E (43.3%), and iron (36.2%), while others fell short in meeting the requirement for vitamin A, folate, calcium, vitamin C, vitamin B6, and Zinc(56). Likewise, a Norwegian study investigating dietary intake among 1,674 pregnant women from the mother-childbirth cohort found low adherence to national dietary guidelines. In this study, 54.4% of women had inadequate folate intake, 49.6% for iron, 36.2% for calcium, 28.7% for vitamin D, 24.4% for iodine, and 41.3% for selenium. Saturated fat intake was excessive, and micronutrient intake was insufficient. Together with micronutrient insufficiency, it could increase the risk of adverse pregnancy and birth outcomes. Consistent with findings from an Australian study (10), this study also observed that women with higher levels of education were more likely to engage in healthier behaviours overall. However, they also reported a higher consumption of alcohol and coffee compared to women with lower educational levels (69)

A Canadian study using data from the Alberta Pregnancy Outcomes and Nutrition (APrON) prospective cohort examined dietary adherence to Canada's Food Guide (CFG) among 1,630 pregnant women aged ≥16 years with singleton pregnancies and complete dietary data. demographic and pre-pregnancy weight data (70). Most participants were highly educated (71% had a university-level education), married or living together (96%), and had an annual household income of over $100,000 (58%). Dietary intake was assessed using a 24-hour recall, and adherence to CFG was measured by evaluating the number of servings of key food groups, including fruits and vegetables (with separate attention to green and orange vegetables), grains (including whole grains), dairy (including reduced-fat milk), and meat and alternatives. Each woman received a score from 0 to 9 based on the number of daily recommendations met, including an additional score for meeting pregnancy-specific recommendations for increased servings. The average CFG adherence score was low (mean 3.2 ± 1.6), indicating that most participants did not meet the national dietary guidelines during pregnancy. Women with a normal

pre-pregnancy BMI had slightly higher scores than those who were underweight, overweight, or obese. Notably, women with obesity had the lowest adherence scores. It was also reported that a lower proportion of overweight or obese women met the recommendation of consuming 7-8 servings of fruit and vegetables per day than those who were underweight or of normal weight (41% and 47% vs 50% and 54%, respectively). Higher CFG adherence scores were also associated with higher levels of education and household income (70).

Overall, the study highlights the complexity of nutrient intake during pregnancy, as many women simultaneously experience both underconsumption and overconsumption. Most individuals exceeded the sodium recommendation and had insufficient intake of essential nutrients, including vitamin D, magnesium, vitamin E, and iron, even when taking supplements (56). This shows the need for more refined dietary guidance to help pregnant women achieve nutrient targets for optimal maternal and fetal outcomes.

Across Australia, New Zealand, and other Western countries, evidence consistently shows that pregnant women struggle to meet national dietary guidelines for both food groups and nutrients. Even when some micronutrient requirements are met, this often occurs alongside excessive intake of saturated fat and energy, as shown in the Australian High-Extras dietary pattern. Moreover, the widespread use of supplements does not make up for poor dietary patterns, nor has it prevented underconsumption, and could lead to overconsumption of key nutrients.

Critically, the reviewed studies rely heavily on self-reported dietary tools, primarily FFQs and 24-hour recalls, which are prone to recall bias, social desirability bias, and misestimation of discretionary foods. Most are cross-sectional, which limits conclusions about changes across pregnancy and causal interpretations. Additionally, there is limited evaluation of adherence relative to the updated 2020 EAG recommendations, and no NZ studies have jointly assessed food group adherence and NRV alignment in pregnancy.

These gaps highlight the need for contemporary, methodologically robust research on dietary intake among pregnant women that uses updated national guidelines and nutrient reference standards.

2.5 Factors influencing dietary intake and adherence

A woman's dietary intake during pregnancy can be influenced by her socioeconomic status, education, cultural beliefs, psychological well-being, physical symptoms during pregnancy, trimesters of pregnancy, and environmental factors. Understanding these factors is essential for interpreting dietary patterns in pregnancy, adherence to national guidelines, and identifying population groups most at risk of nutritional inadequacy.

Socioeconomic status (SES) is associated with diet quality during pregnancy and can strongly predict it. Low income can decrease women's access to healthy foods because of constraints such as affordability, transportation to food retailers that provide healthy food options, or poverty-stricken neighbourhoods that consist of many low-cost restaurants or grocery stores. Research has found that pregnant women of lower income tend to eat less fruit, vegetables, and dairy while consuming more processed foods and foods higher in fat and sugar. One reason for this may be that healthier, nutrient-rich foods tend to be more expensive than their lower-nutrient counterparts on a calorie basis. For example, lean meats or vegetables cost more per calorie than refined grains or fatty meats (71).

A study by Fowels et al. examined predictors of dietary quality among 118 low-income pregnant women in their first trimester. Participants completed three 24-hour dietary recalls, and diet quality was analysed using the Diet Quality Index for Pregnancy (DQI). The findings revealed that most women did not achieve the recommended dietary quality for pregnant women in the United States. Additionally, the study highlighted that psychosocial distress and unhealthy eating behaviours were significant contributors to poor dietary quality among this population (72). A longitudinal study investigating food choices among low-income women during pregnancy and postpartum, with 40 women completing food frequency questionnaires at 6 weeks and 6 months postpartum, found that, across the major food groups, women tended to select options higher in total calories and fat. For example, within the vegetable group, potatoes were commonly chosen; within the dairy group, whole milk and hard cheeses were preferred; and within the protein group, fried meats were the most popular choice. The researchers in the study suggested that economic constraints may explain these dietary patterns, as energy-dense, processed foods are typically less expensive (73).

In addition, low-income neighbourhoods often have a higher density of takeaways and fast-food outlets, which further influences food choices. A New Zealand study investigating neighbourhood deprivation and access to fast food found a strong correlation between higher levels of

neighbourhood deprivation and greater geographic proximity to fast-food restaurants (74). A study involving 2,247 pregnant women from low- and middle-income backgrounds in their second trimester also found that energy-dense foods, such as high-fat biscuits or muffins, French fries or fried potatoes, and whole milk, were commonly consumed among these women (75).

Educational attainment is another strong predictor of maternal diet quality. Higher levels of education generally correspond to greater nutrition knowledge, improved health literacy, and increased ability to interpret and implement dietary guidelines. A study examining dietary intake and health-related factors among Austrian pregnant women found that the intake of 11 out of 27 evaluated nutrients was significantly associated with educational level. Women with higher education demonstrated healthier dietary patterns, lower mean BMI, and were more likely to engage in physical activity (76). Another study by Freisling et al., examining the impact of socioeconomic status on dietary intake, physical activity, and body mass index (BMI) among Austrian pregnant women, also identified education as a strong predictor of both nutrient intake and BMI during pregnancy (76). Similarly, a study of Swiss non-pregnant women found lower intakes of dietary fibre, protein, vitamin D, calcium, and iron among women with lower educational levels (77).

A study investigating the major determinants of nutrient intake among 196 pregnant women in New Zealand, aged 18 to 35 years, found that educational attainment was strongly associated with dietary quality (78). Women with more than 5 years of secondary or higher education had significantly higher intakes of folate (13% higher) and zinc (9% higher) than their less educated counterparts. In contrast, women with lower educational levels had a higher proportion of their energy from fat (38% vs. 36%). This study found that fibre intake was inadequate in most participants, with 81% falling below the Adequate Intake (AI) of 28 g/day. This inadequacy was more common among less educated women (97% < AI) and those receiving welfare support (95% < AI). The study also found that calcium intake was suboptimal among less educated women, with 80% consuming less than the Estimated Average Requirement (EAR) of 850 mg/day.
Additionally, selenium intake was insufficient in most participants, with 89% consuming less than the EAR of 850 mg/day. The study concluded that years of education were a strong predictor of overall dietary quality among pregnant women (78). Bodnar and Siega-Riz assessed the Diet Quality Index for Pregnancy (DQI-P) to examine dietary variation and its association with sociodemographic factors in a sample of 2,063 pregnant women from the Pregnancy, Infection and Nutrition (PIN) study in North Carolina. Using a Food Frequency Questionnaire (FFQ), they

found that older, well-educated women with higher socioeconomic status were most likely to consume less energy from fat and were also more likely to meet the recommended intake of vegetables. Higher vegetable consumption was particularly associated with older age, higher income, and higher educational status (79).

Psychological factors such as stress, depression, and social support can influence dietary behaviour significantly in pregnant women. A study conducted in Michigan examined the mediating effects of sleep and depression on the relationship between stress, fat intake, and fruit and vegetable consumption across pregnancy trimesters in low-income, overweight, and obese women. Findings indicated that women experiencing higher levels of stress during their first trimester were significantly less likely to consume fruits and vegetables (80, 81). These results aligned with the previous study that explored the influence of stress, depression, and social support on eating behaviour and diet quality in low-income women during the first trimester using 24-hour dietary analysis. The study found that both meal skipping and limited control over food preparation were positively correlated with higher stress levels and depressive symptoms (82). A study examining psychosocial influences on dietary patterns during pregnancy assessed the dietary intake of 134 women with low-risk, singleton pregnancies at 29 weeks of gestation using a food frequency questionnaire. The findings revealed that psychosocial factors, such as stress, fatigue, and anxiety, were associated with altered dietary behaviour. Specifically, increased stress was linked to greater consumption of bread and foods high in fat, oils, sweets, and snacks. Similarly, anxiety was associated with higher intake from the same high-fat and high-sugar food groups. Overall, stress-related increases in food intake led to elevated consumption of macronutrients, including carbohydrates, fats, and proteins, and therefore, a higher intake of certain micronutrients, such as iron and zinc (83).

Gastrointestinal changes during pregnancy, such as nausea, vomiting, indigestion, constipation, food cravings, food aversions, and Pica, can influence dietary intake. This physiological change can often result in reduced appetite, selective food avoidance, or increased consumption of non-nutritious substances, all of which can compromise the overall quality of the diet. Importantly, this alteration in eating behaviour can occur irrespective of a woman's nutritional knowledge, motivations or socioeconomic status, highlighting the complex interplay between physiological symptoms and dietary adherence during pregnancy.

Gastroesophageal reflux disease (GERD) is a common symptom of pregnancy. Studies have shown that about 30-80% of reports of GERD symptoms are reported in pregnancy (84-87). Among the women who suffer from GERD, heartburn and regurgitation are the most frequent symptoms (88). The majority of pregnant GERD sufferers report exacerbation of symptoms after eating and at bedtime (89). If most women experience symptoms after eating, they may choose not to eat to avoid them, which can reduce their dietary quality. Crozier et al. (2016) found that the severity of nausea was associated with reduced consumption of vegetables, grains, breakfast cereals, legumes, and citrus fruits, as well as an increased intake of white bread and soft drinks (90). Lee et al. also noted that infants born to mothers with moderate to severe morning sickness had significantly lower birthweight, reduced stature, and reduced chest circumference (91). A study by Rifas-Shiman et al. examined changes in dietary intake from the first to the second trimester among 1,543 pregnant women, using food-frequency questionnaires administered in both trimesters. The study found that a substantial proportion of participants reported experiencing new food cravings (58%) and new food or beverage aversions (55%) during the first trimester (92).

Pregnant women experience food cravings and aversions throughout pregnancy. Both can significantly influence dietary intake by motivating the increased or decreased consumption of certain foods. Cravings often contributed to a higher overall energy intake, whereas aversions are linked to nausea and vomiting, leading to avoidance of specific foods and, in some cases, dietary restrictions (91). These findings are consistent with those of Flaxman and Sherman, who observed that morning sickness primarily induced aversions to animal-based foods, including meat, fish, poultry, and eggs (93).

The nature and intensity of food cravings during pregnancy can strongly influence a woman's food choices, both on individual days and across the course of pregnancy. This is especially relevant during the first trimester, when nausea is highly prevalent, with approximately 89% of women reporting nausea and 34% of women reporting a reduction in overall food intake (90). When cravings for certain tastes or foods are pronounced, other foods may become unappealing or trigger nausea and vomiting, potentially limiting dietary variety and reducing the overall nutritional adequacy of the maternal diet (90, 94). These shifts in food preferences and aversions have important implications for diet quality and nutrient intake. For example, strong aversions to protein-rich foods such as meat and eggs may lead to lower intakes of key micronutrients, including iron, zinc, and vitamin B12(95). Conversely, cravings for sweet or energy-dense foods may increase the consumption of added sugars and saturated fats, which can contribute to

excessive gestational weight gain (96). As a result, pregnancy-related cravings and aversions may affect women's ability to adhere to dietary guidelines, particularly in meeting recommended servings from core food groups such as protein-rich foods and vegetables.

Collectively, the studies' findings show that multiple factors influence dietary behaviours during pregnancy. Low socioeconomic status and limited education constrain access to nutrient-dense foods and reduce the capacity to engage with dietary guidance. Psychological stress and low social support further compromise food choices, while pregnancy-related nausea, cravings, and aversions present biological barriers to guideline adherence, irrespective of knowledge or motivation. Despite strong evidence that these determinants drive dietary patterns, most antenatal nutrition guidelines, including New Zealand's EAGs, focus primarily on individual behaviour change and provide limited guidance for addressing systemic barriers such as affordability, food environments, or emotional well-being.

These insights underscore the need for research that not only measures adherence to dietary guidelines but also considers the broader context shaping women's dietary behaviours during pregnancy. Understanding these influences is important for interpreting dietary intake patterns and identifying effective strategies to support pregnant women, particularly for those women who are at the highest risk of nutritional inadequacy.

2.6 Rationale for this study

The Eating and Activity Guidelines (EAGs) and Nutrient Reference Values (NRVs) are aimed at working together to promote adequate nutrition and support maternal and fetal health. In principle, meeting these guidelines suggests that a person's overall diet is nutritionally adequate. However, a key gap in the literature is the limited evaluation of adherence to the updated 2020 Eating and Activity Guidelines, which introduced pregnancy-specific food group recommendations.

Most existing New Zealand evidence predates this update. Large cohort studies, such as *Growing Up in New Zealand*, provide valuable population-level findings but often rely on brief dietary assessment methods, including short food-frequency questionnaires or single-day dietary recalls. While these approaches are practical for large studies, they may not accurately capture habitual dietary intake or reflect dietary changes that occur across different stages of pregnancy. Consequently, although general patterns of low intake of key nutrients such as iron, folate,

iodine, and vegetables have been reported, few studies have critically assessed whether pregnant women are meeting the specific food group serving targets outlined in the Ministry of Health's Eating and Activity Guidelines.

This study addresses the identified gap by investigating dietary intake and adherence to current dietary guidelines among a sample of pregnant women in New Zealand. By comparing reported dietary intake against both food-based recommendations and nutrient reference values, this study provides insight into current eating patterns during pregnancy and identifies areas where dietary intake may fall short of recommendations. The findings may inform future nutrition education strategies, public health interventions, and policy initiatives to improve maternal nutrition and support healthy pregnancy outcomes in New Zealand.

While the gaps identified above are important, this thesis does not aim to address all of them. The scope of this project is much smaller, limited to analysing a small dataset of pregnant women. Instead of providing a comprehensive solution, this thesis offers an initial look at how well these women adhere to the updated 2020 Eating and Activity Guidelines and how their nutrient intakes compare with the NRVs. Although modest in scale, the study provides useful insights into dietary patterns during pregnancy and highlights areas where larger, further studies are needed in New Zealand.

3 Research study manuscript

3.1 Abstract

National dietary guidelines are created to support maternal and fetal health during pregnancy, when nutrient requirements increase for both the mother and the baby. This study aimed to assess the adherence to the 2020 New Zealand Eating and Activity Guidelines (EAG) for pregnant women and selected Nutrient Reference Values (NRVs) for Australia and New Zealand across pregnancy. This study is a secondary analysis of data from the Koru Study, a longitudinal observational study conducted in New Zealand between 2019 and 2022. Healthy pregnant women aged 18–45 years (n = 23) with naturally conceived singleton pregnancies were recruited for this study. Participants completed a 4-day diet diary at up to 3 time points (trimesters 1, 2, and 3) to estimate daily food group servings and nutrient intakes. The current study found that the overall adherence to food group recommendations was low. More than half of participants (52%)met only one to two food group recommendations, while 45% met none; no participant met all five food group guidelines. Adherence was lowest for grain foods and fruit, with fewer than 10%

meeting recommendations. Vegetable intake was suboptimal, with fewer than 1 in 5 participants meeting the guideline. Adherence to milk and milk products was the highest among food groups, although fewer than one in five women met the recommended Intake. Protein-rich food recommendations were met by 16.7% of participants. The macronutrient distribution showed high adherence to the Acceptable Macronutrient Distribution Range (AMDR) for protein (73.8%. Moderate adherence was seen for carbohydrate (50%), and very low adherence for total fat (4.8%) and saturated fat (14.3%). Adequate fibre intake was achieved by 40.5% of participants. The mean protein intake exceeded the EAR of 49 g/day across all trimesters, with mean intake of 89.5 g/day in Trimester 1, 92.5 g/day in Trimester 2, and 78.8 g/day in Trimester 3, suggesting that most women were likely to have met the protein requirement. The majority of participants did not meet the EAR for iodine (76.2%) or iron (90.5%), or the Adequate Intake for vitamin D (73.8%) or folate (59.5%). Vitamin C showed the highest overall adherence (88.1%). Significant positive correlations were observed between milk and milk product intake and calcium intake ($\rho = 0.683$, $p < 0.001$). There was a positive association found between fruit intake and fibre intake ($\rho = 0.402$, $p = 0.008$) and vitamin C intake ($\rho = 0.351$, $p = 0.022$). Vegetable intake is positively associated with fibre intake ($\rho = 0.535$, $p = <0.001$), folate intake ($\rho = 0.44$, $p = 0.004$), iron intake ($\rho = 0.392$, $p = 0.010$), and iodine intake ($\rho = 0.327$, $p = 0.035$). Protein-rich food intake was positively associated with total protein intake ($\rho = 0.593$, $p = <0.001$), selenium intake ($\rho = 0.354$, $p = 0.021$), and iodine ($\rho = 0.369$, $p = 0.016$). In this current study, the adherence to food group recommendations during pregnancy was suboptimal, with multiple micronutrient inadequacies.

3.2 Introduction

Adequate maternal nutrition during pregnancy plays a fundamental role in supporting maternal health, fetal development, and optimal pregnancy outcomes. Extensive scientific evidence highlights the importance of achieving sufficient intakes of both macro- and micronutrients during pregnancy to lower the risk of complications such as fetal growth restriction, low birth weight, congenital anomalies, and maternal conditions, including preeclampsia, gestational diabetes, and hypertensive disorders (1, 3, 5). Inadequate nutrition can also have lasting consequences on infant health, including impaired neurodevelopment, increased fracture risk due to reduced bone mass, and altered lifelong dietary behaviours (4, 15, 97).

Maternal dietary and nutrient intake are shaped by the consumption of foods rather than isolated nutrients. Therefore, food-based dietary guidelines (such as the New Zealand Eating and Activity Guidelines, EAG) provide a practical and relatable framework for providing advice and assessing

dietary quality during pregnancy. These guidelines promote a balanced intake of vegetables, fruits, grains, dairy (or alternatives), and protein-rich foods such as meat products, legumes, nuts and seeds to ensure women meet their elevated nutritional requirements during gestation, particularly for key nutrients of concern such as folate, iodine, iron, calcium, and vitamin D. In 2020, the Eating and Activity Guidelines were updated to include specific recommendations for pregnancy (57), yet there is limited evidence examining how well pregnant women are adhering to these revised guidelines.

Many international studies show poor adherence to dietary guidelines during pregnancy. Research from Australia, Canada, the United States, Norway, and the United Kingdom reports suboptimal intake of vegetables, fruits, whole grains, and key micronutrients during pregnancy, with many pregnant women exceeding recommendations for sodium and saturated fats while failing to meet other nutrient requirements (e.g., fibre, iron, folate, selenium, iodine) (56, 64, 98, 99). Similar trends are also seen in New Zealand, where limited research suggests that only a small proportion of pregnant women meet food group recommendations. A cohort study in 2011 found that only 27% of women consumed 4 or more servings of vegetables per day, and fewer than 1 in 5 met the recommendations for protein-rich foods; however, this was compared with the previous dietary guidelines (59).

Pregnant women's dietary behaviours are shaped by factors such as socioeconomic status, educational level, cultural beliefs, psychological well-being, and physical symptoms such as nausea and vomiting. Low-income women are particularly vulnerable to inadequate dietary intake due to reduced access to healthy food options, and women with lower education often exhibit poorer dietary quality (71, 78). Psychological stress and depression have also been linked to increased consumption of energy-dense foods (41, 100). Certain cultural practices and pregnancy-related aversions can further complicate adherence to nutritional recommendations (90).

Given these limitations, there is a need for contemporary, population-based research that assesses pregnant women's dietary intake and their adherence to current updated national dietary guidelines.

This study aims to address this gap by evaluating the dietary intakes of pregnant women in New Zealand, assessing their adherence to the 2020 Eating and Activity Guidelines, and evaluating their adherence to the Nutrient Reference Values (NRVs) for Australia and New Zealand.

The findings of this study aim to provide valuable insights into the current state of maternal nutrition and to inform future public health strategies that support healthy pregnancies and improve maternal and infant health outcomes.

3.3 Methods

3.3.1 Study design and Ethical Approval

This study is a secondary analysis of data collected from the Koru Study, which is a longitudinal observational study investigating nutrition during pregnancy. Ethical approval was approved from the Health and Disability Ethics Committee (19/CEN/47). Written informed consent was obtained from all participants.

3.3.2 Study Participants

A cohort of healthy pregnant women aged 18-45 years (n = 23) was recruited between 2019 and 2022. Recruitment was done through general practitioner clinics, midwifery practices, pharmacies, antenatal classes, ultrasound clinics, and social media. Initially, recruitment for the study took place in the Manawatu region through in-person visits; however, due to the COVID-19 pandemic, recruitment later expanded nationwide to include online participation.

Eligible participants had a naturally conceived, singleton pregnancy and were initially between 9 and 13 weeks of gestation at enrolment. However, due to low recruitment at this gestation, the recruitment inclusion criteria were increased to between 20 and 23 weeks of gestation (reflected in the information sheet included). Women were excluded if they had a history of gestational diabetes, pre-eclampsia, hypertension, preterm birth, or a medical condition/medication affecting nutrient metabolism. Data were collected at up to three time points: Trimester 1 (9-13 weeks), Trimester 2 (23-26 weeks), and Trimester 3 (33-36 weeks). Due to difficulties in recruiting women early in pregnancy and pandemic-related constraints, most participants completed only the assessments for Trimesters 2 and 3. Women who completed at least one four-day diary during pregnancy were included in this analysis.

3.3.3 Dietary Assessment

Dietary intake was analysed using a 4-day diet diary (4DDD) completed at home during each trimester. Participants recorded all foods and drinks consumed over the four consecutive days, including one weekend day. The participants were provided with an electronic kitchen scale, household measuring utensils, and written and verbal instructions. Women who were recruited online did not receive the scales or measuring utensils.

Participants were asked to record:

- All food and drink consumed.
- Portion size using grams or household measures.
- Brand names, preparation methods, and recipes.
- Dishes were broken down into individual ingredients where appropriate.

Completed diaries were returned to the researchers and reviewed. Participants were contacted to clarify any missing details, such as food brands, portion sizes, or recipes.

3.3.4 Dietary Data Entry and Nutrient Analysis

Dietary data were entered and analysed using FoodWorks 10 Professional (Xyris Software, Australia) with the New Zealand FOODfiles 2016 database (Plant & Food Research Ltd and Ministry of Health, 2017). When a food item was not present in the database, the following steps were used:

1. Search New Zealand supermarket databases (Countdown, Pak'nSave, New World) for nutritional information, serving size, and ingredients.
2. Match to a comparable item within ±10% of major nutrients (energy, protein, calcium, folate, fibre, thiamine).
3. If no match was available, create a custom recipe using ingredient data verified against product labels.

FoodWorks generated daily mean intake of energy (kJ/day), macronutrients (% energy from carbohydrates, protein, total and saturated fat), protein (g/day), fibre (g/day), and micronutrients (vitamin C, vitamin D, folate, calcium, iron, zinc, selenium, and iodine).

Food Group Classification and Dietary Guideline Adherence

All food items were manually classified into food groups according to the Ministry of Health's (2020) Eating and Activity Guidelines for Pregnant Women(57). Daily serving sizes were calculated according to the guidelines' standard serving definitions. Mixed dishes were disaggregated into their individual component ingredients and allocated to the appropriate food groups based on their composition.

There are currently no explicit serving-size recommendations for discretionary foods in the New Zealand Eating and Activity Guidelines. Consequently, a threshold of less than 2.5 servings per day was adopted based on the Australian Dietary Guidelines (101), which provide specific guidance on limiting discretionary food intake.

Discretionary foods were excluded from core food group calculations and classified separately. These included cakes, sweet biscuits, pastries, processed meats and high-fat or salty sausages, ice cream and ice confections, confectionery, savoury pastries and pies, selected sauces and dressings, jams and marmalades, commercially prepared burgers high in fat, salty snack foods (including some savoury biscuits), palm oil, coconut cream and coconut milk, cream, ghee, butter and dairy blend spreads high in saturated fat, as well as sugar-sweetened beverages such as fruit drinks, soft drinks, cordials, sports drinks, and energy drinks.

Foods classified as discretionary included both *single-ingredient foods* and *mixed or recipe foods*, in line with the Australian National Nutrition and Physical Activity Survey (NNPAS) framework. For example, cream is classified as a discretionary, non-core food due to its high saturated fat content. It is considered a single-ingredient food with no classification within a core food group. In contrast, a commercially prepared hamburger is classified as a discretionary *recipe food* because of its high saturated fat content (>5 g/100 g) and mixed composition across multiple food groups. When disaggregated, the white bread roll was classified within the grain food group; tomato, lettuce, onion, and pickle were classified within the vegetable food group; cheese was classified within the milk and milk products food group; and mayonnaise was classified as a non-core ingredient and added to the discretionary food group (101).

Based on Table 1, participants' intakes were classified as:

- Achieved the recommended number of servings
- Not achieved (below recommendation)
- For discretionary foods, adherence was defined as <2.5 servings/day.

Table 2: Recommended Daily Servings and Standard Serving Size Examples for Key Food Groups as defined in the Ministry of Health. 2020. Eating and Activity Guidelines for New Zealand Adults: Updated 2020. Discretionary food, as defined by the Australian Dietary Guidelines (Eat for Health, 2013)

Food Groups	Serving Size	A standard serving example	Specific Foods Excluded from the Analysis
Vegetables	5 serving	75 g or 1 medium tomato, ½ cup cooked vegetables (e.g., carrot, broccoli, bok choy, taro leaves), ½ cup canned vegetable (e.g. beetroot, sweet corn), 1 cup green leafy vegetable or raw salad vegetables, ½ medium potato ir similar sized kumara	Juice, deep-fried potato, and kumara fries
Fruit	2 serving	150 g or 1 medium apple, banana, orange or pear, 2 small apricots, kiwifruit or plums, 1 cup frozen fruit, e.g. mango, berries, 1 cup diced or canned fruit (drained and with no added sugar)	Dried fruits, fruit drinks
Grains-rich foods	8.5 serving	120 g cooked porridge, 40 g wholegrain bread, 75–120g cooked rice, pasta, ¼ cup (30 g) muesli or 1 slice (40 g) wholegrain bread	Cakes, biscuits, pies, doughnuts, muffins
Protein-rich foods	3.5 serving	150g cooked or canned lentils, 30 g nuts, seeds, 170 g tofu, 100 g cooked fish fillet, 2 large eggs, 80 g cooked lean chicken, 65 g beef, lamb, pork, veal	Processed meats: sausages, ham, salami, battered or deep-fried fish, chicken nuggets, meat pie
Milk and milk products	2.5 serving	250ml milk, 40g of cheese, 200g yoghurt	Ice cream, cream
Discretionary	<2.5 servings	One serves of a discretionary food was defined as the amount providing 600 kJ.	All excluded items were categorised as discretionary

3.3.5 Data Entry and Statistical Analysis

Assessment of Nutrient Adequacy

The Nutrient Reference Values for Australia and New Zealand (NHMRC, 2006) were compared to the mean daily nutrient intakes from food for each participant. Meeting or exceeding the Estimated Average Requirement (EAR) without going over the Upper Level of Intake (UL) was considered nutrient adequacy. The Acceptable Macronutrient Distribution Range (AMDR) was used to evaluate the adequacy of macronutrients. The following was the definition of participant intakes:

- Achieved (>/= EAR but <UL)
- Not achieved (<EAR
- Exceeded (> UL)

All statistical analyses were conducted using IBM SPSS Statistics version 29. Significance was set at $p < 0.05$. Normality was assessed using the Shapiro–Wilk test. Normally distributed data were expressed as mean (± SD), while non-normal data were expressed as median (25th–75th percentile).

Comparisons of food group and nutrient intakes across the three pregnancy trimesters were conducted using one-way ANOVA for normally distributed variables and the Kruskal–Wallis test for non-normally distributed variables.

As there were very few diaries from Trimester 1 (n=6), differences in food and nutrient intakes between Trimester 2 and Trimester 3 were also examined using the nonparametric Mann–Whitney U test. Associations between guideline adherence and nutrient adequacy were assessed using Chi-Square tests, and correlations between food group servings and nutrient intakes were examined using Spearman's rank correlation (as several variables were not normally distributed, Spearman's rank correlation coefficients were used for all correlation analysis).

3.4 Results

3.4.1 Participant characteristics

Table 3: Description of maternal characteristics (n = 23)

Maternal Characteristics	n (%)
Age, years (Mean ± SD)	30.4 ± 3.9
Education—Tertiary	22 (95.7)
Education— Secondary (High school)	1 (4.3)
Ethnicity—Māori/European	2 (8.7)
Ethnicity—European	16 (69.6)
Ethnicity—Asian	3 (13.0)
Ethnicity— Other[1]	2 (8.7)

[1]South African, Unknown

3.4.2 Adherence to recommended food group servings

Table 4: Daily food group servings intake and comparison to the *Eating and Activity Guidelines* (MoH, 2020a) across trimesters of pregnancy

Food Groups	EAG[A] recommended servings	Trimester 1 (n =6)	Trimester 2 (n = 23)	Trimester 3 (n = 13)	P-value**	P-value
Fruit	2	0.7 ± 0.6	1.2 ± 0.8	1.1 ± 0.6	0.6	0.3[1]
Milk	2.5	1.8 ± 1.1	1.8 ± 0.9	1.2 ± 0.7	0.5	0.2[1]
Grains-rich foods	8.5	3.1 (1.9–5.3)*	3.3 (2.4-3.9)*	3.0 (2.5-4.3)*	0.3	0.9[2]
Vegetable	5	2.9(2.2-3.5)*	3.2(1.7-4.)*	2.4(2.0-3.9)*	0.3	0.9[2]
Protein-rich foods	3.5	2.3(1.9-3.5)*	2.5(1.9-3.3)*	2.3(1.9-3.3)*	0.7	0.8[2]
Discretionary	<2.5[B]	3.9(3.1–5.6)*	5.8(3.9–9.0)*	7.4(4.4–11.6)*	0.5	0.1[2]

[A] EAG = eating and activity guidelines (57)

[B] = Australian dietary guidelines (101)

Intakes are mean (±SD) unless otherwise specified.

*= median (IQR)

**= Mann-Whitney U test of significance between the median intake of trimesters 2 and 3

[1]=P-value from One-Way ANOVA

[2]=P-value from Kruskal-Wallis test

Overall, adherence to the recommended daily servings was low across all food groups, and no statistically significant difference was observed between trimesters.

Mean fruit intake was well below the recommended two serves per day, ranging from 0.7 to 1.2 servings/day (Table 2). Milk and milk product intakes ranged from 1.2 to 1.8 servings/day, which is below the recommended level of 2.5 servings. Grain-rich food intake was consistently lower than the recommended 8.5 servings per day, with a median intake of 3.0-3.3 servings/day. Median vegetable intake ranged from 2.4 to 3.2 servings/day, which is below the recommended five servings/day. Protein-rich foods averaged approximately 2.3-2.5 servings/day across trimesters, which is below the recommended 3.5 servings/day. Mean discretionary food consumption ranged from 3.9 to 7.4 servings/day, which is well above the recommendation of less than two servings per day, although this difference was not statistically significant.

Table 5: Percentage of pregnant women meeting the recommended servings for *Eating and Activity Guidelines* (MoH, 2020a) across trimesters of pregnancy.

Food group n (%)	EAG[A] recommended servings	Trimester 1 (n=6)	Trimester 2 (n=23)	Trimester 3 (n=13)	Overall (n=42)
Fruit	2	0 (0%)	3 (13%)	1 (7.7%)	4 (9.5%)
Vegetable	5	0 (0%)	5 (21.7%)	2 (15.4%)	7 (16.7%)
Grain-rich foods	8.5	0 (0%)	1 (4.3%)	0 (0%)	1 (2.4%)
Milk and Milk products	2.5	2 (33.3%)	5 (21.7%)	1 (7.7%)	8 (19%)
Protein-rich foods	3.5	1 (16.7)	5 (21.7%)	1 (7.7%)	7 (16.7%)
Discretionary foods	<2.5 [B]	1 (20%)	3 (13%)	1 (20%)	5 (11.9%)

[A] EAG = eating and activity guidelines (57)

[B] = Australian dietary guidelines (101)

Overall adherence to the recommended daily food group servings was low across all trimesters, with fewer than one in five participants meeting most food group recommendations. (Table 2). No women in this study met all five food group guidelines; approximately 52% met just one of two recommendations, while 45% met no food group recommendations.

Only 9.5% of participants met the recommended two servings of fruit, and 16.7% met the recommended ≥5 servings of vegetables per day. Very few women met the guideline for grain-rich foods, and adherence to the recommended servings of milk and milk products, as well as protein-rich foods, was similarly low across trimesters. Adherence to the discretionary food guideline was low, with only 11.9% of participants following it. Trimester 2 has the lowest adherence of 13%.

There were no significant differences in the proportion achieving the recommendations across the trimesters.

3.4.4 Adherence to daily energy and Macronutrient intake

Table 6: *Macronutrient consumption compared to recommendations* across trimesters of pregnancy (Ministry of Health & National Health and Medical Research Council, 2006).

		Mean intake				
Macronutrients	AMDR[A]	Trimester 1 N= 6	Trimester 2 N= 23	Trimester 3 N= 13	P-value[**]	p-Value[2]
Energy (KJ/day)	NA	8099 ± 1946	9193 ± 2346	8759 ± 1358	0.830	0.49[1]
Protein (% of energy)	15-25	18.13 (16.03-23.71)[*]	17.58 (15.40-18.88)[*]	15.14 (13.35-18.02)[*]	0.103	0.10[2]
Total fat (% energy	20-35	35.31 (29.84-45.19)[*]	38.68 (30.84-44.14)[*]	36.17 (31.66-37.82)[*]	0.229	0.55[2]
Saturated fat (% of energy)	<10	15.2 ± 4.0	14.2 ± 2.9	14.0 ± 2.8	0.729	0.70[1]
Carbohydrate	45-65	42.2 ± 9.5	42.8 ± 8.8	46.2 ± 6.9	0.182	0.45[1]
Protein g	49g (EAR[C])	89.5 ± 15	92.5 ± 23.3	78.8 ± 19.8	0.090	0.19[1]
Fiber g	28g (AI[B])	23.8 ± 7.1	26.3 ± 9.9	27.9 ± 7.3	0.339	0.65[1]

Intakes are mean (±SD) unless otherwise specified.

[A]= AMDR = Acceptable macronutrient distribution range

[B]= RDI = Recommended dietary intake

[C=] EAR = Estimated average requirement

[*]= median (IQR)

[**]= Mann-Whitney U test of significance between the median intake of trimesters 2 and 3

[1]=P-value from One-Way ANOVA

[2]=P-value from Kruskal-Wallis test

Mean daily energy intake ranged from 8099 (± 1946) kJ to 9193 (± 2346) kJ, with similar values across all trimesters (Table 3). Mean protein intake was above the EAR and RDI (49 and 60 g/day, respectively), and mean protein also contributed 15–18% of total energy, falling within the AMDR. Median total fat intake exceeded the AMDR (20-35% of energy), and mean saturated fat intake was above the recommended level (<10% of energy) in all trimesters.

Mean carbohydrates contributed a lower proportion of total energy than the AMDR (45–65% of energy). Mean fibre intake was also below the recommended 28 g/day at each trimester. Overall, there were no statistically significant differences in total energy or macronutrient intake across trimesters.

Table 7: *Percentage of participants meeting macronutrient recommendations compared to recommendations* across trimesters of pregnancy (Ministry of Health & National Health and Medical Research Council, 2006).

Macronutrients	AMDR[A]	Trimester 1 (n=6	Trimester 2 (n=23)	Trimester 3 (n=13)	Overall (n=42)
Protein	15-25%	5 (83.3%)	20 (87%)	6 (46.2%)	31 (73.8%)
Carbohydrate	45-65%	2 (33.3%)	10 (43.5%)	9 (69.2%)	21 (50%)
Total fat	20-35%	1 (16.7%)	1 (4.3%)	0 (0%)	2 (4.8%)
Saturated fat	<10%	2 (33.3%)	3 (13%)	1 (7.7%)	6 (14.3%)
Protein	49g (EAR[C])	6 (100%)	21 (91.3%)	13 (100%)	40 (95.2%)
Fiber	28g (AI[B])	2 (33.3%)	9 (39.1%)	6 (46.2%)	17 (40.5%)

[A]= AMDR = Acceptable macronutrient distribution range

[B]= AI = Adequate intake

[C]=EAR = Estimated average requirement

Most participants met the AMDR for protein, with 83.3% in Trimester 1, 87.0% in Trimester 2, and 46.2% in Trimester 3 achieving the recommended 15–25% of energy intake. Adherence to the carbohydrate AMDR (45–65% of energy) ranged from 33.3% in Trimester 1 to 69.2% in Trimester 3. Very few women met the recommended AMDR for total fat (20–35% of energy intake), with only 2 participants (4.8%) meeting this guideline. Adherence to the saturated fat recommendation (<10% of energy) was also low across all trimesters, ranging from 7.7% to 33.3%.

Almost all participants met the Estimated Average Requirement for protein (49 g/day), with 100% in Trimesters 1 and 3 and 91.3% in Trimester 2 meeting the requirement. Fibre intake, assessed against the Adequate Intake of 28 g/day, was met by 33.3% of participants in Trimester 1, 39.1% in Trimester 2, and 46.2% in Trimester 3, resulting in an overall rate of 40.5%.

There was no significant difference in the percentage of energy from macronutrients (protein or fibre) across the trimesters. (all $p > 0.05$).

3.4.5 Adherence to daily micronutrient intake

Table 8: Micronutrient intakes compared to recommendations across trimesters of pregnancy.

Micronutrients	Recommended EAR/AI levels	Trimester 1	Trimester 2	Trimester 3	p-Value	p-value[3]
Vitamin C (mg/day)	40 [A]	55.3(18.7-109.2) *	105.6(81.1-190.2) *	130.1(80.8-274.9) *	0.1[2]	0.4
Vitamin D (µg/day)	5[B]	2.6(1.3-4.2) *	3.2(1.5-7.0) *	3.5(2.7-8.0) *	0.4[2]	0.4
Folate (µg/day)	520 [A]	465.3(292.8-545.8) *	476.3(353-657) *	458.9(329-566) *	0.7[2]	0.6
Calcium (mg)	840 [A]	927.5± 324	993.2±363.2	878.1± 269.5	0.3[1]	0.4
Iron (mg/day)	22 [A]	12.2(10.3-14.6) *	13.4(11.5-17.9) *	17.2(11.6-28.9) *	0.1[2]	0.1
Zinc (mg/day)	9 [A]	10.7(7.9-13.7)	10.6(8.4-14.8)	9.6(8.2-13.9)	0.9[2]	0.8
Selenium (µg/day)	55 [A]	65.1 ± 16.9	58.1± 16.07	56.9 ±21.5	0.6[1]	0.4

Iodine (µg/day)	160 [A]	64.7(45.5-106.0) *	123.7(67.1-173.1) *	83.1(66-151.9) *	0.2[2]	0.6

Intakes are mean (±SD) unless otherwise specified.

[A]EAR = Estimated average requirement

[B]AI = Adequate intake

*= *= median (IQR)

[1]=P-value from One-Way ANOVA

[2]=P-value from Kruskal-Wallis test

[3]=P-value from Mann–Whitney U tests comparing trimester 2 and trimester 3

Overall, micronutrient intakes varied widely among participants, with most micronutrient intakes showing no statistically significant differences between trimesters (all $p > 0.05$), except for vitamin C, which increased significantly across pregnancy ($p = 0.046$). Median vitamin C intake increased from 55.3 mg/day in Trimester 1 to 105.6 mg/day in Trimester 2 and 130.1 mg/day in Trimester 3, exceeding the EAR of 40 mg/day.

Vitamin D intake remained consistently below the EAR of 5 µg/day across all trimesters. Median intakes ranged from 2.6 µg/day in Trimester 1 to 3.2 µg/day in Trimesters 2 and 3, with no significant difference between trimesters ($p = 0.427$).

Median folate intake ranged from 458.9 to 476.3 µg/day across trimesters, remaining below the EAR of 520 µg/day. No significant differences were seen between trimesters ($p = 0.682$).

Mean calcium intake exceeded the EAR of 840 mg/day in all trimesters, with mean values ranging from 878.08 mg/day to 993.2 mg/day. There was no statistically significant difference in calcium intake across trimesters ($p = 0.31$).

Median iron intake remained below the EAR of 22 mg/day across all trimesters, ranging from 12.2 mg/day in Trimester 1 to 13.4 mg/day in Trimester 2 and 17.2 mg/day in Trimester 3. No significant differences were found across trimesters ($p = 0.122$).

Median zinc intake was above the EAR of 9 mg/day across all trimesters, with median intakes ranging from 9.6 mg/day to 10.7 mg/day. No significant differences were observed between trimesters ($p = 0.883$).

Mean selenium intake exceeded the EAR of 55 µg/day across all trimesters, with mean intakes ranging from 58.10 µg/day to 65.1 µg/day. There were no significant trimester differences (p = 0.642).

Median iodine intake remained below the EAR of 160 µg/day in all trimesters, ranging from 64.7 µg/day in Trimester 1 to 123.7 µg/day in Trimester 2 and 83.1 µg/day in Trimester 3. No significant differences were seen across trimesters (p = 0.212).

Table 9: Proportion of pregnant women meeting the micronutrient recommendations across trimesters of pregnancy.

Micronutrients	Recommended EAR/AI levels	Trimester 1 (n=6)	Trimester 2 (n=23)	Trimester 3 (n=13)	Overall (n=42)
Vitamin C (mg/day)	40 [A]	4 (66.7%)	20 (87%)	13 (100%)	37 (88.1%)
Vitamin D (µg/day)	5 [B]	1 (16.7%)	6 (26.1%)	4 (30.8%)	11 (26.2%)
Folate (µg/day)	520 [A]	2 (33.3%)	11 (47.8%)	4 (30.8%)	17 (40.5%)
Calcium (mg/day)	840 [A]	4 (66.7%)	13 (56.5%)	7 (53.8%)	24 (57.1%)
Iron (mg/day)	22 [A]	0 (0%)	2 (8.7%)	2 (15.4%)	4 (9.5%)
Zinc (mg/day)	9 [A]	4 (66.7%)	16 (69.6%)	9 (69.2%)	29 (69%)
Selenium (µg/day)	55 [A]	5 (83.3%)	17 (73.9%)	9 (69.2%)	31 (73.8%)
Iodine (µg/day)	160 [A]	1 (16.7%)	7 (30.4%)	2 (15.4%)	10 (23.8%)

[A]EAR = Estimated average requirement

[B]AI = Adequate intake

Overall, adherence to the recommended Estimated Average Requirement (EAR) or Adequate Intake (AI) varied substantially across nutrients. Over 50% of participants met the recommendations for vitamin C, zinc, selenium, and calcium, but adherence to iron, iodine, vitamin D, and folate was low (below 40%). The study also found that many women have inadequate intakes, which were below the EAR/AI for fibre, calcium, folate, iodine, iron, and vitamin D, with only 62% meeting three or fewer EAR/AI values.

Vitamin C showed the highest adherence rate, ranging from 66.77% to 100%. Zinc and selenium intake were adequate for many participants, with approximately 69-74% meeting recommendations across all trimesters. Calcium intake was sufficient for over half of the participants in each trimester (53.8% to 66.7%).

In contrast, vitamin D intake remained consistently low across all trimesters, with only 16.7–30.8% of participants meeting the EAR of 5 µg/day, indicating potential insufficiency. Iron intake remained low, with no participants meeting the EAR in Trimester 1 and only 8.7% and 15.4% meeting the EAR in Trimesters 2 and 3, respectively. Folate intake met recommendations in 33.3% of participants in Trimester 1, 47.8% in Trimester 2, and 30.8%% in Trimester 3. Iodine intake was below the EAR (160 µg/day) for most participants, with only 16.7% meeting the recommendation in Trimester 1, 30.4% in Trimester 2, and 15.4% in Trimester 3.

3.4.6 Association between nutrient intake and food group intake:

There was a positive association between fruit intake and fibre intake (ρ = 0.402, p = 0.008) and vitamin C intake (ρ = 0.351. p = 0.022. Vegetable intake is positively associated with fibre intake (ρ = 0.535, p = <0.001), folate intake (ρ= 0.44, p = 0.004), iron intake (ρ= 0.392, p 0.010), and iodine intake (ρ = 0.327, p = 0.035). Milk and milk products showed a strong association with calcium intake (ρ = 0.683, p < 0.001), and a positive association with iodine intake (r_s = 0.331, p = 0.032). Protein-rich food intake was positively associated with total protein intake (ρ = 0.593, p = <0.001), selenium intake (ρ = 0.354, p = 0.021), and iodine (ρ= 0.369, p = 0.016).

Discretionary food intake was positively associated with the percentage of energy from carbohydrate (ρ = 0.35, p = 0.02) and with total protein intake (ρ = 0.31, p = 0.0048). As expected, strong inverse associations were observed between the percentage of energy from carbohydrate and both total fat (ρ = -0.91, p = <0.001) and saturated fat (ρ = -0.50, p <0.001), while the percentage of energy from total fat was positively associated with saturated fat intake (ρ = 0.53, p <0.001).

3.4.7 Relationship between achieving food group and nutrient intake recommendations.

The current study found a statistically significant association between meeting the EAR for vitamin C and meeting the discretionary EAG (p = 0.006). Predictably, meeting the calcium EAR was also significantly associated with meeting the milk and milk product EAG (p = 0.025). A significant relationship was observed between meeting the AI for Vitamin D and meeting the

protein-rich food EAG (p = 0.041), and between meeting the iodine EAR and meeting the vegetable EAG (p = 0.001).

For macronutrients, there was a significant association between meeting the carbohydrate AMDR and meeting the fruit EAG (p = 0.027), as well as between meeting the AI for fibre and meeting the fruit EAG (p = 0.011). Meeting the saturated fat AMDR was significantly associated with meeting the vegetable EAG (p < 0.001), and meeting the protein AMDR was significantly associated with meeting the protein-rich food EAG (p = 0.023).

There were no other statistically significant associations between meeting nutrient reference values (NRVs) or acceptable macronutrient distribution ranges (AMDRs) and meeting the Ministry of Health food group guidelines.

3.5 Discussion

3.5.1 Summary of Findings

This small study found that many pregnant participants were not meeting the updated New Zealand food-based dietary guidelines throughout pregnancy. No women met all five food group guidelines, and approximately 52% met just one of the two recommendations, while 45% met no food group recommendations. The study also found that many women have inadequate intakes below the EAR/AI for fibre, folate, iodine, iron, and vitamin D. Only 62% of the women met the EAR/AI for at least three of these nutrients, highlighting the prevalence of nutrient inadequacy during pregnancy.

3.5.2 Recommended food group servings

The current guideline for vegetables is at least 5 servings per day for pregnant women. The current study found that the median daily vegetable intake ranged across the trimesters from 2.9 to 3.2 servings per day, with only 7% of women meeting the vegetable intake recommendation overall. These findings are notably lower than those reported in the GUiNZ birth cohort study (n = 4365), in which 27% of pregnant women met vegetable intake recommendations(59). However, since the GUiNZ study was conducted under previous dietary guidelines that recommended a lower intake of 4 vegetable servings per day, a direct comparison between the two studies should be interpreted with caution. Consequently, rather than increased vegetable consumption, the higher adherence observed in the GUiNZ cohort might be due to a lower intake target. Importantly, the mean/median intake of food groups was not reported in the GUiNZ study. The current study's

median vegetable intake is still lower than both the previous and current recommendations, indicating a continuing discrepancy between pregnant women's actual intake and the recommendations. The findings of this study are higher than those from an Australian study (n = 857), which reported that pregnant women consumed an average of two servings of vegetables per day (64). Similarly, an Australian study involving 18,266 pregnant women found that fewer than 2% met the recommended vegetable intake levels set by the Australian Dietary Guidelines, indicating lower adherence than observed in the current study (102). However, a Norwegian study (n = 1674) on pregnant women recruited at approximately 18 weeks' gestational age found that about 75.6% met the recommended intake. However, the Norwegian study's recommendation of more than 250 g per day is lower than the current NZ guideline of 375 g per day (equivalent to five servings), suggesting that adherence would be higher at a lower threshold. In addition, differences in dietary assessment methods, the timing of dietary assessment during pregnancy, and habitual nutritional patterns may also contribute to the higher adherence observed in the Norwegian cohort (99). Overall, adherence to vegetable guidelines is poor among the study population, and daily vegetable intake is well below the guidelines.

Mean fruit intake in the current study was below the recommended 2 servings/day, ranging from 0.7 to 1.2 servings/day, with only 9.5% meeting the recommendation. These findings are notably lower than those reported in the GUiNZ birth cohort study (n = 4365), in which 82% of pregnant women met the fruit recommendation (2 servings/day) (59). The lower fruit intake observed in the current study compared with that in the GUiNZ cohort may be partly explained by differences in dietary assessment methods. The GUiNZ study assessed intake using a food frequency questionnaire (FFQ), which estimates usual intake over an extended period and is known to overestimate consumption of foods perceived as healthy, including fruit. In contrast, the current study used prospective food diaries (4DDD), which are generally considered more accurate but tend to produce lower intake estimates due to short-term variability and reduced social desirability bias. Differences in how the fruit group was defined may have further contributed to the observed discrepancy. In the current study, fruit juices and dried fruits were excluded from the total number of daily fruit servings.

In contrast, the GUiNZ study included one serving of fruit juice or dried fruit as part of total daily fruit intake, whereas the updated 2020 guidelines exclude these foods due to their higher sugar content; consequently, they were not included in this study. This broader classification in GUiNZ is likely to have contributed to higher estimates of fruit consumption and a higher proportion of

women meeting the recommendations. Sample size and representativeness are additional important considerations. The GUiNZ cohort is a large, nationally representative sample (n = 4365), whereas the current study included a relatively small number of participants (n = 23) with uneven distribution across trimesters. Smaller samples are more sensitive to individual dietary behaviours, which can disproportionately influence mean and median intakes, leading to an underestimation of typical fruit consumption patterns. Comparable findings were reported in an Australian study (n = 857), which found a median fruit intake of two servings per day, with 56% of pregnant women meeting the recommended intake (64). Similarly, a Norwegian study (n = 1674) that recruited women at approximately 18 weeks' gestation reported that 42.1% of participants met the Norwegian fruit intake recommendation of 250 g per day (approximately 1.7 servings per day). It is important to note that differences in adherence between countries may partly reflect variation in national dietary guidelines. The New Zealand Eating and Activity Guidelines recommend at least 2 servings of fruit per day (approximately 300g); thus, the higher adherence reported in the Norwegian cohort may partly reflect a lower recommended intake rather than higher fruit consumption.

The median intake of grain-rich foods in the present study was significantly below the recommended 8.5 servings per day across all trimesters(57), ranging from 3.0 to 3.3 servings/day, representing less than half of the recommended level, with only one participant in trimester 2 meeting the recommendation. The overall adherence to the grain's guideline was 16.7% among the participants. When compared with the GUiNZ study (n = 4365), the bread and cereals recommendation (at least 6 servings/day) was met by 26% of the women. Although adherence to grain-rich food recommendations was lower in the current study compared with the GUiNZ cohort, the difference is likely due to the use of updated guidelines. An Australian study (n = 857) that applied a similar recommended intake for grain-rich foods (8.5 servings per day) reported a median intake of four servings per day, with only 4% of participants meeting the recommendation. These findings are comparable to those of the current study, in which the median grain intake was similarly low and overall adherence to the recommended intake was minimal(64). These findings suggest that meeting the recommended intake for grain-rich foods during pregnancy is challenging, particularly given the high number of servings required.

Consumption of milk and milk products remained consistently below recommended levels across all trimesters of pregnancy. Only 19% of participants met the guideline of 2.5 servings per day for milk and milk products. Mean daily intake ranged from 1.2 to 1.8 servings. In comparison,

findings from the Growing Up in New Zealand (GUiNZ) study (n = 4,365) reported that approximately 58% of women met the recommended intake of three or more servings of milk and milk products per day, indicating substantially higher adherence than observed in the current study (59). Pregnancy-related gastrointestinal discomfort, taste changes, perceived intolerance to dairy foods, or concerns regarding fat content may influence low intake of milk and milk products during pregnancy. Additionally, some women may substitute dairy foods with discretionary alternatives that lack comparable nutrient density, further contributing to inadequate intake.

Median discretionary food intake exceeded the recommended limit of fewer than 2.5 servings per day across all trimesters of pregnancy; increasing progressively from trimester one (3.9 servings/day) to trimester two (5.8 servings/day), with the highest intake observed in trimester three (7.4 servings/day). Overall adherence to discretionary food recommendations was poor, with 88.1% of participants exceeding the guideline. This pattern indicates a high reliance on energy-dense, nutrient-poor foods during pregnancy, particularly in the later stages of gestation. These findings are consistent with evidence from Australia (103). An extensive national study of Australian adults (n = 9,341) using data from the 2011–2012 National Nutrition and Physical Activity Survey reported that approximately 90% of adults consumed discretionary foods, with more than 60% exceeding 3 discretionary servings per day and a mean intake of 5 servings per day. Notably, individuals consuming an average of 10 discretionary servings per day had lower usual fruit intake and higher overall energy intake, suggesting displacement of core food groups (103).

Excessive consumption of discretionary foods during pregnancy may contribute to excessive gestational weight gain, which is associated with a higher risk of gestational diabetes(104) and long-term maternal obesity (105). Adverse outcomes have also been observed for infants. Diets characterised by high intakes of ‘junk food’, such as consuming more than two cups of sugar-sweetened beverages or more than two servings of fast food per day, have been independently associated with an increased risk of infant birthweight exceeding 4 kg (106). This is of concern, as high birthweight infants have increased risks for the neonate and developing overweight and obesity later in (107, 108).

Several factors may have contributed to the high intake of discretionary foods observed in this cohort, including pregnancy-related fatigue, food cravings, time constraints, and an increased

reliance on convenience (109). Additional barriers to healthy eating may have included limited knowledge of nutritional guidelines (26) and insufficient nutrition education or counselling from healthcare providers during pregnancy (110). It is also possible that some women experienced financial constraints affecting their ability to purchase nutritious foods; however, food security was not assessed in the current study. Furthermore, the timing of data collection during the COVID-19 pandemic may have influenced dietary behaviours, with reduced access to fresh foods due to food shortages and distribution constraints, and a greater reliance on shelf-stable and convenience foods (111-114).

The study also found a significant association between meeting the EAR for vitamin C and adherence to the discretionary food guideline. Although discretionary foods are not recommended sources of vitamin C, certain discretionary items, such as fruit juices, tomato-based sauces, sweet chilli sauce, and ice blocks, can contribute appreciable amounts of vitamin C. The intake of these foods may partly explain the observed association between meeting the discretionary food guideline and achieving the EAR for vitamin C in this study.

3.5.3 Nutrient Reference Values

The intake of protein-rich foods remained below recommended levels across all trimesters. Mean daily intake ranged from 2.0 to 2.3 servings. Overall, only 16.7% of participants met the Ministry of Health recommendation of 3.5 servings of protein-rich foods per day during pregnancy. Although adherence was highest in trimester two (21.7%), it declined substantially in trimester three (7.7%). In contrast, when protein intake was assessed in grams per day, overall protein adequacy was high, with 91-100% achieving the EAR (49 g/day). This apparent discrepancy likely reflects the contribution of protein from grain or discretionary food sources, such as sausages and pies, which contributed to total protein intake but were classified as discretionary foods in this analysis. As a result, total protein intake appears adequate despite low adherence to food-based protein recommendations.

These findings are consistent with evidence from New Zealand and other high-income countries, where protein intake commonly exceeds recommended levels, even when adherence to protein-rich food group guidelines is low. Together, these results highlight the importance of considering both food-based recommendations and nutrient-based measures when assessing dietary adequacy during pregnancy, as meeting nutrient requirements does not necessarily indicate alignment with recommended dietary guidelines.

An Australian study (n = 857) that applied a similar recommended intake for protein-rich foods (3.5 servings per day) reported a median intake of 1 serving per day, with only 2% of participants meeting the recommendation (64). This level of adherence was lower than that observed in the current study. In contrast, the Australian Longitudinal Study on Women's Health (ALSWH) reported substantially higher adherence to protein-rich food recommendations, with 85% of women meeting the guideline and a mean intake of 1.9 servings per day. However, this study applied an earlier recommendation of 1.5 servings per day, whereas the current study used the updated recommendation of 3.5 servings per day(64). Differences in adherence between studies, therefore, likely reflect variation in guideline thresholds rather than higher protein intake alone.

A substantial proportion of participants in the present study had macronutrient intake that did not align with the nutrient recommendations. Across all trimesters, total fat and saturated fat contributed a disproportionately high percentage of total energy intake. Fewer than 5% of women met the total fat recommendation, and only 14% met the saturated fat guideline, with the majority exceeding both recommendations. Median total fat intake exceeded the Acceptable Macronutrient Distribution Range (AMDR; 20–35% of total energy) in all trimesters, at 35.3% in trimester one, 38.7% in trimester two, and 36.2% in trimester three. In contrast, many participants had intake below the recommendation for carbohydrate (45–65% of total energy), with only 50% of participants meeting the recommendation of Overall, this macronutrient profile is consistent with findings among women in other high-income countries, as reported in a systematic review of 90 studies (115).

In the current study, fewer than half of the participants (40.5%) met the Adequate Intake (AI) for dietary fibre. Median dietary fibre intake across pregnancy ranged from 23.8 to 27.8 g/day, remaining below the recommended adequate intake of 28 g/day. The low adherence to fibre recommendations is concerning, given the well-established benefits of dietary fibre for maternal health, including improved gastrointestinal function, glycaemic control, and long-term cardiovascular health. (116). Furthermore, low fibre intake may reflect broader dietary patterns characterised by inadequate consumption of fruits, vegetables, whole grains, and legumes, which are key contributors to both fibre and essential micronutrient intake during pregnancy. Increasing intake of fruits, vegetables, and grains to meet recommendations during pregnancy would improve dietary fibre intake, enhance overall diet quality, and support maternal health

beyond pregnancy. These findings highlight the importance of food-based dietary guidance that emphasises the consumption of fibre-rich plant foods throughout all stages of pregnancy (117).

The observed associations between food group intake and nutrient intake further support these findings. Fruit and vegetable intake showed a positive association with dietary fibre intake, indicating that women who consumed higher amounts of these food groups were more likely to achieve higher fibre intakes. Fruit intake was positively associated with both fibre and vitamin C intake. In contrast, vegetable intake was positively associated with fibre and several key micronutrients, including folate, iron, and iodine. These associations show that low fibre intake reflects broader dietary patterns characterised by insufficient consumption of fruits and vegetables, rather than isolated inadequacies in fibre intake alone.

A substantial proportion of pregnant women were at risk of micronutrient inadequacy across all trimesters, particularly for vitamin D, folate, iron, and iodine(118, 119). Vitamin D Intake was inadequate, with only 26.2% of participants meeting the AI overall. This finding aligns with existing evidence demonstrating that dietary vitamin D intake is generally insufficient among pregnant women, particularly in settings where sunlight exposure is the primary source of vitamin D. Given the critical role of vitamin D in bone health, immune function, and fetal skeletal development, low dietary intake may place women at increased risk of suboptimal vitamin D status, especially during winter months or among those with limited sun exposure (120).

Iron intake was also inadequate, with only 9.5% of women meeting the EAR overall. This finding is consistent with the well-documented difficulty of meeting increased iron requirements through diet alone during pregnancy (121-123). Low dietary iron intake may contribute to iron deficiency and anaemia, which are associated with adverse maternal and neonatal outcomes. These results suggest that dietary intake alone is unlikely to meet the iron requirements of most pregnant women (124), reinforcing the importance of supplementation where clinically indicated.

The current study found a significant association between meeting the vegetable food group guideline and achieving the EAR for iodine. Although vegetables are not a primary dietary source of iodine, individuals who consume more vegetables may be more likely to use iodised salt during cooking or seasoning, which is a key contributor to iodine intake in New Zealand (31, 101, 125-127). In addition, vegetables are commonly consumed as part of mixed meals alongside iodine-rich foods such as eggs, seafood, and bread made with iodised salt. Together, these factors may

help explain the association between meeting the vegetable food group guideline and achieving the EAR for iodine, rather than a direct contribution of iodine from vegetables themselves.

Median folate intakes remained below the EAR, and only 40.5% of participants met the EAR. Overall, Iodine intake was also low, with fewer than one-quarter of participants (23.8%) meeting the EAR. However, supplementation with both iodine and folic acid is recommended during pregnancy in NZ. However, dietary supplement use was not included in the present study; thus, actual intakes may be higher. The current finding highlights the limitations of diet alone in meeting increased folate requirements during pregnancy.

In contrast, a higher proportion of women met recommendations for vitamin C (88%), zinc (69%), selenium (73.8%) and calcium (57%). Mean vitamin C intake increased significantly across trimesters, from 55.3 to 130.1 mg ($p = 0.046$), with 88% of participants meeting the EAR overall. While this suggests adequate intake of some micronutrients, it also highlights disparities in dietary quality, where nutrients abundant in fruits and certain animal foods are more readily met than those who rely on fortified foods or supplementation.

The study also found positive associations between milk and milk products with calcium and iodine intake. The study also found an association between protein-rich foods and total protein, selenium, and iodine intake, highlighting the role of core food groups as primary contributors to nutrient adequacy during pregnancy. Together, these findings support a food-based approach to dietary guidance, indicating that improved adherence to food group recommendations increases consumption of fruits, vegetables, whole grains, and other core foods, thereby improving dietary fibre intake and overall micronutrient adequacy. This underscores the importance of promoting fibre-rich, nutrient-dense food choices throughout pregnancy to support maternal health.

3.5.4 Strengths and limitations of the study

This current study is one of the most recent investigations in New Zealand to compare the dietary intake of pregnant women with the updated Eating and Activity Guidelines for Pregnant Women (Ministry of Health, 2020). By applying the revised guidelines, this study addresses a significant gap in the literature, as limited research has examined adherence to these updated recommendations among pregnant women in New Zealand. The dietary assessment approach used in this study was detailed and comprehensive, contributing valuable insights into the nutritional adequacy of pregnant women's diets.

A key methodological strength of this study is the use of a four-day weighed food diary, which enabled a detailed assessment of both food group servings and nutrient intake at the individual level. This method enabled the calculation of average daily intake and facilitated more accurate estimation of usual dietary intake than retrospective methods such as food frequency questionnaires. As a result, this approach provided high-quality, granular data on dietary patterns and nutrient intake. However, as with all self-reported dietary assessment methods, the potential for under-reporting or over-reporting of certain foods cannot be excluded, particularly for discretionary foods.

Despite these strengths, several limitations should be acknowledged. First, the sample size was relatively small, limiting statistical power and the ability to detect more minor differences or associations. Additionally, the study population was predominantly of New Zealand European descent, resulting in limited ethnic diversity. Given the ethnically diverse nature of the New Zealand population, this lack of representation limits the generalisability of the findings to all pregnant women in New Zealand.

Dietary data for the study were collected as part of the Koru study between 2019 and 2022, meaning they were up to 5 years old at the time of analysis. Importantly, the updated Eating and Activity Guidelines for pregnancy were released in 2020. Consequently, women recruited before or shortly after the guideline update may not have been aware of, or exposed to, the revised recommendations and may have continued to follow earlier guidance. This timing may have contributed to the low adherence observed in this study.

Finally, some data collection occurred during the COVID-19 pandemic. There were disruptions to food availability, increased food costs, and reduced access to fresh produce during this time. These factors may have influenced dietary behaviours and food choices during pregnancy and should be considered when interpreting this study's findings**.** A further limitation of this study is the lack of information on dietary supplement use. Although nutrient intakes were estimated from food sources, data on supplement use were not captured in the analysis. As supplements are used daily during pregnancy and can contribute to total micronutrient intake (e.g., folate, iodine, iron, and vitamin D), the absence of this information may have led to an underestimation of total nutrient intake and misclassification of adherence to selected Nutrient Reference Values. These considerations highlight the importance of interpreting dietary intake data alongside supplement

use when assessing overall micronutrient adequacy and reinforce the need for combined food-based strategies and appropriate supplementation guidance to support optimal maternal and fetal health.

3.5.5 Conclusion

To our knowledge, this study provides the first assessment of pregnant women's dietary intake and adherence to the updated New Zealand Eating and Activity Guidelines (Ministry of Health, 2020a) using food diaries. Overall adherence to food group, macronutrient, and micronutrient recommendations was low across all trimesters of pregnancy.

Fewer than 1 in 5 participants met the recommended serving size for most core food groups, including vegetables, fruit, grain-rich foods, and protein-rich foods. However, protein intake was above the EAR, suggesting that protein was obtained from discretionary foods such as pies, sausage rolls, and salami, as well as from grain-rich foods. These findings suggest that many pregnant women may find it difficult to meet the updated dietary guidelines for vegetables and grains in practice. This may be influenced by the higher serving-size recommendations introduced in the updated guidelines, as well as by limited awareness of these changes among pregnant women.

Macronutrient intake patterns further highlighted imbalances in dietary quality. Total fat and saturated fat contributed disproportionately to total energy intake. While carbohydrate and dietary fibre intakes were inadequate among the pregnant women. These findings suggest a nutritional pattern characterised by energy-dense, nutrient-poor food choices and insufficient intake of fibre-rich plant foods.

Micronutrient analysis revealed that a substantial proportion of participants were at risk of inadequate intake of several key nutrients that are important for maternal and fetal health, particularly vitamin D, folate, iron, iodine, and calcium. The intakes of vitamin C, zinc, and selenium were adequate for most women. However, overall adherence to micronutrient recommendations remained consistently low across trimesters. It is also important to note that dietary supplement use was not captured in this study. The observed nutrient intakes reflect only the sources of nutrients. This may partially explain the low intakes observed for folate and iodine, which are commonly supplemented during pregnancy.

In the broader context, this research makes an essential contribution to the field by providing the first New Zealand-based evaluation of pregnant women's dietary intake against the updated 2020 Eating and Activity Guidelines. The findings highlight a substantial gap between national recommendations and real-world dietary practices, raising essential questions about the feasibility, communication, and implementation of current guidelines. These results have implications for public health policy, clinical nutrition practice, and antenatal nutrition education, emphasising the need for more straightforward, more practical, and food-based guidance tailored to pregnant women.

Future research should continue to explore dietary intake among larger, more representative groups of pregnant women across New Zealand. Including information on dietary supplement use, as well as biomarker data, would provide a clear picture of women's overall nutrient intake and nutritional status during pregnancy, rather than relying solely on food intake data.
In practice, antenatal nutrition support should focus on helping women increase their intake of vegetables, fruits, whole grains, and iodine- and iron-rich foods. These strategies should be practical and should fit into women's everyday lives, which will be more effective than simply restating the recommendations.

These findings support the premise underlying the Eating and Activity Guidelines that consuming a variety of core food groups is essential to meeting nutrient requirements.

4 Conclusion and Recommendations

4.1 Conclusion

The current study investigated whether pregnant women (aged 18-45 years) in New Zealand met the current food group, macronutrient, and micronutrient recommendations. The study found that many women had inadequate intakes of fruits, vegetables, and grain-rich foods. No women met all five food group guidelines, and approximately 52% met just one of the two recommendations, while 45% met no food group recommendations. The study also found that many women have inadequate intakes below the EAR/AI for fibre, folate, iodine, iron, and vitamin D, with only 62% meeting three or fewer EAR/AI values.

Participants in this study had the best adherence to milk and milk-based products. The participants had inadequate intakes of percentage energy from macronutrients (carbohydrate, total and saturated fat), fibre, iron, iodine, vitamin D, and folate. In contrast, most women

consumed adequate amounts of protein, vitamin C, calcium, zinc, and selenium. These findings are also consistent with the literature from around the world, which has shown poor adherence to dietary-based guidelines and a below-recommended intake of iron, vitamin D, iodine, and folate without supplementation. Vegetable and fruit intake were positively associated with dietary fibre intake, with vegetable intake also predicting vitamin C and iodine intake. Milk and milk product intake were moderately associated with calcium intake and with iodine intake. Protein-rich food intake was associated with zinc, selenium, and total protein intake. Overall, this study's findings suggest that promoting balanced consumption across multiple core food groups may improve nutrient adequacy during pregnancy.

This study addressed a gap in the literature by comparing the food and nutrient intake of pregnant women with the current Ministry of Health guidelines, updated in 2020. To our knowledge, no New Zealand studies have used the most recent guidelines. This study hypothesised that pregnant women aged 18-45 years living in New Zealand do not fully adhere to the national dietary and nutrient recommendations set out in the EAGs or the NRVs, with significant variation in dietary intake across food groups, particularly vegetables, fruits, dairy products, and protein-rich foods. The results of this study supported this hypothesis, as no women met all the dietary guidelines in the EAGs, and only a few met the nutrient recommendation for one of the investigated nutrients. The study also hypothesised that pregnant women who adhere more closely to the Eating and Activity Guidelines will be more likely to meet the Nutrient Reference Values. This was partially supported: the study found that women who met the recommended serving sizes for fruits and vegetables were more likely to meet the fibre recommendation. The study also found that participants who met the milk and milk product serving sizes met the EAR for calcium. The study also found that adhering to the protein-rich food guidelines was positively associated with meeting total protein, selenium, and iodine intake goals. The study found no other statistically significant associations between meeting nutrient reference values (NRVs) or acceptable macronutrient distribution ranges (AMDRs) and meeting the Ministry of Health food group guidelines.

This study also investigated the intake of eight micronutrients (vitamin C, calcium, folate, Iron, vitamin D, zinc, selenium, and iodine) among women and compared it to the New Zealand/Australia Nutrient Reference Values (NRVs). The study found a high proportion of Intake below the EAR for folate, iodine, vitamin C, and Iron. In the current study, fewer than 16% of women met the iron requirement even in late pregnancy (Trimester 3), and 0% met the

recommendation in Trimester 1. The current study found that women were adhering well to the recommendations of Vitamin C, calcium, zinc, and selenium. Vitamin C intake increased progressively from trimester one to three (p=0.05). Vitamin D and iodine were low, with fewer than one-third of participants meeting recommendations at any stage of pregnancy (128). Half of the participants met the calcium EAR, and fewer than half met the folate EAR. Supplementation with iodine and folic acid is recommended during pregnancy; however, dietary supplement use was not included in this study. Overall, micronutrient adherence was low. While some women met multiple micronutrient recommendations, most participants (61.9%) met three or fewer EAR or AI values, indicating widespread micronutrient inadequacy.

This study assessed the average daily number of servings consumed for the five food groups (Fruits, Vegetables, Protein-rich foods, Milk and milk products, and Grains) and compared the results to the updated EAG recommendations. The low adherence to food group recommendations observed in this study suggests a gap between national dietary guidelines and real-world dietary intakes among pregnant women. Most of the women who participated in the study did not meet the recommended daily number of servings for all food groups. The food group with the highest adherence to the dietary guideline was Milk and Milk products, with an adherence rate of 19%. Grain adherence was poor, with only 2.4% of women following the guideline. Fruits were also poorly adhered to (9.5%), and vegetables and protein-rich foods had adherence rates of 16.7%. No women met all five food group guidelines; 52% met 1-2 guidelines, while 45% met no food group recommendations. This study's findings show that pregnant women consumed suboptimal intakes of fruits, vegetables, milk and milk products, grains, and protein-rich foods.

The current study found that 73.8% of pregnant women adhered to the AMDR for protein, with protein intake generally above the RDI and only a few women falling below the EAR, suggesting dietary adequacy. Adherence to total fat and saturated fat recommendations was low: 4.8% of the women were within the AMDR for total fat, and only 14.3% were within the AMDR for saturated fat. Mean Saturated fat intake was well above the recommended limit of less than 10% of total energy throughout pregnancy. The AMDR for carbohydrate was met by only 50% of the women. In this study, about 40% of the women achieved the Fibre AI recommendation.

A positive relationship was observed between meeting the fruit guideline and meeting the Adequate Intake for dietary fibre, indicating that higher fruit consumption may contribute to

improved fibre intake. Similarly, vegetable intake was positively associated with fibre and vitamin C intake, suggesting that increasing vegetable consumption may play a key role in improving the intake of multiple nutrients that were commonly inadequate in this cohort.

As expected, Intake of milk and milk products was strongly associated with calcium intake, and meeting the milk and milk product guideline was significantly associated with meeting the calcium EAR. Milk and milk products were also moderately associated with iodine intake, reflecting the contribution of dairy foods to iodine in the New Zealand food supply. These findings reinforce the importance of calcium-rich dairy foods as a good dietary source of both calcium and iodine during pregnancy.

Several associations observed in this study need further investigation. For example, vegetable intake was significantly associated with iodine intake, and meeting the vegetable guideline was associated with meeting the iodine EAR. This may reflect dietary patterns in which women who consume higher amounts of vegetables also engage in broader health-conscious behaviours, such as the greater use of iodised salt in home cooking or higher consumption of mixed dishes containing iodine-rich ingredients.

Protein-rich food intake was positively associated with total protein, selenium, and iodine intake, suggesting that higher consumption of protein-rich foods may support Intake of these minerals. However, no significant association was observed between protein intake and iron intake, highlighting that meeting protein requirements does not necessarily ensure adequate iron intake during pregnancy. This finding highlights the importance of food choice within food groups, as iron intake is influenced by the type of protein-rich foods consumed and their bioavailability.

Overall, the findings of this study indicate that a substantial proportion of pregnant women are not meeting current dietary recommendations, resulting in inadequate Intake of several key nutrients. These results underscore the need for further research to better understand the social, environmental, and behavioural factors that influence dietary choices during pregnancy. Gaining insight into these factors would support the development of more effective, targeted public health nutrition interventions. Given that food group recommendations for pregnancy have recently been updated, improving awareness, understanding, and the practical application of these guidelines among pregnant women is essential to support dietary behaviour change and optimise maternal and fetal health outcomes.

4.2 Study Strengths and Limitations

The dietary analysis approach used in this study was thorough, enabling a detailed understanding of the nutritional adequacy of pregnant women's diets in New Zealand. Using 4-day diet diaries provided a clear picture of what women were actually eating, including both daily nutrient intake and servings from each food group. This method helped capture real-life eating patterns during pregnancy, rather than relying on short or less detailed assessments. Importantly, this is one of the most recent New Zealand studies to compare pregnant women's dietary intake across trimesters against both the Nutrient Reference Values (NRVs) and national food-based dietary guidelines. By examining these frameworks together, the study offers meaningful insights that can help inform future maternal nutrition guidance and support more practical, evidence-based recommendations for pregnant women.

Several limitations should be considered when interpreting the findings of this study. Firstly, the sample size was small, which limits the generalizability of the results to the broader population of pregnant women in New Zealand.

Secondly, information on participants' ethnicity, socioeconomic status, and physical activity levels was unavailable. The lack of demographic diversity restricts the ability to examine how social, cultural, or lifestyle factors may have influenced dietary intake and adherence to guidelines in these women. Thirdly, data collection occurred during the COVID-19 pandemic, a period characterised by lockdowns, increased food prices, and restricted access to fresh produce and core food groups. These external factors may have influenced dietary behaviours, food availability, and affordability, potentially leading to reduced consumption of fruits, vegetables, and dairy products than would typically be observed under usual conditions.

Additionally, dietary data were self-reported through 4-day food diaries. Food diaries are subject to recall bias and potential under- or over-reporting. The study only recruited women who conceived naturally and excluded participants with gestational diabetes or pregnancy complications, which may limit the representativeness of the sample size. As such, the results of this study should be interpreted as indicative rather than definitive. This study provides a snapshot of dietary patterns of a small cohort of healthy pregnant women rather than the broader maternal population in Aotearoa New Zealand.

4.3 Final recommendations and future directions

Based on the findings of this study, several recommendations can be made. Future research should involve larger, more representative samples of pregnant women across New Zealand to confirm the extent of non-adherence to updated dietary guidelines. Incorporating dietary supplement data and biomarker measures would provide a more comprehensive assessment of nutritional adequacy and status. Research should also investigate the barriers and enablers of optimal food choice.

From a practical perspective, antenatal nutrition interventions should prioritise increasing the Intake of vegetables, fruits, whole grains, and iodine-rich foods, alongside clear guidance on the appropriate use of supplements. Emphasis on food-based strategies and culturally sensitive messaging may improve adherence to dietary recommendations in women and support optimal maternal and fetal health outcomes.

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Appendices

Appendix A: Participation Information Sheet

MASSEY UNIVERSITY
TE KUNENGA KI PŪREHUROA
UNIVERSITY OF NEW ZEALAND

Participant Information Sheet

Study title: *The Koru Study*

Location: Human Nutrition Research Unit, Massey University, Palmerston North

Ethics Committee ref: 19/CEN/47

Lead Investigator: Ciara Funnell (PhD Student) **Contact:** +64 (06) 951 6366

Email: thekorustudy@massey.ac.nz **Mobile**: +64 (0)[redacted]

You are invited to take part in a study on how body composition changes during pregnancy and how these changes affect your baby's birth weight and body composition. This study is led by PhD student Mrs Ciara Funnell. Whether or not you take part is your choice. If you do not want to take part, you do not have to give a reason, and it will not affect the care you receive. If you do 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 and your baby (when he/she is born) would like to take part. It sets out why we are doing the study, what your and your baby's participation would involve, what the benefits and risks to you or your baby might be, and what happens after the study ends. We will go through this information with you and answer any questions you may have. You do not have to decide today whether or not you or your baby will participate in this study. Before you decide, you may want to talk about the study with other people, such as family, whānau, friends, or healthcare providers. Feel free to do this.

If you agree to take part in this study, you will be asked to sign the Consent Forms at the end of this document. One consent form is for you to sign during your pregnancy. If you agree for your baby to take part in this study when he/she is born, you will be asked to sign another Consent Form for your baby, which is on the last page of this document. You will be given a copy of both the Participant Information Sheet and the Consent Form(s) to keep.

This document is 8 pages long, including the Consent Forms for both you and your baby. Please make sure you have read and understood all the pages. If you have any questions, please do not hesitate to contact me or any of the team and we will answer any questions you may have.

What is the purpose of the study?

The purpose of this study is to look at changes in mothers' body composition during pregnancy and if diet and exercise affect these changes, and how these changes impact the infants birth weight and body composition during the first 4 months of life. Body composition is the amount of fat and lean tissue, which is in the body. Very little research on body composition in pregnant women or early infancy has been carried out in New Zealand.

It is important that we understand both weight and body composition (both fat and lean tissue) changes throughout pregnancy, because it affects the health of mothers and infants and possibly future generations. We also need to understand how changes in both weight and body composition may shape the outcome of a pregnancy.

The study is observational – This means we would like to observe and document certain aspects of your pregnancy to get a better understanding of what happens during and after pregnancy. We would also like to observe changes in body composition your baby may have during the first 4 months of their life.

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Massey University's School of Food and Advanced Technology will initially fund this study. Other funding may be sought at a later stage. Should you have any questions about this study you may contact the following people:

Ciara Funnell: PhD Student, School of Food and Advanced Technology, Massey University, Palmerston North Campus.
Phone: [redacted] Work: +64 (06) 9516366
Email: C.funnell@massey.ac.nz

Dr Louise Brough: Senior Lecturer, School of Food and Advanced Technology, Massey University, Palmerston North Campus.
Phone: +64 (06) 9516099
Email: L.Brough@massey.ac.nz

The ethical consideration of this study has been approved by the Health and Disability Ethics Committee (HDEC). You can contact HDEC via email on hdecs@health.govt.nz giving the study reference no.: 19/CEN/47

What will my participation in the study involve?

Participation in the study requires you to have met certain criteria. The criteria are:

- Between 18-45 years old
- **Between 20 - 23 weeks pregnant**
- Singleton pregnancy (only 1 fetus)
- Conceived naturally
- No history of diabetes or gestational diabetes

The study will require you and your baby to visit the Massey University, Human Nutrition Research Unit on the Palmerston North Campus. You will need to be available for **FOUR** visits. Two visits during pregnancy and two visits with your baby, with an additional online survey when your baby is 4 months old. A flow chart of the study is located on page 6 of this information sheet.

When you are between 20 – 23 weeks pregnant, we will make an appointment for you to come into the Human Nutrition Research Unit. We will take the following measurements and collect the following data and samples:

- **Body weight** will be measured using calibrated weighing scales (you will be asked to remove your shoes and outer clothing) and standing height will be measured using a wall measure. Height and weight measurements will be carried out in a private room.

- **Body composition** is measured using a machine called a BodPod®. You sit comfortably inside the BodPod (which is like a space capsule with a seat and a big window) while computerised pressure sensors determine the amount of air displaced by your body. Testing is highly accurate, safe, and quick, with a complete analysis in about 5 minutes. You will be asked to wear close fitting clothing to the visit (OR we can provide various sized bathing suits) while in the BodPod® and will also be provided with a dressing gown to wear both before and after your measurement. The room is private, and you can enter the BodPod® in complete privacy. This will be carried out in all **FOUR** visits to our Human Nutrition Unit. Body composition results will be available immediately and can be discussed with a health care professional should you have any concerns.

- **Resting energy expenditure** (REE) will be measured using a machine called a metabolic cart. This will be carried out during your two visits during pregnancy and again when your baby is 6 weeks old. REE is the amount of energy that your body uses without movement. You will be asked to lie on a bed in the research unit, until you are nice and comfortable. The metabolic cart has a hood attached to it and you will breath into the hood, the machine will then carry out a measurement of your REE. This measurement will be available immediately.

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- **Haemoglobin levels** will be measured using a machine called a Haemocue® to give an indication of your iron status. A small spot of blood is taken from the tip of the middle finger. The blood is drawn into a microcuvette, which is then placed, into the Haemocue® for a hemoglobin measurement. This will be carried out during visits 1, 2, and 4. The results of the haemoglobin test will be available immediately and can be discussed with a health care professional should any abnormalities be found.

- We will also ask you for a **small sample of blood (15 ml) at visits 1 and 4**. A phlebotomist (a person who is trained and experienced with taking venous blood) will take the venous blood samples. The blood will be used to test for serum ferritin and C - reactive protein for a better understanding of your iron status. The blood sample will also be used to test for the vitamin folate, which is important during pregnancy. We will also measure thyroid hormones and selenium in your blood, both selenium and iodine are required for the production of thyroid hormones, people in New Zealand are at risk of deficiency of these nutrients. These results will be available at a later stage. You will be sent a letter if any abnormalities in your bloods are found which you can discuss with your health care provider.

- We will ask you to provide a **small urine sample** to measure iodine & selenium levels during visits 1, 2 and 4. These urine samples will be frozen and sent for analysis. Results will be available at a later stage.

- We will ask you to **complete a 4-day food record** to measure your food intake at home in your own time. We will provide all the equipment you need. We would like this to be completed after visits one and two during pregnancy.

- We will ask you **questions** about supplement use, physical activity history and dietary advice received. In addition, some questions on weight gain guidelines during pregnancy and some personal questions regarding your age and work status. These questionnaires can be completed at home in your own time or during your visit to the Human Nutrition Research Unit. We would like you to complete these during trimester two and three of your pregnancy and when your baby is newborn, 6 weeks and 4 months old.

- At home, we would like you to **measure your physical activity over a 4-day period**. We will provide all the equipment you need. We would like you to place a machine called an accelerometer on your wrist and a heart rate monitor just under your rib cage, which measures your movement you have while you are awake. We would like you to wear this device during trimesters two and three of your pregnancy.

- We will provide you with two small bags to collect your **toenail clippings** in. Toenails can be used to assess your selenium, zinc and manganese status. We would like to collect your nails clippings during trimesters two and three of your pregnancy. We would also like you to continue collecting your toenail clippings after your baby is born. Collection will finish when your baby is 4 months old.

- When you visit the Human Nutrition Research Unit after your baby is born, we would also like to collect some **information on your baby**. Before we do so, we will ask you to sign the consent form for your baby. We would like to weigh and measure the length of your baby. This will be done with standard infant weighing scales and an infant measuring box (like those used by the Plunket nurses). We also have a new PEAPOD®, which is the baby version of the BodPod® to measure your baby's body composition. It works the same way as the BodPod® with your baby lying in the machine while the measurement is taken. We would also like to collect a sample of your baby's urine to measure their iodine and selenium status. This is done by placing a small urine bag under your baby's nappy for about 20 minutes. At home we would like you to collect your infants nail clippings (in a small bag provided) from when they are 6 weeks to 4 months old to assess their selenium, zinc and manganese status.

Each visit to the Human Nutrition Research Unit should take no more than 2 hours. You are welcome to come with a friend– they may even want to take part in the study themselves if they are pregnant.

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What are the possible benefits and risks of this study?

You will receive an individual assessment of your dietary intake and body composition measurements at each visit. Your baby will receive an additional weight and height check and body composition measurements.

Foreseeable risk, adverse-effects and discomforts that you may encounter by taking part in this study are minimal but could include possible infection at the site from which the blood sample is taken. There may be some minor bruising from the blood-sampling site. There is no foreseeable risk for the baby.

Who pays for the study?

There is no cost to you, the participant, for taking part in the study.

In recognition for your time and participation in this study, we will offer you a koha of $20 per visit.

What if something goes wrong?

If you were injured in this study, you would be eligible to apply for compensation from ACC just as you would be if you were injured in an accident at work or at home. This does not mean that your claim will automatically be accepted. You will have to lodge a claim with ACC, which may take some time to assess. If your claim is accepted, you will receive funding to assist in your recovery.

If you have private health or life insurance, you may wish to check with your insurer that taking part in this study will not affect your cover.

What are my rights?

Participating in this study is voluntary for you and your baby. Consent for this study for you and your baby can be withdrawn at any time.

You, the participant have the right to access information about you or your baby, collected as part of this study.

Continued participation in this study will be stopped in the event of a fetal abnormality diagnosis or complications to the pregnancy that may affect fetal growth. In the event of a miscarriage, stillbirth or preterm birth, your data may not be included in the study.

It is important to us that we maintain your privacy throughout this study. Your name and contact information will be held electronically and stored on the Principal Investigators password protected computer only for data recording purposes. Each participant and her baby in the study will be allocated a number. Staff involved in blood sampling and analysis will have access to participant numbers only. All data from test sessions will be recorded against your participant ID number and your name will never be used in any report, correspondence or publication. Your involvement in this study is confidential.

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What happens after the study or if I change my mind?

The study data will be stored at a secure location at Massey University Palmerston North Campus. Electronic data and records will be the responsibility of the principal investigator. All data will be kept for 20 years, at which point it will be destroyed using university security methods for removal of confidential material. The collected biological samples will be frozen, labelled with a unique code (no personal information will be displayed on the samples), and then stored for 10 years at Massey University Palmerston North Campus. Samples stored will be used only for future analyses related to this study, they will not be used for any research unrelated to this project. After 10 years, the samples will be properly disposed in biohazard bags to be incinerated (burned) by a professional company who specialise in destroying biological samples.
You may hold beliefs about a sacred and shared value of all or any tissue samples removed. The cultural issues associated with storing your tissue should be discussed with your family/ whānau as appropriate. There are a range of views held by Māori around these issues; some iwi disagree with storage of samples citing whakapapa and advise their people to consult before participating in research where this occurs. However, it is acknowledged that individuals have the right to choose. However, we are unable to return body fluids such as blood and urine due to safety (microbiological) issues.

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 the researcher of the study.

If you want to talk to someone who is not involved with the study, you can contact an independent health and disability advocate on:

Phone : 0800 555 050
Fax: 0800 2 SUPPORT (0800 2787 7678)
Email: advocacy@advocacy.org.nz

For Maori health support please contact :

Name: Dr Sharon Henare. *Lecturer: School of Health Science, Massey University, Palmerston North.*
Telephone number: +64 (06) 356 9099 ext. 84289
Email: S.J.Henare@massey.ac.nz

You can also contact the health and disability ethics committee (HDEC) that approved this study on:

Phone: 0800 4 ETHICS
Email: hdecs@health.govt.nz

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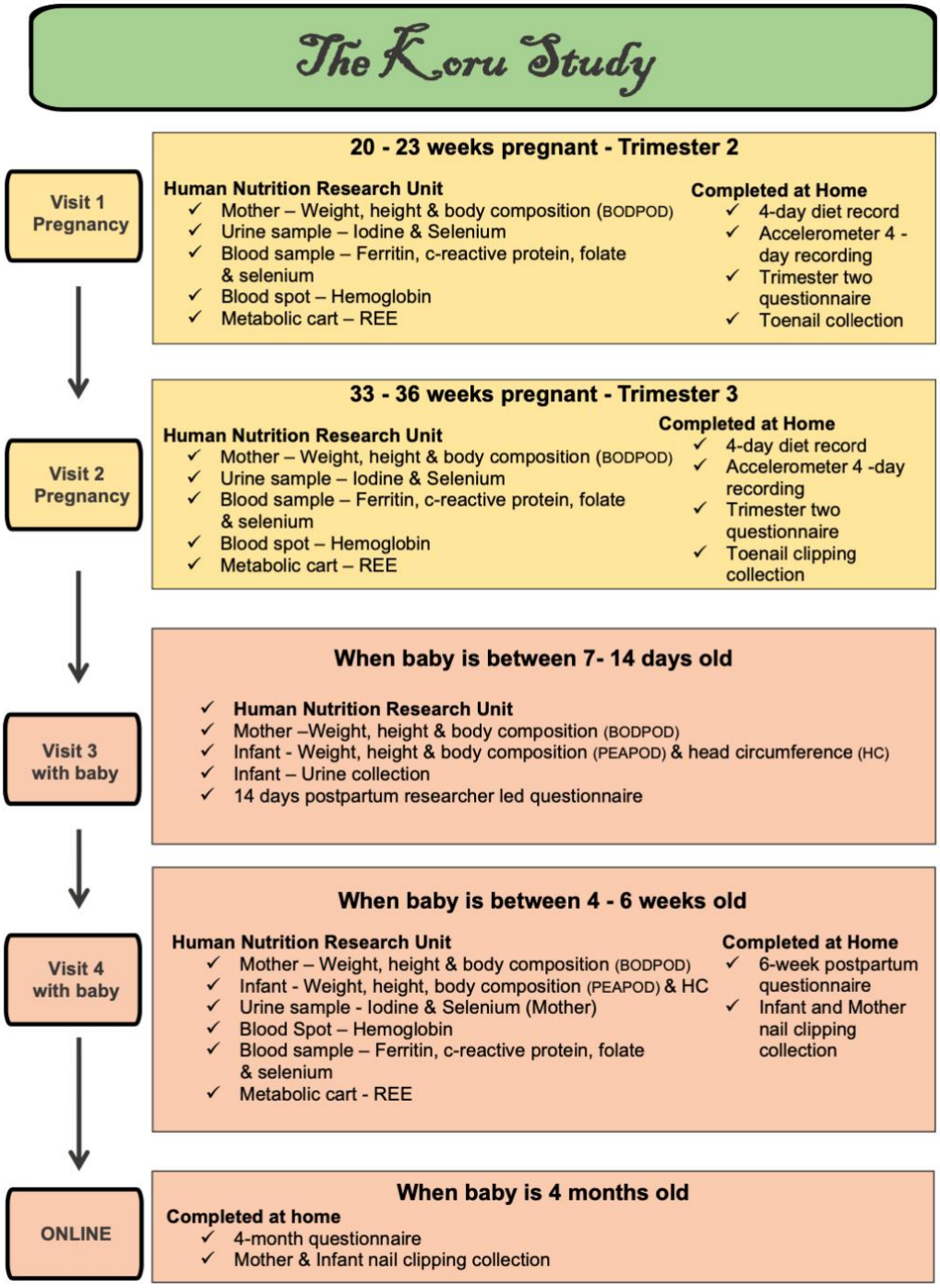
The Koru Study Flowchart



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Consent Form for ADULT - The Koru Study

Please tick to indicate you consent to the following
If you need an INTERPRETER, please tell us

I have read, or have had read to me in my first language, and I understand the Participant Information Sheet.	Yes ☐	No ☐
I have been given sufficient time to consider whether or not to participate in this study.	Yes ☐	No ☐
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.	Yes ☐	No ☐
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.	Yes ☐	No ☐
I understand that taking part in this study is voluntary (my choice) and that I may withdraw from the study at any time without this affecting my medical care.	Yes ☐	No ☐
I consent to the research staff collecting and processing my information, including information about my health.	Yes ☐	No ☐
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.	Yes ☐	No ☐
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.	Yes ☐	No ☐
I know who to contact if I have any questions about the study in general.	Yes ☐	No ☐
I consent to the research staff collecting information about my baby's health when he/she is born.	Yes ☐	No ☐
I understand my responsibilities as a study participant.	Yes ☐	No ☐
I wish to receive a summary of the results from the study.	Yes ☐	No ☐

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:** _____

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Consent Form for Baby - The Koru Study

Please tick to indicate you consent for your baby to the following

If you need an INTERPRETER, please tell us.

I have read, or have had read to me in my first language, and I understand the Participant Information Sheet.	Yes ☐	No ☐
I have been given sufficient time to consider whether or not to allow my baby to take part.	Yes ☐	No ☐
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.	Yes ☐	No ☐
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.	Yes ☐	No ☐
I understand that the participation of my baby in this study is voluntary (Parents/Guardians choice) and that he/she may withdraw from the study at any time without this affecting his/her medical care.	Yes ☐	No ☐
I consent to the research staff collecting and processing my baby's information, including information about their health.	Yes ☐	No ☐
I consent to the research staff using my baby's health information collected at birth.	Yes ☐	No ☐
If I decide to withdraw from the study, I agree that the information collected about my baby up to the point when I withdraw may continue to be processed.	Yes ☐	No ☐
I understand that my baby's participation in this study is confidential and that no material, which could identify my baby personally, will be used in any reports on this study.	Yes ☐	No ☐
I know who to contact if I have any questions about the study in general.	Yes ☐	No ☐
I understand the responsibilities for my baby in participating	Yes ☐	No ☐
I wish to receive a summary of the results from the study.	Yes ☐	No ☐

Declaration by parent/caregiver:

I, _____ (Full name),

Caregivers of _____ (Baby's name if known)

Hereby consent to my baby taking part in this study

Signature: _____ **Date:** _____

Declaration by member of research team:

I have given a verbal explanation of the research project to the parent/caregiver, and have answered the participant's questions about it. I believe that the parent/caregiver understands the study and has given informed consent for their baby to participate.

Researcher's name: _____

Signature: _____ **Date:** _____