Adherence to food and nutrition guidelines in community dwelling older adults living in New Zealand

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Abstract

Aim and objectives: The aim of this research was to determine the level of adherence to food and nutrition guidelines in community dwelling older adults living in New Zealand using data from the Researching Eating, Activity and Cognitive Health (REACH) study. The objectives of this research were to compare dietary intakes of participants against age and sex specific food and nutrition guidelines and Nutrient Reference Values (NRVs).

Methods: Cross-sectional data were collected from community dwelling older adults (n=371) aged 65-74 years between 2018-2019. Participants completed a health and demographic questionnaire and a four-day food record as part of the REACH study. Completed data (n=330) were analysed and compared with New Zealand food and nutrition guidelines including recommended food group servings (RFGS) and NRVs for older adults.

Results: Less than 50% of overall participants adhered to RFGS for fruits, vegetables, grains, and dairy products. Protein was the most adhered to RFGS (54% of males, 58% of females) while dairy products were the least adhered to (11% of males, 1% of females). Nutrient Reference Values (estimated average requirement (EAR) or adequate intake (AI)) were generally well adhered to (>50% adherence) except for calcium (49% of males, 23% of females). Adherence to acceptable macronutrient distribution ranges (AMDR) was low (<50%) for total fat and carbohydrates. Protein was the most adhered to AMDR (70% of males, 76% of females), while the recommended limit for saturated fat was the least adhered to (19% of males, 16% of females). Overall, participants had low adherence to food and nutrition guidelines.

Conclusion: This research identified that the community dwelling older adults who participated in this research had generally low adherence to food and nutrition guidelines. As poor nutritional status and dietary intake has been directly associated with poor health outcomes, especially in older adults, these findings highlight the need for further investigation of adherence to food and nutrition guidelines using a sample which is representative of the New Zealand older adult population.

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List of Abbreviations and Symbols

Abbreviation or symbol	Definition
4-DFR	4-day food record
AI	Adequate intake
AMDR	Acceptable macronutrient distribution range
BMI	Body mass index
BMR	Basal metabolic rate
CVD	Cardiovascular disease
EAR	Estimated average requirement
FBDG	Food based dietary guideline
HNRU	Human Nutrition Research Unit
NCD	Non-communicable disease
NRV	Nutrient reference value
NZ	New Zealand
NZANS	New Zealand Adult Nutrition Survey
NZHS	New Zealand Health Survey
NZRD	New Zealand Registered Dietitian
RDI	Recommended dietary intake
REACH	Researching Eating, Activity and Cognitive Health
RFGS	Recommended food group serving
SD	Standard deviation
SDT	Suggested dietary target
T2DM	Type 2 diabetes mellitus
Y	Year
%	Percent
<	Less than
≤	Equal to or less than
=	Equal to
>	Greater than
≥	Equal to or greater than
±	Plus-minus

Chapter 1. Introduction

1.1 Background

Dietary intake in older adults in New Zealand is of particular interest due to population aging and the known link between nutritional status and related health outcomes. By 2051, the population aged 65 years and older is expected to double and this age group will make up a quarter of New Zealand's population (Ministry of Health, 2013a). As people age, their nutrient requirements change and increasing age has been linked to multiple nutritional deficiencies. Changes to appetite, normal physiological processes, chewing and swallowing difficulties, and an overall decreased oral intake can all contribute to nutritional deficiencies seen in older adults (Ministry of Health, 2013a; Tay, 2021). In older people, good nutrition is associated with multiple positive health outcomes including the prevention of malnutrition, optimal physical functioning, reduced risk of chronic diseases, better mental health, and prevention of disabilities (Ministry of Health, 2013a).

Food and nutrition guidelines refers to eating guidelines which inform optimal eating habits based on consumption of different food groups. The purpose of food and nutrition guidelines is to provide an easy-to-follow framework for the public as well as a guide for health professionals to assess adequacy of dietary intake. They are unique to each country and are developed using currently accepted scientific literature. Adoption of food and nutrition guidelines is associated with positive health outcomes. For healthy older adults, the current New Zealand food and nutrition guidelines are presented as the 'Eating for Healthy Older People/Te kai tōtika e ora ai te hunga kaumātau' booklet, revised in 2021 (HealthEd & Ministry of Health, 2006). Information included in the booklet is based on the 'Food & Nutrition Guidelines for Older People: A Background Paper' including the 2006 Nutrient Reference Values (NRVs) (Ministry of Health, 2013a) and the 'New Serving Size Advice: Info Sheet' (Ministry of Health, 2020d). In 2020, the 'New Serving Size Advice: Info Sheet' was released which provided updated recommended daily food group servings and serving sizes. The purpose of the updated serving recommendations was to align with Australian servings sizes and with the NRV age groups.

Nutrient Reference Values for Australia and New Zealand were published in 2006 as a joint initiative between the Australian National Health and Medical Research Council, Australian Government Department of Health and Ageing, and the New Zealand Ministry of Health

(Australian National Health and Medical Research Council et al., 2006). Nutrient Reference Values were developed to provide recommendations on daily intakes of essential nutrients to promote optimal health outcomes (Ministry of Health, 2006). They are nutrient based guidelines and were intended for use by healthcare professionals (Ministry of Health, 2013c).

International studies on adherence to food and nutrition guidelines have found that levels of adherence vary between countries. The most recent nationwide New Zealand Adult Nutrition Survey (NZANS) was completed in 2008/09 (University of Otago & Ministry of Health, 2011) and the most recent New Zealand Health Survey (NZHS) in 2021/22 (Ministry of Health, 2022a). The 2008/09 NZANS and 2021/22 NZHS assessed adherence to food and nutrition guidelines for recommended food group servings (RFGS) for fruits and vegetables only. The 2008/09 NZANS assessed adherence to Nutrient Reference Values (NRV) while the 2021/22 NZHS did not. Key findings of the 2008/09 NZANS found: mean daily intake of saturated fat for all adults >51y exceeded the recommended limit, mean intake of dietary fibre did not meet adequate intake (AI) for all adults >51y, mean intake of calcium did not meet EAR for males >70y and females >51y. Data from the 2008/09 NZANS are more than 13 years old and therefore levels of adherence to NRV may no longer be accurate.

1.2 Purpose of the study

Currently, there is limited evidence regarding the level of adherence to food and nutrition guidelines and NRVs in older adults living in New Zealand. This research aims to provide insight and fill the gap in the literature regarding the current levels of adherence to food and nutrition guidelines in older adults living in New Zealand. The findings of this research will allow for a better understanding of the current eating habits of older New Zealanders and to identify if there is a need for further research.

1.3 Aims and objectives

The aim was to determine the level of adherence to food and nutrition guidelines in community dwelling older adults living in New Zealand using data from the Researching Eating, Activity and Cognitive Health (REACH) study.

Objectives:

1. To compare the dietary intake of older adults against recommended food group servings (RFGS).
2. To compare the nutrient intakes of older adults against Nutrient Reference Values (NRV).

1.4 Structure of thesis

This thesis is divided into four chapters. Chapter one is the introduction chapter, it introduces the background including the purpose, aims and objectives of the research. Chapter two is a narrative review of the current literature relevant to this research including links between dietary intake and health status in older adults, development of food and nutrition guidelines, and prior research on levels of adherence to guidelines in older adults. Chapter three is presented as a manuscript in a journal formatted style and includes a concise summary of the methods, results, and discussion. Chapter four provides the final conclusions to the research with recommendations for future research. The appendices provide additional information and supplementary materials including the participant questionnaire and four day food record template used for data collection.

1.5 Research contributions

Table 1. *Researchers' contributions to the study*

Researcher	Contributions to research
Rebecca Sidford	Main researcher and author. Responsible for determining dietary intake of food groups and nutrients, statistical analysis, interpretation, writing, editing and final thesis preparation.
Associate Professor Kathryn Beck	Main academic supervisor for the research. Principal investigator on the REACH study.
Associate Professor Cathryn Conlon	Co-academic supervisor for the research. Co-investigator on the REACH study.
Dr Karen Mumme	Co-academic supervisor for the research. Co-investigator on the REACH study. Assistance with data collection, data entry and statistical analysis.

Professor Pamela von Hurst	Co-investigator on the REACH study.
Owen Mugridge	Co-ordinator of the REACH study. Participant recruitment and data collection.
Cassie Slade	Participant recruitment, data collection, and data entry.
Nicola Gillies, Cherise Pendergrast, Angela Yu, Kimberly Brown and Harriet Guy	Assistance with data collection and data entry.

Chapter 2. Literature review

This chapter reviews the current literature on the relationship between nutritional status and health outcomes with increasing age, purpose and development of food and nutrition guidelines internationally, the current food and nutrition guidelines for older adults, current knowledge of dietary intake in older adults living in New Zealand, and international rates of adherence to food and nutrition guidelines.

2.1 Introduction to the literature review and search strategy

There are three sub-categories of interest which this literature review will explore:

1. Background information including population aging, the effects of aging on health and nutritional status, and selected nutrients of concern for older adults.
2. The purpose and development of food and nutrition guidelines and Nutrient Reference Values for healthy older adults.
3. Previous studies on the nutritional intake and adherence to food and nutrition guidelines in older adults.

The literature review search was completed between October 2021 and December 2022. Databases searched included Google Scholar, Massey Library Discover, PubMed, and ScienceDirect. Statistics New Zealand and the Ministry of Health provided current statistical data. Search terms were derived from the study objectives for each literature review subparagraph (Figure 1).

Date searched: October 2021 – December 2022

Search criteria: Older adults OR geriatric OR elderly OR older people OR retired. Aging and nutrition* status OR aging and nutrition* requirements OR aging and health status. Food based dietary guidelines OR food and nutrition guidelines OR nutrition* guidelines OR nutrient recommendations OR FBDG adher* OR compliance. food and nutrition guidelines and dietary intake in older adults. New Zealand OR NZ OR Aotearoa OR developed countries OR developing countries

Filters: Past 5 years, Past 10 years, Past 15 years

Electronic databases: Google Scholar, Massey Library Discover, PubMed, and ScienceDirect.

Figure 1. *Search strategy for the literature review*

2.2 The relationship between aging, nutritional status, and health outcomes

Nutritional requirements change with increasing age. As the body ages, it becomes more susceptible to deleterious health conditions. Poor nutritional status is directly correlated with an increased risk of developing poor health outcomes. Therefore, it is important that nutritional requirements are met, especially with increasing age, to promote positive health outcomes for individuals and populations.

2.2.1 Aging and the effects of aging on health status

The number of New Zealanders aged 65 and older is projected to double by the year 2048 with the percentage of New Zealanders aged 65 years plus increasing from 16% in 2020 to 21-26% in 2048 (Statistics New Zealand, 2020). This demographic shift in median age has been termed 'population aging' (World Health Organisation, 2022) and is thought to be the result of multiple factors. Increased life expectancy, decreased fertility rates, and aging of the 'baby boomer' generation are thought to be contributing factors to population aging (Boz & Ozsari, 2020; Clegg & Williams, 2018; United States Census Bereau, 2019). With population aging comes an increased demand for health care (Boz & Ozsari, 2020). It is predicted that the increased proportion of New Zealanders aged 65 years and older will result in a significant increase in the demand for health care and disability support services (Cornwall & Davey, 2004; Dale, 2017; Ministry of Health, 2002).

There is an increased interest in health with increasing age due to the health-related changes experienced with aging (Lahmann & Kumanyika, 1999). Biologically, aging is described as the result of the accumulation of molecular and cellular damage. This results in the gradual decrease in physical capacity and mental functioning which increases the risk of poor health and ultimately results in death (World Health Organisation, 2022). This is reflected statistically as older people aged 65 years and above sustained more than one third (37%) of total health loss despite making up only 12% of the population (Ministry of Health, 2013b). Additionally, the 2021/22 New Zealand Health Survey (NZHS) identified that there is a positive linear

relationship between increasing age and likelihood of seeking healthcare from a general practitioner (GP) or medical practice within the past 12 months (Ministry of Health, 2022a).

Older people have a greater degree of variability in organ function compared to younger people (Steves et al., 2012), meaning that there is a wide range of health status seen in older adults (Boyce et al., 2020). Therefore some individuals may experience good health with aging whilst others may experience decline in physical and/or mental capacity which may require long term care (World Health Organisation, 2015). The World Health Organisation has estimated that approximately half of all poor health outcomes seen in older people could potentially be avoided with lifestyle changes (World Health Organisation, 2015). Healthy aging, also referred to as positive aging, is described as having "high physical, psychological and social functioning in old age without major diseases," (Rowe & Kahn, 1987). Healthy aging is influenced not only by genetic factors but also environmental and social influences (World Health Organisation, 2021).

2.2.2 Physiological, social, and environmental factors that can affect nutritional status

Increasing age is independently associated with a decreased nutritional status (Forster & Gariballa, 2005). The cause of decreased nutritional status in older adults is related to multiple factors including physiological, social, and physical environment changes which are often seen with aging (Bardon et al., 2021).

Physiological

There is an accumulation of evidence which has found that the physiological mechanisms that control food intake and body composition diminish with increasing age (De Castro, 2002). Physiological changes with increasing age which may affect nutritional status include altered taste and olfaction, changes to the oral cavity, changes to the gastrointestinal tract and slower gastric emptying, altered hormonal responses and decreased basal metabolic rate (Drewnowski & Shultz, 2001).

- Taste and olfaction - These sensory stimuli contribute to food preferences, appetite, and hunger cues. Older adults demonstrate a significantly diminished sense of both odour and taste when compared to younger adults (Kaneda et al., 2000). Individuals living with olfactory disorders enjoy food less and are more likely to have a diminished appetite (Croy

et al., 2014; Gopinath et al., 2016). This supports the idea that physiological changes in sensory function seen in aging may affect food intake and therefore nutritional status.

- Oral cavity - Changes to the oral cavity, and gastric secretions of digestive juice are also seen with increasing age which have an effect on nutrient intake (Brownie, 2006). With increasing age changes to the oral cavity often results in pain, tooth loss, and swallowing difficulties. These changes may influence the types and amounts of food which are consumed (Walls et al., 2000). Ervin and Dye (2009) found that older people with no teeth or who wore dentures were likely to consume less fruit and vegetables.
- Gastrointestinal tract - Changes to the gastrointestinal tract with increasing age include changes to the oesophagus, reduced gastric secretions, decreased motility of the intestines, and delayed colonic transit (Firth & Prather, 2002). Presbyoesophagus, which refers to age related changes of the oesophagus, can cause decreased oesophageal sphincter function which may result in dysphagia or gastroesophageal reflux disease. Changes in swallowing ability can affect the type and quantity of food and drink ingested due to fears of choking or pain. It is reported that 39.2% of individuals with dysphagia are at risk of malnutrition (Ueshima et al., 2021). Normal aging is associated with decreased gut motility (O'Mahony et al., 2002) which can lead to feelings of early satiety and prolonged feelings of fullness as gastric motility is a key mediator in feelings of hunger, satiety, and satiation (Janssen et al., 2011).
- Hormone secretion - Increasing age is associated with altered hormone secretion. With increasing age there is an increase in satiety hormones including peptide tyrosine (PYY) and cholecystokinin (CCK) with a simultaneous decrease in hunger hormones such as ghrelin (Moss et al., 2012). Changes in gut hormones affect the mechanisms regulating appetite and satiation and can contribute to decreased dietary intake in older adults (Atalayer & Astbury, 2013).
- Basal metabolic rate – Basal metabolic rate refers to the amount of energy which the body expends whilst at complete rest. Basal metabolic rate decreases at an almost linear rate with increasing age which may be due wholly to reduced lean muscle mass which is observed with increasing age (Shimokata & Kuzuya, 1993). Reduced basal metabolic rate with age means that energy requirements decrease with increasing age and excess energy intake may result in accumulation of fat stores and contribute to the development of obesity (Roberts & Rosenberg, 2006).

Social

Social influences are another contributing factor which may lead to decreased nutritional status in older adults. Bereavement and social isolation may occur with increasing age and can have a large influence on the dietary intake of older adults.

Bereavement, meaning the grieving process following the loss of a relative or close friend to death, can occur at any stage in life but is more common with increasing age. Bereavement in older adults has been identified as a strong risk factor for poor overall health outcomes, including nutritional status (Stahl & Schulz, 2014). Loss of a spouse in older adults has been causally associated with an overall increased risk of mortality with one study finding a 12% decrease in life expectancy following spousal bereavement (van den Berg et al., 2011).

Older adults are at an increased risk of social isolation and loneliness due to retirement, unexpected loss of loved ones, separation from friends and family, loss of mobility and reduced access to transportation (National Institute on Aging, 2019). The social facilitation of eating refers to the empirical fact that individuals eat more when eating with friends or family compared to eating alone (Herman et al., 2019; Ruddock et al., 2021). Social isolation and loneliness have been directly associated with dietary inadequacies, especially for energy and calcium in older adults (Walker & Beauchene, 1991).

Physical environment

With increasing age, individuals may experience changes in environmental factors which may impact their nutritional status. Examples of environmental factors include changes to employment, economic status, and mobility. The common age for retirement in New Zealand is 65 years old which is the qualifying age for superannuation (Employment New Zealand, n.d.). With retirement comes changes to lifestyle and economic status. A systematic review reported it was unclear whether retirement had favourable or unfavourable impacts on lifestyle choices and nutritional status (Zantinge et al., 2014). Some studies have found that retirement is linked to an increase in alcohol consumption, decreased mental capacity, and in males an increased body mass index (BMI) (Feng et al., 2020; Rohwedder & Willis, 2010; Zantinge et al., 2014). Others have found that retirement can have a positive effect on dietary intake, including increased vegetable consumption, and healthier food choices in women (Helldán et al., 2012; Plessz et al., 2015). Retirement is associated with a 5-16% increase in difficulties

relating to mobility (Dave et al., 2008). Additionally, increasing age itself is associated with decreased mobility (Ferrucci et al., 2016). Limited mobility and issues with transportation cause issues with food procurement processes and meal preparation (Wham & Bowden, 2011). In particular, home-bound older adults may confront challenges in accessing fresh foods including fruits and vegetables (Nicklett & Kadell, 2013). Difficulties with food procurement and preparation due to mobility and transportation issues may result in food insecurity and increased risk of poor nutritional status and malnutrition (Vilar-Compte et al., 2021).

2.2.3 Poor health outcomes related to decreased nutritional status in older adults

As outlined above, there are numerous physiological, social, and environmental factors which can contribute to decreased nutritional status in older adults. It is important to acknowledge the potential poor health outcomes that can result from decreased nutritional status seen in older adults. This section will review the current literature on the nutrition related states of disease significant to older adults in New Zealand.

Malnutrition

The generally accepted definition for malnutrition refers to the state where nutritional requirements are not met due to either nutritional deficiency, excess, or imbalance and results in measurable adverse health outcomes (Alemu, 2020; Saunders & Smith, 2010). Malnutrition is often used synonymously with undernutrition, however, in correct terms, malnutrition denotes both under and over nutrition (Maleta, 2006)

- Undernutrition – This type of malnutrition refers to the insufficient intake of energy and nutrients to meet the requirements of an individual to maintain good health (Maleta, 2006). When energy and nutrients are insufficient, it is likely that the intake of vitamins and minerals will also be insufficient (Morley, 2022). Long term insufficient intake of energy and nutrients results in the depletion of body stores and can result in numerous serious poor health outcomes including fat and muscle wasting, frailty and loss of independence (Salminen et al., 2020).
- Overnutrition – Overnutrition refers to the overconsumption of nutrients leading to accumulation of body fat and impairment of health (overweight/obesity) (Mathur & Pillai, 2019). Overweight and obesity are associated with increased risk of serious health consequences including cardiovascular diseases, type 2 diabetes mellitus, osteoarthritis and some cancers (World Health Organisation, 2013).

Non-communicable diseases

Nutrition related diseases are not spread from person to person and are therefore referred to as non-communicable diseases (NCDs) (United Nations Children's Fund (UNICEF), n.d.). Non-communicable diseases are often complex diseases linked to multiple contributing factors including genetic predisposition, environmental influences, and modifiable lifestyle risk factors including nutritional status (Peters et al., 2019; World Health Organisation, n.d.). Selected NCDs relevant to older adults with significant nutritional risk factors are outlined in Table 2.

Table 2. *Selected NCDs, definitions and nutritional risk factors of each*

NCD	Definition	Lifestyle and nutritional risk factors
Cardiovascular diseases (CVDs)	A group of diseases relating to the heart and blood vessels including stroke, heart disease and high blood pressure.	Being overweight/obese. High consumption of saturated fat, trans-fat, added sugars, and sodium. Low intake of fruits and vegetables, wholegrains, low fat dairy products, and lean protein (Centres for Disease Control and Prevention (CDC), n.d.).
Type 2 diabetes mellitus (T2DM)	Inability for the body to effectively utilise glucose which results in abnormally high blood glucose levels.	Being overweight/obese. High consumption of refined grains, processed foods, and added sugars. Low intake of fruits and vegetables, wholegrains, nuts, and legumes (Ardisson Korat et al., 2014).
Some cancers	The uncontrolled division of abnormal cells which destroy healthy body cells.	Being overweight/obese. High consumption of alcohol, saturated fats, trans fat, added sugars, red and processed meat. Low intake of fruits and vegetables, wholegrains, and legumes (Key et al., 2020; *Preventing cancer*, n.d.)
Osteoporosis	Weak and brittle bones caused by reduced bone mineral density.	Being malnourished. Low dietary intake of calcium, protein energy, zinc, magnesium, and vitamin C. (Ilich et al., 2003).

2.2.4 Specific nutrients of concern for older adults

Nutritional requirements change with age due to decreased basal metabolic rate, loss of lean muscle mass, and reduced level of physical activity. This means that the nutritional needs of an older adult are different to those of a younger adult. Table 3 outlines specific nutrients of concern for older adults and their primary function in the body.

Table 3. *Specific nutrients of concern and significance for older adults*

Nutrient	Significance in older adults
Energy	Energy is essential for normal daily body functions. If energy requirements are not met through dietary intake, body stores of fat and protein are used as energy. If dietary intake does not provide adequate energy intake over time muscle and fat wasting will occur and eventually malnutrition will develop (Saunders & Smith, 2010).
Protein	Adequate protein intake is essential for maintaining lean muscle mass. Older adults (>70y) have a 25% higher recommended protein intake per day than younger adults (National Health and Medical Research Council et al., 2006). Adequate protein intake in older adults can promote muscle health and strength and prevent muscle wasting and the development of sarcopenia (Coelho-Junior et al., 2022; Paddon-Jones & Rasmussen, 2009).
Dietary fibre	Dietary fibre plays an important role in maintaining health by providing satiation and promoting bowel motions. Inadequate dietary fibre intake can lead to constipation and increased risk of chronic diseases including obesity, diabetes, cardiovascular diseases, and colon cancer (Dahl & Stewart, 2015). Due to reduced gut motility and related increased risk of constipation seen in older adults, consuming adequate dietary fibre is important in maintaining bowel health.
Calcium	Calcium plays a central role in maintaining bone and teeth health and is an important component in blood clotting and muscle and nerve functioning. Older adults have increased calcium requirements due to an increased rate of bone breakdown which is experienced with aging, especially in females. If calcium intake does not meet requirements, bone breakdown occurs to release calcium into the blood stream. Over time inadequate calcium intake causes low bone mineral density which increases the risk of fracture and the development of osteoporosis (Kim et al., 2014).
Vitamin B6	Vitamin B6 is a coenzyme which plays an essential role in numerous reactions in the body, including metabolism, cognitive function, immunity and haemoglobin formation (Institute of Medicine, 1998). Older adults have higher dietary requirements of vitamin B6 due to reduced absorption, increased catabolism, and decreased phosphorylation with increased age (Kjeldby et al., 2013; Morris et al., 2008).
Vitamin B12	Vitamin B12 is essential for nerve and brain function and the formation of red blood cells and deoxyribonucleic acid (DNA). Long term deficiency can lead to a decline in cognitive function and permanent nerve damage (Center for Peripheral Neuropathy, 2010). With increasing age, the body's ability to absorb vitamin B12 from dietary sources declines. This is primarily due to decreased stomach acid secretions which reduces the absorption of food-bound vitamin B12 (Stover, 2010). This decrease in vitamin B12 absorption from dietary sources in older adults highlights the importance of meeting dietary recommendations.
Vitamin E	Vitamin E is a potent fat soluble antioxidant which has been associated with reduced cardiovascular disease risk (Rimm et al., 1993), diabetic complications (Institute of Medicine, 2000), certain cancers (Yong et al., 1997) and cataracts (Knekt et al., 1992). As increased age is linked to an increased risk of these diseases, adequate vitamin E intake may reduce likelihood of development.

Sodium	The body needs small amount of sodium to function properly, however, excessive sodium intake is associated with increased blood pressure which is a major risk factor for cardiovascular disease and stroke (Center for Disease Control, 2021; Cogswell et al., 2016).
Potassium	The main roles of potassium are to maintain fluid balance and promote muscle contractions (National Institutes of Health, 2022). The body requires potassium levels to stay within a very narrow range and even minor fluctuations in potassium levels can have severe consequences on the body. With increasing age there are often changes to the kidney which affect its ability to filter potassium from the blood resulting in decreased potassium excretion in the urine and increased risk of hyperkalaemia (Schlanger et al., 2010). Oppositely, being on some medications including diuretics can increase the rate of potassium excretion and increase risk of hypokalaemia (Franse et al., 2000).
Magnesium	Magnesium is a key mineral in the body and is required for numerous reactions and is most well-known for its role in nerve and muscle functioning (Institute of Medicine, 1997). Depletion of magnesium has been associated with insulin resistance and impaired insulin secretion (Paolissa et al., 1990) and supplementation may improve glucose tolerance and insulin response in the elderly (Paolissa et al., 1992).

2.3 Introduction to food and nutrition guidelines

Food and nutrition guidelines are a set of dietary recommendations based on consumption of different food groups and nutrients. They are developed using accepted scientific literature and the adoption of food and nutrition guidelines contributes to promotion of human health and reduces risk of malnutrition (Cámara et al., 2021).

2.3.1 Purpose and development of food and nutrition guidelines internationally

Food and nutrition guidelines are unique to each country and are designed specifically based on the cultural eating practices and behaviours of a nation (Andrade & Andrade, 2016; Cámara et al., 2021). The Food and Agriculture Organization (FAO) is the international organisation which assists countries in the development, revision, and implementation of dietary guidelines which are in line with the most recent scientific literature (Food and Agriculture Organization, n.d.). To date, more than 100 countries have implemented food and nutrition guidelines with the assistance of FAO. The purpose of food and nutrition guidelines is to provide guidance for policies which foster healthy eating habits and lifestyles in public health, nutrition education, and agriculture sectors (Food and Agriculture Organization, n.d.). Adoption of food and nutrition guidelines at country specific levels contributes to prevention of all forms of malnutrition and the promotion of optimal health status (Cámara et al., 2021).

2.3.2 Development of New Zealand food and nutrition guidelines for older adults

New Zealand food and nutrition guidelines for older adults were first published in June 1993 as 'Food & Nutrition Guidelines for Older People' by The Public Health Commission. There have since been numerous updates to the guidelines to reflect updated nutritional literature (Table 4). The current dietary guidelines for older adults are titled 'Food & Nutrition Guidelines for Older People: A Background Paper' and were published by the Ministry of Health in 2013. The most recent update to the guidelines was published in 2020 as a supporting document titled 'New Serving Size Advice: Info Sheet'. This 2020 update was released as previous serving sizes were produced in 1991 and were based on food items and serving sizes that were consumed in the late 80s. New Zealand's food environment and eating patterns have significantly changed since then (Ministry of Health, 2020d). The updated 2020 'New Serving Size Advice: Info Sheet' implemented evidence-based Australian serving size advice (Ministry of Health, 2020c). The guidelines are designed for use by health professionals. The 'Eating for Healthy Older People/Te kai tōtika e ora ai te hunga kaumātau' booklet was originally based on 'Food & Nutrition Guidelines for Older People: A Background Paper' and provides easy to understand dietary guidance for the public. The 'Eating for Healthy Older People/Te kai tōtika e ora ai te hunga kaumātau' booklet was revised in 2021 and includes up-to-date serving sizes and RFGS based on the 2020 'New Serving Size Advice: Info Sheet'.

Table 4. *Timeline of updates to the Food and Nutrition Guidelines for Healthy Older People*

Year	Title	Publisher
1993 (June)	Food & Nutrition Guidelines for Older People: A Background Paper	Public Health Commission (1993)
1996	Food And Nutrition Guidelines for Healthy Older People: A Background Paper	Ministry of Health (1996)
2003 (June)	Eating for Healthy Older People/Te kai tōtika e ora ai te hunga kaumātau booklet	Ministry of Health / HealthEd
2010	Food And Nutrition Guidelines for Healthy Older People: A Background Paper	Ministry of Health (2010)
2013 (January)	Food And Nutrition Guidelines for Healthy Older People: A Background Paper *Note: Updated from 2010 version to include data from 2008/09 NZANS*	Ministry of Health (2013a)
2020 (November)	New Serving Size Advice: Info Sheet	Ministry of Health (2020d)
2021 (April)	Eating for Healthy Older People/Te kai tōtika e ora ai te hunga kaumātau booklet	HealthEd and Ministry of Health (2006)

Recommended food group servings

The Eating for Healthy Older People/Te kai tōtika e ora ai te hunga kaumātau booklet provides healthy eating and lifestyle recommendations specific to promoting optimal health outcomes in older adults (HealthEd & Ministry of Health, 2006). Recommended food group servings (RFGS) are included in the booklet and provide age and sex specific serving recommendations for each food group. The RFGS differ by sex and age group due to the different nutritional requirements seen between sexes and throughout the lifespan. In New Zealand, there are five main food groups including fruits, vegetables, protein foods, dairy and fortified alternatives, and grains. The RFGS are practical food based guidelines which promote adequate intake of nutrients to meet Nutrient Reference Values (Australian National Health and Medical Research Council et al., 2006). In addition to the RFGS, the booklet provides general healthy lifestyle guidance for older adults. Additional information includes education around choosing foods low in fat, salt, and sugar, drinking plenty of fluids, important vitamins and minerals in aging, food safety recommendations, and guidance around exercising and achieving a healthy body weight (HealthEd & Ministry of Health, 2006).

Nutrient Reference Values

The Nutrient Reference Values (NRV) were developed in 2006 as a joint initiative by the Australian National Health and Medical Research Council (NHMRC), Australian Government Department of Health and Ageing, and the New Zealand Ministry of Health (Australian National Health and Medical Research Council et al., 2006). They provide recommended dietary intakes of essential nutrients including energy, protein, dietary fibre, vitamins, and minerals. The NRVs are nutrient based guidelines rather than food based guidelines and are intended for use by healthcare professionals (Ministry of Health, 2013c). The NRV guidelines were developed to provide reference ranges for intakes of nutrients to promote optimal health outcomes (Ministry of Health, 2006). The NRVs developed in 2006 were incorporated into ‘The Food and Nutrition Guidelines for Healthy Older People: A Background Paper’ in 2010 as appendix 3. Within the NRVs, there are several reference ranges which have been developed based on available scientific literature. Nutrient Reference Value terminology is found in Table 5.

Table 5. *Nutrient reference value terminology*

NRV term	Definition
Acceptable macronutrient distribution range (AMDR)	The estimated percent of energy from each of the macronutrients which would allow for the provision of adequate nutrients while providing optimal health outcomes.
Recommended daily intake (RDI)	The average amount needed to meet 97-98% of the requirements of healthy individuals of a particular age and sex. (RDI = EAR + 2 standard deviations).
Estimated average requirement (EAR)	The amount needed to meet half of the requirements of healthy individuals of a particular age and sex.
Adequate intake (AI)	Used when an RDI cannot be determined. Based on the average intake of healthy individuals who are assumed to have adequate intake.
Upper limit (UL)	The highest level of nutrient intake which is not likely to pose health risks.
Suggested dietary target (SDT)	Average daily intake that may help prevent chronic diseases.

Note: Information sourced from National Health and Medical Research Council & Ministry of Health (2017)

2.3.3 Previous studies of dietary intake in older adults living in New Zealand

There is limited evidence on dietary intake in older adults living in New Zealand. This research considers healthy community dwelling older adults, therefore studies that include very old (>80 years) or frail adults are not included in this section of the literature review.

Nationwide nutrition surveys are used as a method of assessing the dietary choices and nutritional intakes of populations. The New Zealand Adult Nutrition Survey (NZANS) is a national survey which collects information on the food and nutrient intakes of New Zealanders (Ministry of Health, 2011b). The most recent in NZANS was completed in 2008/09 and included a 24-hour food recall, a health questionnaire, and a biological component which included anthropometric and biochemical aspects. Data were collected for 4721 New Zealanders aged 15+ years.

The 2008/09 NZANS reported adherence to RFGS for fruits and vegetables only. Comparison of 2008/09 NZANS data with RFGS guidelines found females were more likely to adhere to both fruit and vegetable RFGS than males for all age groups (Table 6). Updated serving guidelines for vegetables were released in 2020 which recommended an increase to 5.5 servings for males 51-70y and 5 servings for males >70 years and all females and males

(Ministry of Health, 2020d). Therefore, due to updates in RFGS for vegetables, levels of adherence reported in the 2008/09 NZANS are no longer relevant for direct comparison.

Table 6. *Level of adherence to fruit and vegetable RFGS by sex and age group from the 2008/09 NZANS data*

Level of adherence to RFGS	Males 51-70y	Males >70y	Females 51-70y	Females >70y
Fruit (2+ servings/day)	60%	63%	73%	72%
Vegetables (3+ servings/day)	66%	77%	83%	81%

Comparison of the 2008/09 NZANS data against NRV guidelines found that the mean daily intake of multiple nutrients failed to meet recommendations which raises concerns. Mean daily intake of dietary fibre failed to meet AI guidelines for all age and sex groups. Mean daily intake of calcium failed to meet EAR guidelines in males >70y and females >51y. Mean intake of potassium for males and females aged >70y failed to meet AI guidelines. Mean energy contribution from protein, total fat, and carbohydrate were within acceptable macronutrient distribution ranges (AMDR). Mean energy contribution from alcohol was within the recommended limit of <5% of today daily energy intake for all age and sex groups except for males aged 51-70y. Mean energy contribution from saturated fat exceeded the recommended <10% of total energy intake from saturated fat and trans-fat together for all age and sex groups. Table 7 presents the mean nutrient intakes of older adults and comparison with NRV guidelines from the 2008/09 NZANS.

Table 7. *2008/09 NZANS mean nutrient intakes of older adults compared with NRV guidelines*

Nutrient	Males 51-70y	Males >70y	Females 51-70y	Females >70y
Protein (g)	92	79	71	62
Energy from protein (%)	17	16	17	17
Total fat (g)	85	69	66	53
% Energy from total fat	33	32	34	32
Saturated fat (g)	33	27	25	20
% Energy from saturated fat	13***	12***	13***	12***
Carbohydrate (g)	249	227	197	177
% Energy from carbohydrate	46	48	46	49
Dietary fibre (g)	22**	21**	19**	18**
Alcohol (g)	19	13	10	6
% Energy from alcohol	5***	4	4	3
Calcium (mg)	868	785*	775*	710*
Vitamin B6 (mg)	1.9	1.6	1.5	1.3
Vitamin B12 (ug)	5.2	5.7	3.5	3.2

Vitamin E (mg)	11.3	10.5	10.2	8.7
Sodium (mg)	Not reported			
Iron (mg)	13.4	11.8	10.2	9.3
Potassium (mg)	3407**	3176**	2921	2634**
Magnesium (mg)	Not reported			

Notes:
**mean intake does not meet EAR*
***mean intake does not meet AI*
****mean energy contribution does not fall within AMDR range/recommended limit*

The New Zealand Health Survey (NZHS) is completed annually and collects health data for >17,000 adults and children living in New Zealand. The purpose of the NZHS is to gather health information to monitor population health and provide evidence for health policies and strategy developments (Ministry of Health, 2022b). The 2021/22 NZHS assessed adherence to RFGS for fruit and vegetables only using the updated 2020 serving guidelines. The data was not separated by sex and found ~60% of total older adults >65y adhered to fruit guidelines (2+ serves/day) and ~12% adhered to vegetable guidelines (5-5.5+ serves/day) in the 2021/22 NZHS (Ministry of Health, 2022a). The level of adherence to fruit and vegetable guidelines in older adults >65y was similar between the 2020/21 and 2021/22 NZHS.

2.3.4 Previous international studies investigating adherence to food and nutrition guidelines

This section of the literature review will summarise the key findings of international studies which have investigated levels of adherence to food and nutrition guidelines in older adults. Studies selected included those investigating older adults living in developed countries. The key findings demonstrated that levels of adherence differed between countries (Table 8). Differences in levels of adherence between countries may be due to differences in the guidelines rather than differences in dietary intake itself. For example, different countries have different recommended daily servings of food groups and different serving size guidelines. For example, American guidelines recommend ≥2-2.5 servings of vegetables per day whereas Australian and New Zealand guidelines recommend ≥5–5.5 servings. Additionally, serving sizes of food items differ between countries. For example, in New Zealand a serving of cooked vegetables is 75g (Ministry of Health, 2020a) whereas in Switzerland it is 120g (Swiss Society for Nutrition, 2011). Adherence to guidelines for vegetables was low (<50%) across all study populations except for Dutch older adults (65% adherence) (Dijkstra et al., 2014). Adherence to vegetable guidelines was lowest in Australian males 55-65y with 6% adherence (Thorpe et al., 2016). Adherence to RFGS for dairy/dairy alternatives was low across all study populations

in which adherence was assessed (America, Switzerland, and Australia). Adherence to dairy/dairy alternatives was lowest in American females aged 51-70y with only 2% adherence (Krebs-Smith et al., 2010).

Table 8. *Key findings for levels of adherence to food and nutrition guidelines among older adults in developed countries*

Author and year	Study population	Dietary assessment tool	Guidelines used and recommended servings per day	% Adhering to guidelines	
Krebs-Smith et al. (2010)	USA, N=2362, 51-70y	Interviewer administered 24hr food recall	MyPyramid:	Males:	Females:
			Fruit ≥1.5-2	17	27
			Vegetables ≥2-2.5	21	24
			Dairy/alt ≥3	5	2
			Grains ≥5-6	66	59
			Wholegrains ≥3	2	1
			Meat/legumes ≥5-5.5	73	43
de Abreu et al. (2013)	Switzerland, N=4371, mean age 57.6y (±10.5)	Self-administered FFQ	Swiss dietary recommendations:	Total for 60-69y:	
			Fruits ≥2	45	
			Vegetables ≥3	8	
			Meat ≤5/week	66	
			Dairy ≥3	10	
Dijkstra et al. (2014)	Netherlands, N=1057, 55-85y	Self-administered FFQ	Dutch dietary guidelines:	Total:	
			Fruits ≥2	83	
			Vegetables ≥4 tbsp (350g)	65	
Thorpe et al. (2016)	Australia, N= 3468, 55-65y	FFQ	2013 Australian dietary guidelines:	Males:	Females:
			Vegetables ≥5-5.5	6	13
			Fruit ≥2	54	69
			Cereals ≥4-6	2	7
			Meat/alt ≥2-2.5	31	53
			Dairy/alt ≥2.5-4	16	4
			Alcohol <2	83	94

Notes: FFQ (food frequency questionnaire), USA (United States of America) ± (standard deviation), alt (alternative)

2.3 Summary of the literature review

The population is aging with the number of New Zealanders aged 65 years plus expected to double by 2048 (Statistics New Zealand, 2020). Health status and aging are closely related and good nutrition plays an important role in promoting healthy aging (Ministry of Health, 2013c). With increasing age, there is an increased risk of poor nutritional status due to physiological, social, and physical environment changes (Bardon et al., 2021). It has been established that

poor nutritional status can directly increase the risk of developing chronic diseases including malnutrition, cardiovascular disease, type 2 diabetes mellitus, some cancers and osteoporosis (Ardisson Korat et al., 2014; Centres for Disease Control and Prevention (CDC), n.d.; Ilich et al., 2003; Key et al., 2020). There are multiple nutrients of concern which should be considered when analysing the dietary intake of older adults due to their key roles in promoting optimal health status. Specific nutrients of concern for older adults are energy, protein, dietary fibre, calcium, vitamin B6, vitamin B12, vitamin E, sodium, potassium, and magnesium.

Internationally, food and nutrition guidelines have been developed based on the nutritional requirements of older adults. Each country has individualised guidelines based on the eating habits and behaviours of the nation (Andrade & Andrade, 2016; Cámara et al., 2021). The most recent New Zealand food and nutrition guidelines, 'Food & Nutrition Guidelines for Older People: A Background Paper,' were published in 2013 with updates to serving sizes published as a supporting document in 2020. The 'Eating for Healthy Older People/Te kai tōtika e ora ai te hunga kaumātau' booklet was published in 2021 and provides food based guidelines to the public based on New Zealand food and nutrition guidelines. Nutrient Reference Values are nutrient based guidelines that were developed for use by healthcare professionals to assess adequacy of individual and population dietary intake.

Previous international studies on adherence to food and nutrition guidelines found that there are differences in levels of adherence between countries. The most recent New Zealand Adult Nutrition Survey (NZANS) was completed in 2008/09 before the updated 2013 Food and Nutrition Guidelines for older adults and the 2020 update to serving sizes were published. The 2008/09 NZANS found mean daily intake of dietary fibre failed to meet NRV (AI) guidelines and mean energy contribution from saturated fat failed to the recommended limit of <10% total daily energy intake for all age and sex groups. Mean daily intake of calcium failed to meet NRV (EAR) guidelines for males >70y and females >51y. The 2021/22 New Zealand Health Survey (NZHS) only investigated adherence to recommended food group servings for fruit and vegetables and did not provide information on adherence to other food and nutrition guidelines. Therefore, a current gap in the literature has been identified. There is currently limited knowledge on the dietary intake of older adults in New Zealand and therefore the level adherence to national food and nutrition guidelines is unknown.

Chapter 3. Manuscript

3.1 Abstract

The proportion of older people in the population is increasing and good nutrition plays a role in positive aging and improving health outcomes. Dietary guidelines have been developed internationally to promote food intake from different food groups to meet country and population specific dietary guidelines. The aim of this research was to investigate the level of adherence to food and nutrition guidelines and Nutrient Reference Values (NRVs) including Estimated Average Requirements (EAR) and Adequate Intakes (AI) among community dwelling older adults living in Auckland, New Zealand. Data used in this research were collected as part of the Researching Eating, Activity and Cognitive Health (REACH) study. This cross-sectional study recruited community dwelling older adults (n=371) aged 65-74 years between 2018-2019 who were living in Auckland, New Zealand. Participants completed a health and demographic questionnaire and a four-day food record. Completed data (n=330) were analysed and compared with food and nutrition guidelines and NRVs. Adherence to food and nutrition guidelines were reported as a percentage by sex. Less than 50% of participants adhered to recommended food group servings (RFGS) for fruits, vegetables, grains, and dairy products. The protein group was the most adhered to RFGS (54% of males, 58% of females) while dairy products were the least adhered to (11% of males, 1% of females). Nutrient Reference Values were generally well adhered to (>50% adherence) except for calcium (EAR) (49% of males, 23% of females). Adherence to acceptable macronutrient distribution ranges (AMDR) was low for total fat and carbohydrates. Adherence to the recommended limit for saturated fat was also low (19% of males, 16% of females). Overall, participants had low adherence to food and nutrition guidelines. As poor nutritional status has been directly associated with poor health outcomes, especially in older adults, low adherence to food and nutrition guidelines is cause for concern. These findings highlight the need for further investigation into nationwide adherence to food and nutrition guidelines and NRVs in older adults using a sample which is representative of the entire New Zealand older adult population.

3.2 Introduction

Dietary intake and nutritional status of older adults in New Zealand is of particular interest due to population aging. By 2051, the number of New Zealanders aged 65 years and older is expected to double and this age group will make up a quarter of New Zealand's population (Ministry of Health, 2013a). With increasing age, there are changes in nutritional requirements

due to natural physiological changes including reduced lean body mass, decreased bone mineral density, and decreased basal metabolic rate (Jafari-Nasabian et al., 2017; St-Onge & Gallagher, 2010). Alongside changes in nutritional requirements, there are multiple factors that can affect nutritional intake and result in an overall decreased intake, leading to an increased risk of poor nutritional status in older adults (Ministry of Health, 2013a; Tay, 2021). In older people, good nutrition is associated with positive health outcomes including prevention of malnutrition, optimal physical functioning, reduced risk of chronic diseases, better mental health and cognitive function, and prevention of disabilities (Chen et al., 2019; Ministry of Health, 2013a; van Dronkelaar et al., 2018).

Food and nutrition guidelines have been implemented in more than 100 countries (Food and Agriculture Organization, n.d.). Food and nutrition guidelines are developed utilising scientific evidence and are specific to the eating habits of the country which they are designed for. The purpose of food and nutrition guidelines is to provide an easy to follow framework for healthy eating behaviours and provide direction for the development of health promotion policies and nutrition programs (United Nations Children's Fund (UNICEF), 2021). Food and nutrition guidelines were first introduced in New Zealand in the 1990s. Since then, there have been multiple reviews and updates to the guidelines based on the latest scientific evidence (Oliver & Associates, 2011). The New Zealand Ministry of Health originally released the Food and Nutrition Guidelines for Healthy Older People in 1993. Updated versions of Food and Nutrition Guidelines for Healthy Older People were subsequently released in 1996, 2010, 2013 and serving sizes were updated in 2020 (Ministry of Health, 2013a, 2020d). The Food and Nutrition Guidelines for Healthy Older People include recommended food group servings (RFGS) and informed the development of a user-friendly booklet, 'Eating for Healthy Older People/Te kai tōtika e ora ai te hunga kaumātau' which was first released in 2003 and revised in 2021. 'Eating for Healthy Older People/Te kai tōtika e ora ai te hunga kaumātau' includes RFGS and serving sizes for common foods from each of the five food groups. The booklet also includes additional healthy lifestyle guidance for older adults. Additional information includes education around choosing foods low in fat, salt, and sugar, drinking plenty of fluids, important vitamins and minerals in aging, food safety recommendations, and guidance around exercising and achieving a healthy body weight (HealthEd & Ministry of Health, 2006).

Updated serving size advice, released in 2020, provides guidelines for the recommended number of servings that should be consumed from each of the food groups per day. They are

specific to age and sex, and are estimated to provide adequate nutrient intake to meet Nutrient Reference Values (NRV). The 2006 Nutrient Reference Values for Australia and New Zealand were developed as a joint initiative between the Australian National Health and Medical Research Council (NHMRC), Australian Government Department of Health and Ageing, and the New Zealand Ministry of Health. The NRV provide recommendations for individual nutrients including protein, fibre, vitamins, and minerals rather than food based recommendations. Additionally, NRV includes acceptable macronutrient distribution ranges (AMDR) which describe suitable ranges of energy contribution from the macronutrients towards total daily energy intake. They are intended for use by health professionals to assess the dietary intake of nutrients by individuals and populations (National Health and Medical Research Council et al., 2006).

Multiple international studies have been completed investigating levels of adherence to food and nutrition guidelines among different age groups and sex. However, there is a gap in the literature concerning the dietary intake of older adults compared to guidelines in New Zealand. The results of this research will fill the gap in the literature and provide insight into the dietary intakes of older adults in New Zealand and how they compare with food and nutrition guidelines and NRVs.

3.3 Methods

3.3.1 Study design and participants

The data used in this research were collected as part of the REACH study (Researching Eating, Activity and Cognitive Health), described elsewhere (Mumme et al., 2019). Funding was provided for the REACH study by the Health Research Council of New Zealand, Grant 17/566. Ethical approval was granted by Massey University Human Ethics Committee: Southern A, Application 17/69. All participants provided informed written consent prior to data collection. This was a cross-sectional study which recruited a convenience sample. A sample size of 350 participants was required to identify medium size effect (Pearson correlation of 0.3) with 80% power for the primary objectives of the REACH study, which were to examine associations between dietary patterns and cognitive function in older adults. Data were collected from 371 participants to allow for dropout rates and inaccurate data. Data collection took 10 months to complete, beginning in April 2018 and concluding in February 2019.

Participants and recruitment

Participants were recruited through multiple channels including Massey University participant database, press releases and radio interviews by Massey University, flyers and posters distributed at local libraries, recreation centres, community centres, sports and hobby clubs, retirement villages, second-hand stores, and inclusion in relevant newsletters such as Age Concern New Zealand, and online promotion on appropriate social media platforms including GrownUps, and Office for Seniors Facebook page (Mumme et al., 2019). Potential participants were directed to the REACH study website which provided further information and to register their interest in the study. Those who expressed interest were provided with an information sheet and underwent a screening interview via telephone to ensure all inclusion criteria were met. Inclusion criteria included both male and female participants who were aged 65-74 years, community dwelling, living in Auckland, New Zealand, and proficient in English language.

Exclusion criteria

Exclusion criteria for participants were colour blindness, dementia diagnosis, any other diagnosis which may impact cognitive function (e.g., stroke, traumatic brain or head injury, any psychiatric or neurological conditions), or use of any medication which may affect cognitive function. Additionally, participants were excluded if they had experienced any event in the previous two years which may have affected their dietary intake (e.g., significant illness or death of a family member). Only one person per household was eligible to participate.

3.3.2 Data collection

Participants were required to attend the Human Nutrition Research Unit (HNRU), Massey University, Auckland, New Zealand, on one occasion for 4-5 hours. At this appointment, data were collected to meet objectives of the wider REACH study. Only relevant data collected for this research project are described in these methods. Relevant data included selected questions from a health and demographic questionnaire and a four-day food record (4-DFR).

Health and demographic questionnaire

At the appointment, participants completed a health and demographic questionnaire (Appendix A). The health and demographic questionnaire collected data including age, sex, level of deprivation, ethnicity, highest level of education, marital status and living arrangements. Level of deprivation was measured using the New Zealand Indices of Multiple Deprivation (IMD).

The New Zealand IMD calculates index scores based on residential address in relation to employment rates, income, crime, housing, health, education, and access to basic amenities for that residential area (University of Auckland, 2018). Additionally participant height and weight were measured by trained researchers at the HNRU using a stadiometer and Tanita Electronic Scales respectively. Height and weight were used to calculate participant body mass index (BMI) (kg/m^2).

Dietary data

Dietary data was collected via an estimated four-day food record (4-DFR) undertaken within 1-2 weeks following their appointment (Appendix B). At the appointment, participants watched an instructional video which provided information on correctly completing their 4-DFR. This included instructions for correctly reporting all food and beverages consumed with the brand, type and cooking method listed. Participants were also given written instructions on estimating food quantities using household measures, food scales and food pictures (Nelson & Haraldsdóttir, 1998). At their appointment. participants were assigned four consecutive days to complete their record, including one weekend day. Completed 4-DFRs were then posted back to the HNRU and checked for completeness. Any 4-DFRs with missing information or that were unclear were followed up by researchers either by email or with a phone call for clarification.

3.3.3 Data handling

4-DFR FoodWorks data entry

Completed 4-DFRs were processed by four qualified nutritionists using Foodworks 10 (Xyris Pty Ltd, 2019). The nutrient databases used were New Zealand FOODfiles ™ 2016 (The New Zealand Institute for Plant & Food Research Limited & Ministry of Health, 2017) and AusFoods 2017 (Food Standards Australia New Zealand). Where participant recorded food items not available in the food composition database, a food item with similar nutritional composition was entered e.g., ‘nut butter’ would be entered into Foodworks as ‘peanut butter.’ A register of commonly entered food items was kept ensuring consistency in data entry between the nutritionists. A New Zealand Registered Dietitian (NZRD) reviewed all 4-DFR data entry to ensure accuracy and consistency. Following completion of data entry, an analysis was conducted to identify implausible data points and avoid inaccurate results. To account for under- and over- reporting, average daily energy consumption was considered implausible for

women when recorded as <500 kcal (2,100 kJ) or >3,500 kcal (14,700 kJ) and for men when recorded as <800 kcal (3,360 kJ) or >4000 kcal (16,800 kJ) (Willett, 2012). Nutrient histograms were created to identify outliers which were then checked back against the original food diaries for accuracy.

Food grouping methodology and measurement of adherence to RFGS

Data from the 4-DFR were assigned to one of 109 food items. Each food item was then allocated to one of five foods groups which were vegetables; fruit; breads and cereals; milk and milk products; and legumes, nuts, seeds, fish and other seafood, eggs, poultry, or red meat (referred to as 'protein food'). This enabled data to be compared with RFGS. Some food items did not fall into any of the five food groups e.g., sweetened beverages and potato crisps and therefore were not relevant for measuring adherence to RFGS. Food items which did not fall into one of the five food groups were excluded from comparison against RFGS. Standard serving sizes in grams were determined for each food item using the 'Eating for Healthy Older People/Te kai tōtika e ora ai te hunga kaumātau' (HealthEd & Ministry of Health, 2006) and New Serving Size Advice (Ministry of Health, 2020b) guidelines (Appendix C). Food intake from participant 4-DFRs were reported in grams and converted into the determined standard serving sizes for each food item. The mean number of servings for intake of each food group per day by participant were compared with RFGS for age and sex. Participants were reported as either meeting or not meeting recommended food group servings.

Measurement of adherence to NRV

To calculate the level of adherence to NRVs, output data from 4-DFR FoodWorks analysis were used. Output data provided information for the mean daily nutrient intake for each participant. Nutrient intakes were compared with the appropriate sex and age group NRV. For comparison of vitamin and mineral intake against guidelines, estimated average requirement (EAR) was used rather than recommended daily intake (RDI). This is because using RDI for assessing population intake results in an overestimation of the prevalence of inadequate intake (Australian Bureau of Statistics, 2015). Where EAR was not established, adequate intake (AI) was used instead. For sodium, the suggested dietary target (SDT) was used. Participants who were grouped as 'did not adhere' to NRV (EAR and AI) had inadequate intakes of nutrients, except for sodium. The SDT for sodium is set at <2000mg/day for adults >50y. Therefore participants who were grouped as 'did not adhere' to sodium guidelines exceeded the NRV

(SDT) recommendations. Acceptable macronutrient distribution ranges (AMDR) were used to compare macronutrient energy contribution towards total daily energy intake against guidelines. Alcohol and saturated fat were included in the AMDR section of this research as they add important insight into the energy contribution and quality of food choices in older adults. The NRV guidelines recommend that saturated fat and trans-fat together should be limited to <10%, and alcohol should be limited to <5% of total daily energy intake (Australian National Health and Medical Research Council et al., 2006; National Health and Medical Research Council, 1999). The percent of participants meeting guidelines was reported by sex.

Statistical analysis

Statistical analysis was performed using Microsoft Excel. According to the central limit theorem (Kwak & Kim, 2017), the large sample size of this data (n=330) assumed that the data were normally distributed. Levene's test of homogeneity was performed to confirm approximate equal variance between samples. Independent samples t-tests were performed to compare the mean intakes of each nutrient between males and females. Chi-squared tests were performed to compare the percentage adhering to guidelines between males and females. A *p* value of <0.05 was used to determine statistical significance.

3.4 Results

3.4.1 Participant characteristics

After excluding data which were incomplete, unclear, or implausible, data from 330 participants were included in data analysis. Mean age of participants was 69.8 years with the majority being female (n=216, 65%), European (95%), and well educated with 78% of participants completing post-secondary level education or higher. Sixty four percent of participants were in a relationship or cohabiting and 70% of participants were living with others (Table 9). Females were younger, had a lower education status, were more likely to be divorced and live alone, and consume a lower daily energy intake when compared with males.

Table 9. *Participant characteristics*

Characteristic	Overall	Female	Male	p-value[1]
Sex, n (%)	330 (100%)	216 (100%)	114 (100%)	**<0.001**
Age, mean years (SD)	69.8 (2.58)	69.5 (2.61)	70.3 (2.45)	**0.01**
IMD rank[2], mean (SD)	2,115 (1,441)	2,204 (1,407)	1,946 (1,494)	0.08
Ethnicity, n (%)				>0.99
Asian	9 (3%)	6 (3%)	3 (3%)	
European	313 (95%)	205 (95%)	108 (95%)	
Māori	6 (2%)	3 (1%)	3 (3%)	
Pacific	2 (<1%)	2 (<1%)	0 (0%)	
Education level, n (%)				**0.001**
Secondary	74 (22%)	59 (27%)	15 (13%)	
Post-secondary	138 (42%)	93 (43%)	45 (39%)	
University	118 (36%)	64 (30%)	54 (47%)	
Marital status, n (%)				**<0.001**
Divorced/separated	66 (20%)	59 (27%)	7 (6%)	
Married/cohabiting/civil-union/de facto	212 (64%)	115 (53%)	97 (86%)	
Single	13 (4%)	9 (4%)	4 (4%)	
Widowed	38 (12%)	33 (15%)	5 (4%)	
Unknown	1	0	1	
Living arrangement, n (%)				**<0.001**
With others	231 (70%)	131 (61%)	100 (88%)	
Alone	99 (30%)	85 (39%)	14 (12%)	
BMI[3] (kg/m^2), mean (SD)	26.0 (4.34)	25.7 (4.52)	26.6 (3.94)	**0.01**
Energy (kJ), mean (SD)	8,117 (1,910)	7,452 (1,488)	9,376 (1,991)	**<0.001**

Notes:

[1]*Wilcoxon rank sum test; Fisher's exact test; Pearson's Chi-squared test*

[2]*IMD (Index of Multiple Deprivation) a higher score represents a greater level of deprivation*

[3]*BMI (Body Mass Index)*

3.4.2 Adherence to recommended food group servings

Adherence to RFGS by sex is displayed in Figure 2. Overall, adherence to RFGS was low (<50%), with protein being the only RFGS guideline that >50% of participants adhered to (54% of males, 58% of females). For grain RFGS, the mean daily servings for older males and females (>70y) met the guidelines while younger males and females (51-70y) did not. There was a statistically significant difference in the level of adherence to dairy and grain RFGS between males and females (both $p<0.01$). Males were more likely to adhere to dairy guidelines whereas females were more likely to adhere to grain guidelines. Statistically, males had a significantly higher mean daily servings of dairy, grain, and protein compared to females (all $p<0.01$) (Table 10). Differences in mean daily servings between males and females was expected due to the higher mean daily energy intake observed in males (Table 9).

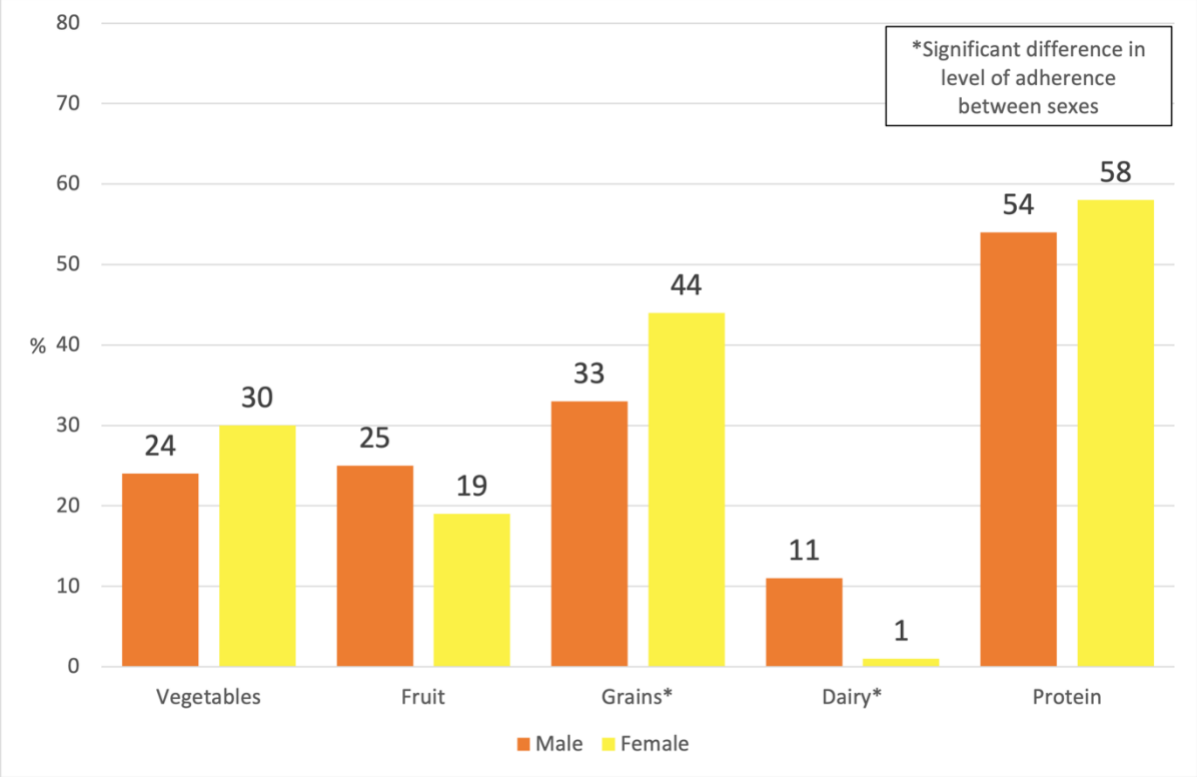

Figure 2. *Percentage of older adults adhering to recommended food group servings*

Table 10. *Mean servings of foods groups and comparison with guidelines by sex*

Food groups	Recommended food group servings (males)	Mean servings ± SD (males)	Recommended food group servings (females)	Mean servings ± SD (females)	Chi-squared (*p-value*)[1]	T-test (*p-value*)[2]
Vegetables	5.5 (51-70y) 5 (>70y)	4.1 ± 3.3 (51-70y) 4.3 ± 2.4 (>70y)	5 (>50y)	4.1 ± 2.4	0.35	0.89
Fruit	2 (>50y)	1.4 ± 0.9	2 (>50y)	1.3 ± 0.9	0.29	0.57
Grain	6 (51-70y) 4.5 (>70y)	4.8 ± 1.6 (51-70y) 4.8 ± 1.9 (>70y)	4 (51-70y) 3 (>70y)	3.6 ± 2.2 (51-70y) 4.0 ± 3.3 (>70y)	**<0.01**	**<0.01**
Dairy	2.5 (51-70y) 3.5 (>70y)	1.7 ± 0.9 (51-70y) 1.7 ± 1.1 (>70y)	4 (>50y)	1.4 ± 0.8	**<0.01**	**0.02**
Protein	2.5 (>50y)	2.7 ± 1.3	2 (>50y)	2.3 ± 0.9	0.58	**<0.01**

Notes:
[1]Chi-squared test (to test difference between % adherence to guidelines male vs female).
[2]T-test (to test difference between mean daily servings male vs female).
SD (standard deviation).

3.4.3 Adherence to NRV guidelines

Levels of adherence to each NRV by sex is displayed in Figure 3. The lowest adherence to NRVs was observed for calcium (EAR) in both males and females (49% and 23% respectively). The mean daily calcium intake of younger males (51-70y) met NRV (EAR) guidelines whereas the mean daily intake of older males (>70y) did not. There was a statistically significant difference in levels of adherence to NRV guidelines between males and females for protein, vitamin B6, vitamin E, calcium, potassium, and sodium (all $p<0.01$). Further, there was a statistically significant difference in mean daily intake for all nutrients analysed with males more likely to have a higher mean daily intake than females (all $p<0.01$) (Table 11).

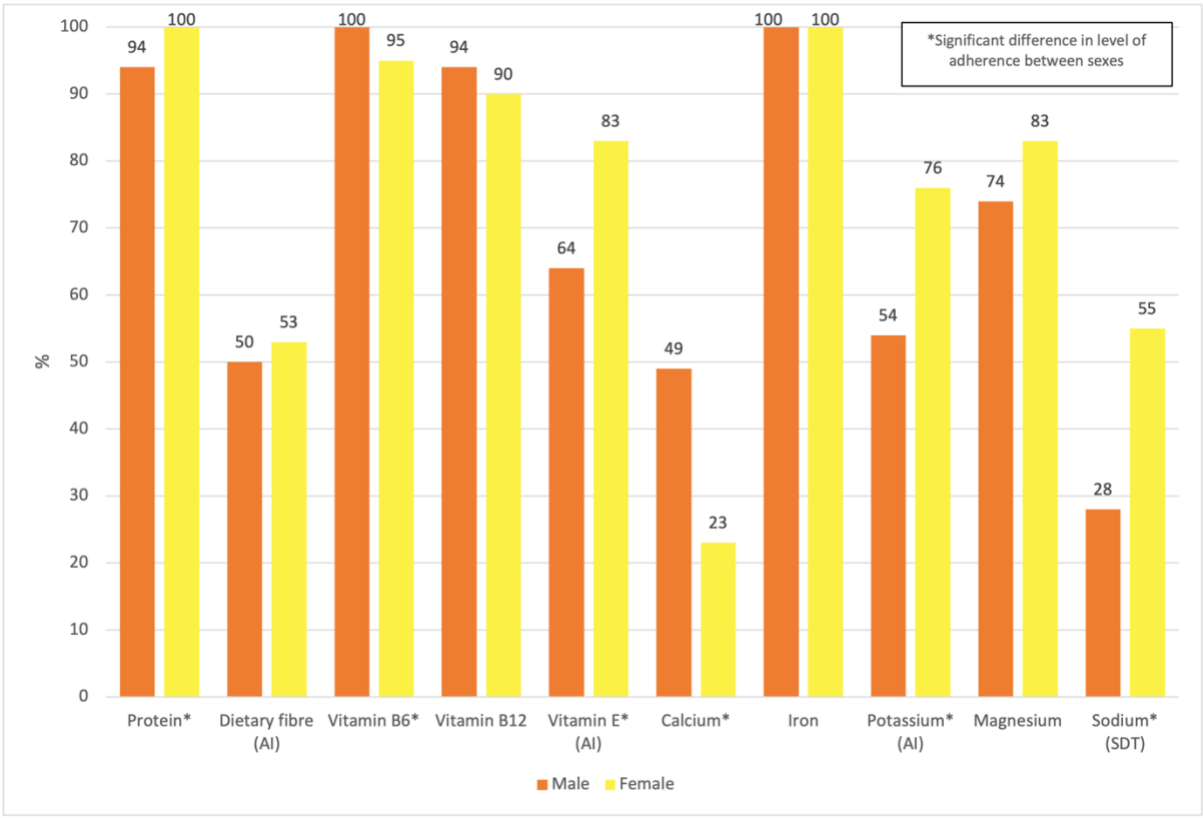

Figure 3. *Percentage of older adults adhering to Nutrient Reference Values (EAR or as specified)*

Table 11. *Mean nutrient intake and comparison with NRV by sex*

Nutrient	EAR (or specified NRV) (males)	Mean intake ± SD (males)	EAR (or specified NRV) (females)	Mean intake ± SD (females)	Chi-squared (*p-value*)[1]	T-test (*p-value*)[2]
Protein (g)	52 (51-70y) 65 (>70y)	97 ± 21 (51-70y) 92 ± 21 (>70y)	37 (51-70y) 46 (>70y)	77 ±16 (51-70y) 75 ± 16 (>70y)	**<0.01**	**<0.01**
Dietary fibre (g)	30 (>50y) (AI)	31.5 ± 11.2	25 (>50y) (AI)	26.8 ± 8.7	0.67	**<0.01**
Vitamin B6 (mg)	1.4 (>50y)	2.8 ± 1.0	1.3 (>50y)	2.4 ± 0.8	**<0.01**	**<0.01**
Vitamin B12 (ug)	2 (>50y)	4.7 ± 3.5	2 (>50y)	3.9 ± 3.6	0.30	**<0.01**
Vitamin E (mg)	10 (>50y) (AI)	12.3 ± 4.8	7 (>50y) (AI)	10.4 ± 3.8	**<0.01**	**<0.01**
Calcium (mg)	840 (51-70y) 1100 (>70y)	1018 ± 316 (51-70y) 978 ± 346 (>70y)	1100 (>50y)	878 ± 325	**<0.01**	**<0.01**
Iron (mg)	6 (>50y)	14.5 ± 4.2	5 (>50y)	11.3 ± 3.1	0.32	**<0.01**

Potassium (mg)	3800 (>50y) (AI)	4045 ± 1067	2800 (>50y) (AI)	3437 ± 808	**<0.01**	**<0.01**
Magnesium (mg)	350 (>50y)	430 ± 130	265 (>50y)	358 ± 97	0.12	**<0.01**
Sodium (mg)	<2000 (>50y) (SDT)	2466 ± 765	<2000 (>50y) (SDT)	1996 ± 622	**<0.01**	**<0.01**

Notes:
[1]Chi-squared test (to test difference between % adherence to guidelines male vs female).
[2]T-test (to test difference between mean daily intake male vs female).
AI (adequate intake), SDT (suggested dietary target), SD (standard deviation).

3.4.4 Adherence to AMDR guidelines

Protein was the most well adhered to AMDR recommendation with 70% adherence in males and 76% adherence in females. Saturated fat recommended limit had the lowest adherence with 19% of male and 16% of female participants adhering (Figure 4). Figure 5 demonstrates the percentage of participants who either exceeded or had insufficient energy contribution from each macronutrient (protein, carbohydrate and fat). There was a statistically significant difference in level of adherence to carbohydrate AMDR guidelines, with males more likely to adhere than females ($p<0.01$). Further, there was a statistically significant difference in mean daily energy contribution from carbohydrates and fat observed between male and female participants (<0.01 and 0.03 respectively) (Table 12).

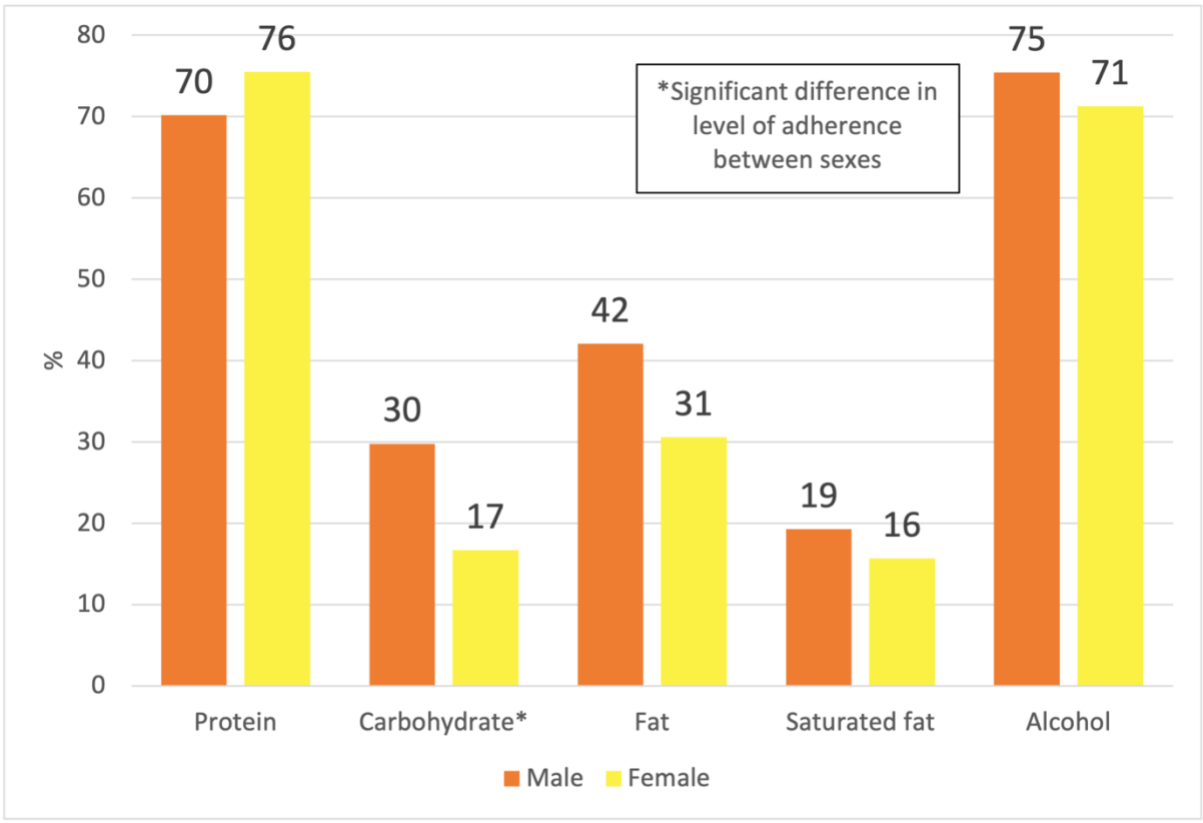

***Figure 4**. Percentage of older adults adhering to AMDR recommendations*

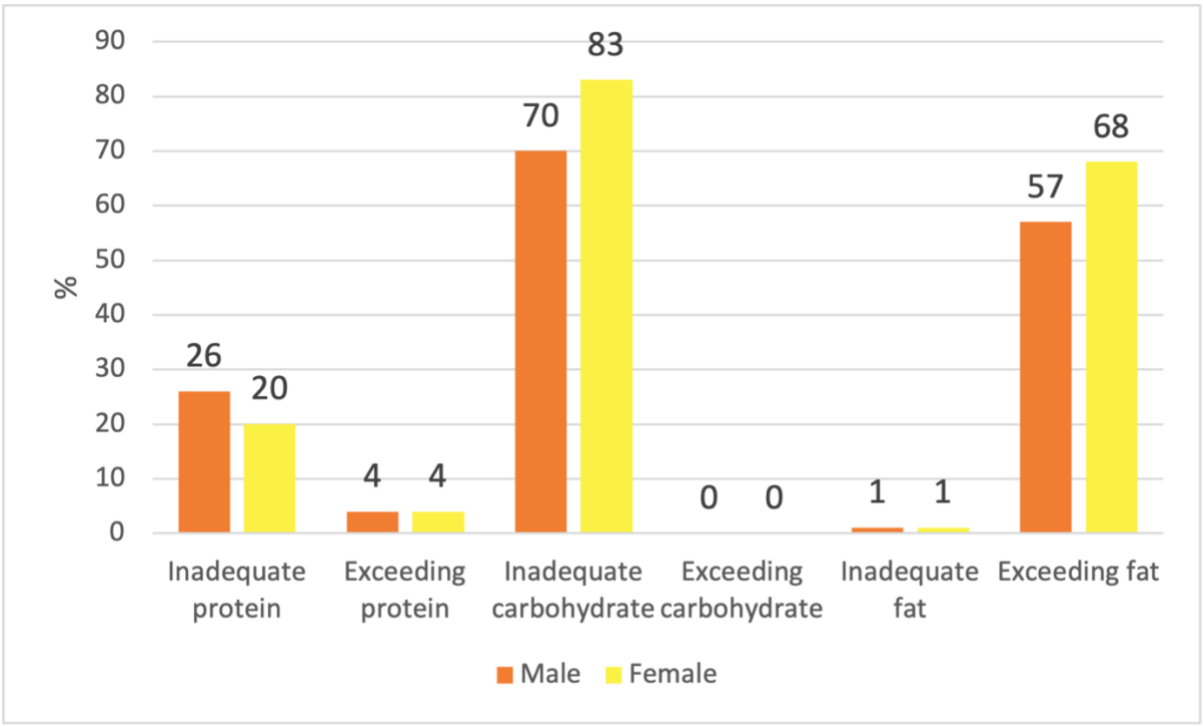

***Figure 5.** Percentage of older adults with excessive vs. inadequate energy contribution toward AMDR*

Table 12. *Mean energy contribution and comparison with AMDR guidelines by sex*

Macronutrient	AMDR / recommended limit (all adults)	Mean energy contribution ± SD (%) (males)	Mean energy contribution ± SD (%) (females)	Chi-squared (*p-value*)[1]	T-test (*p-value*)[2]
Protein	15-25%	17.1 ± 3.3	17.4 ± 3.5	0.4	0.48
Carbohydrate	45-65%	40.7 ± 6.9	38.3 ± 6.7	**0.03**	**<0.01**
Fat	20-35%	36 ± 6.4	37.6 ± 6.8	0.09	**0.03**
Saturated fat	<10%	13.2 ± 3.3	13.6 ± 3.7	0.5	0.25
Alcohol	<5%	3.3 ± 3.8	3.7 ± 5.1	0.51	0.39

Notes:
[1]Chi-squared test (to test difference between % adherence to guidelines male vs female).
[2]T-test (to test difference between mean % daily energy contribution male vs female).
AMDR (acceptable macronutrient distribution range); SD (standard deviation)

3.5 Discussion

This study aimed to investigate the level of adherence to food and nutrition guidelines in community dwelling older adults living in New Zealand using data from the REACH study. The findings demonstrate that overall, New Zealand food and nutrition guidelines were not well adhered to within the study population. Specifically, there was low overall adherence (<50%) to four out of five of the recommended food group servings (RFGS) including for fruit, vegetables, grains, and dairy products, the Nutrient Reference Values (NRV) for calcium, acceptable macronutrient distribution ranges (AMDR) for total fat and carbohydrates, and the recommended limit for saturated fat.

It is important to acknowledge that the study population is not representative of the wider New Zealand population including for ethnicity and education levels. In 2018, the same year that data collection started for this research, 70% of the New Zealand population identified as European (Environmental Health Intelligence New Zealand (EHINZ)). This is much lower than the study population in which 95% of participant identified as European. Additionally, in 2014, 30% of adults aged 25-64y had completed a bachelor's degree or higher (Ministry of Social Development, 2016). Again, this is much different to the study population in which 78% of participants had completed post-secondary level of education or higher. This identifies that the

study population had a higher percentage of Europeans and a higher level of education compared to the general New Zealand population. Therefore, the results are not representative of the general New Zealand older adult population and must be considered with caution.

3.5.1 Fruit intake

Only 25% of male and 19% of female participants adhered to RFGS for fruit (≥2 servings per day). There was no significant difference in level of adherence to RFGS for fruit or mean daily servings of fruit between the sexes. These findings are lower than findings from both the 2008/09 NZANS and the 2021/22 NZHS. The 2008/09 NZANS found that 60-64% of males and 72-73% of females aged >51y adhered to RFGS for fruit (Ministry of Health, 2011a). While the 2021/22 NZHS found that ~60% of older adults >65y adhered. In comparison with the 2021/22 NZHS, there was a difference in the total percentage of older adults adhering to fruit RFGS by ~40 percentage points. Fruit was the only food group which was not affected by the 'New Serving Size Advice' released by the New Zealand Ministry of Health in 2020. Meaning that the RFGS for fruit remained at ≥2 servings per day. It could therefore be assumed that levels of adherence to RFGS for fruit would be similar to those observed in previous nationwide nutrition surveys. However, this was not evident in this research which found a significantly decreased level of adherence to RFGS for fruit. This is an interesting and unexpected finding which could be investigated further in future research. It is possible that data coding was different between the 2008/09 NZANS, the 2021/22 NZHS and this research. For example, in this research, dried fruit was grouped as "sweet treats" and fruit/vegetable juices were grouped as "fluids" and did not count towards daily fruit intake. When the findings of this research were compared to international literature for older adults, there are similarities and differences. Similar levels of adherence to RFGS for fruit included 17% of male and 27% of female American participants (≥1.5-2 servings/day) (Krebs-Smith et al., 2010). However, much higher levels of adherence to RFGS for fruit were observed in Swiss older adults (45%, ≥2 servings/day) (de Abreu et al., 2013), Dutch older adults (83%, ≥2 servings/day) (Dijkstra et al., 2014), and Australian older adults (54% of males, 69% of females, ≥2 servings/day) (Thorpe et al., 2016).

3.5.2 Vegetable intake

Overall, 24% of males and 30% of females adhered to RFGS for vegetables (≥5-5.5 servings per day). There was no significant difference in level of adherence to RFGS for vegetables or

mean daily servings of vegetables between the sexes. It must be acknowledged that at the time of data collection, the RFGS for vegetables was ≥3 servings a day for all adults. However, participant intakes were compared against the 2020 updated serving size guidelines which saw an increase in RFGS for vegetables to ≥5.5 servings for males 51-70y and ≥5 servings for males >70y and females >51y. The 2008/09 NZANS found that 66-77% of males and 81-83% of females aged >51y adhered to outdated RFGS for vegetables (≥3 servings a day). The 2021/22 NZHS found that ~12% of older adults >65y adhered to updated RFGS for vegetables (≥5-5.5 servings per day). In comparison with the 2021/22 NZHS, there is an increase in the total percentage of older adults adhering to vegetable RFGS by ~16 percentage points. This increase in adherence to RFGS for vegetables compared to the 2021/22 NZHS may be associated with the difference in demographics between this study population compared to the wider New Zealand older adult population in the NZHS. As vegetables are widely thought of as an expensive food group, those with higher socioeconomic status may be more likely to have higher intake of vegetables. When compared with international literature, the participants of this study had a generally higher level of adherence to vegetable RFGS guidelines. Lower levels of adherence to vegetable guidelines were observed for American older adults (21% of males, 24% of females, ≥2-2.5 servings/day) (Krebs-Smith et al., 2010), Swiss older adults (8%, ≥3 servings/day) (de Abreu et al., 2013), and Australian older adults (6% of males, 13% of females, ≥5-5.5 servings/day) (Thorpe et al., 2016). Higher adherence to vegetable RFGS guidelines was observed in Dutch older adults (65%, ≥4 tbsp/350g) (Dijkstra et al., 2014).

3.5.3 Grain intake

Thirty-three percent of male and forty-four percent of female participants adhered to RFGS guidelines for grain foods (≥3-6 servings per day). There was a significant difference in levels of adherence to RFGS for grains between males and females (p=<0.01) with females more likely to adhere. Additionally, mean daily grain servings for older males and females (>70y) met RFGS guidelines for grains while mean daily servings for younger males and females (51-70y) did not. This is likely a reflection of the decreased number of grain servings recommended for adults aged >70y. Males consumed significantly higher daily servings of grains compared with females (p=<0.01). At the time of data collection, the RFGS for grain foods was ≥6 servings per day for all adults. Participant intakes were compared with updated serving size guidelines released in 2020 in which the RFGS for grains decreased for males >70y to ≥4.5 servings per day, females 51-70y to ≥4 servings per day, and females >70y to ≥3 servings per

day. The 2008/09 NZANS did not assess adherence to RFGS for grains and therefore the findings of this research cannot be compared. International studies have found differing levels of adherence to RFGS for grains. A higher level of adherence to grain guidelines was observed in American older adults (66% of males, 59% of females, ≥5-6 servings/day) (Krebs-Smith et al., 2010). Oppositely, Australian older adults had significantly lower adherence to grain guidelines (2% of males, 7% of females, ≥4-6 servings/day) (Thorpe et al., 2016).

3.5.4 Dairy intake

Dairy was the least well adhered to RFGS guideline with only 11% of male and 1% of female participants adhering to the ≥2.5-4.0 servings recommended per day. There was a significant difference in levels of adherence to RFGS for dairy between males and females (p=<0.01) with males more likely to adhere. Further, males consumed significantly higher daily servings of dairy compared with females (p=0.02). At the time of data collection, the RFGS for dairy was ≥3 servings for all adults. However, participant intakes were compared against the 2020 updated servings which saw changes to recommended servings of dairy products to ≥2.5 for males 51-70y, ≥3.5 for males >70y, and ≥4 for females >51y. The 2008/09 NZANS did not assess adherence to RFGS for dairy products and therefore findings were not compared. International literature found a similar level of adherence to RFGS for dairy products. Similar levels of adherence to dairy guidelines were observed in American older adults (5% of males, 2% of females, ≥3 servings/day) (Krebs-Smith et al., 2010), Swiss older adults (10%, ≥3 servings/day) de Abreu et al. (2013), and Australian older adults (16% of males, 4% of females, ≥2.5-4 servings/day) Thorpe et al. (2016). Dairy products and fortified alternatives are a key source of calcium which is a key nutrient of concern for older adults. The low level of adherence to RFGS for dairy is likely associated with the observed low adherence to calcium NRVs.

3.5.5 Protein intake

The protein food group was the most well adhered to RFGS guideline with 54% of males, and 58% of females adhering. There was no significant difference in levels of adherence to RFGS for the protein food group between males and females. Males consumed significantly higher daily servings of protein foods compared with females (p=<0.01). Similar to vegetables, grains, and dairy products, the RFGS guidelines for protein were updated in 2020 which saw an increase in recommended daily servings from ≥1 serving to ≥2.5 for males >51y and ≥2 for

females >51y. Additionally, there were changes in serving sizes of protein foods including increased serving sizes for legumes (1 cup) and eggs (2 eggs), whereas serving sizes for cooked lean red meat decreased to 65g. Participant intakes were compared with the 2020 updated guidelines. Adherence to RFGS for the protein food group was not assessed in the 2008/09 NZANS, therefore findings were not compared. Comparison with international literature must be considered with caution due to differences in recommendations. The Swiss dietary recommendations and the Flemish Food Triangle, for example, recommend limiting protein intake from meat sources to ≤5 servings per week and <100g per day respectively. Comparison with international studies identified that protein guidelines generally had >50% adherence internationally with similar findings in levels of adherence. Similar levels of adherence to protein guidelines were observed in American older adults (73% of males, 43% of females, ≥5−5.5 servings/day) (Krebs-Smith et al., 2010), Swiss older adults (66%, ≤5 servings/week) (de Abreu et al., 2013), and Australian older adults (31% of males, 53% of females, ≥2-2.5 servings/day) Thorpe et al. (2016).

3.5.6 Nutrient Reference Values

Overall, NRV guidelines demonstrated adherence of >50% except for calcium with 49% adherence in males and 23% adherence in females. This is an interesting finding as adherence to RFGS was generally low. It could be expected that if participants failed to meet RFGS, then they would also fail to meet NRV guidelines. However, this was not the case. This raises questions about the necessity of consuming the recommended number of servings from each food group to meet daily NRV.

Comparison of findings with the 2008/09 NZANS demonstrates a consistent trend in adherence for all reported nutrients, except for dietary fibre. The 2008/09 NZANS reported the mean daily intake of dietary fibre failed to meet NRV (AI) for all age groups. However, the findings of this study report the mean daily intake of dietary fibre for both sexes meet NRV (AI) guidelines with 50% of males and 53% of females adhering. This increase in adherence to NRV (AI) for dietary fibre may be associated with the differences in demographics seen between participants of this research compared with the participants of the 2008/09 NZANS. As the participants in this research have a higher level of education compared with the general NZ population, they may be more aware of the positive health benefits associated with dietary fibre intake. Therefore, participants in this research may be more likely to choose foods higher in dietary

fibre. A higher intake in mean daily intake of dietary fibre may be associated with increased positive health outcomes such as reduced risk of chronic diseases including obesity, diabetes, cardiovascular diseases, and colon cancer (Dahl & Stewart, 2015). Therefore, this increase in percentage of older adults adhering to NRV (AI) guidelines for dietary fibre is beneficial to improve health outcomes.

Inadequate calcium intake was noted between both this study and the 2008/09 NZANS. The 2008/09 NZANS found the mean intake of males >70y and females >50y failed to meet NRV (EAR) guidelines. This was consistent with the findings of this research which found the mean intake for males >70y and females >50y also failed to meet calcium NRV (EAR) recommendations. It is likely that younger males were more likely to meet calcium NRV (EAR) as the recommendation is set significantly lower at 840mg for males 51-70y compared to 1100mg for males >70y and females >50y. As dairy products are the largest contributor toward calcium intake, a correlation between low adherence to RFGS for dairy products and low adherence to NRV for calcium could be expected. As calcium is a specific nutrient of concern for older adults, low adherence to NRV guidelines is of concern. Low adherence to calcium NRV guidelines may lead to increased risk of poor health outcomes including fractures and osteoporosis (Kim et al., 2014).

The 2008/09 NZANS did not report on sodium intakes and therefore findings could not be compared. The findings of this research identified that only 28% of male participants adhered to NRV (SDT) guidelines for sodium. This means that 72% of male participants exceeded recommendations for sodium. Sodium is a specific nutrient of concern for older adults due to its association with increased risk of cardiovascular diseases (Center for Disease Control, 2021; Cogswell et al., 2016).

Iron was the most well adhered to NRV (EAR) with 100% adherence in both male and female participants. Additionally, protein NRV (EAR) was also well adhered to with 94% of males and 100% of females adhering. As iron is found in high concentrations in protein containing foods including red meat, seafood, and nuts, there may be an association between high adherence to protein recommendations and high adherence to iron NRVs.

3.5.7 Acceptable Macronutrient Distribution Ranges

Similarly to RFGS guidelines, AMDR guidelines for protein were well adhered to with 70% of males and 76% of females adhering. The mean energy contribution from protein was 17% (±3.3) for males and 17% (±3.5) for females which falls within AMDR guidelines for protein (15-25% of total energy intake). These findings are similar to the 2008/09 NZANS findings which found the mean energy contribution from protein was 16-17% for males and 17% for females. The recommended limit for alcohol was well adhered to with 75% of males and 71% of females adhering. The mean energy contribution from alcohol was 3% (±3.8) for males and 4% (±5.1) for females which fell within recommended limit for alcohol (<5% total energy intake). These findings align with findings from the 2008/09 NZANS which found a mean energy contribution from alcohol of 4-5% for males and 3-4% for females. Although mean energy contribution is within the recommended limit, this information does not provide insight into the patterns of alcohol consumption.

Overall, there was poor adherence to AMDR guidelines for total fat, carbohydrate, and the recommended limit for saturated fat. For carbohydrate, 30% of males and 17% of females met AMDR guidelines. The mean energy contribution from carbohydrates was 41% (±6.9) for males and 38% (±6.7) for females, this was below the AMDR for carbohydrates (45-65% of total energy intake). These findings are lower than the 2008/09 NZANS which found a mean energy contribution from carbohydrates of 46-48% in males and 46-49% in females. This research found that the mean energy contribution from carbohydrates was lower than the 2008/09 NZANS, however, a higher percentage of participants met dietary fibre NRV (AI) compared to the 2008/09 NZANS. This finding suggests that participants may have been more likely choose carbohydrate foods with a higher dietary fibre content over refined products e.g. wholegrain or wholemeal vs. white. Further, as participants had a higher level of adherence to vegetable RFGS, they may have been more likely to choose vegetables with high dietary fibre and low carbohydrate content.

Total fat AMDR was also poorly adhered to with only 42% of males and 31% of females adhering to guidelines. The mean energy contribution from total fat exceeded AMDR guidelines (20-35% of total energy intake) at 36% (±6.4) for males and 38% (±6.8) for females. Like carbohydrate, these findings do not align with findings from the 2008/09 NZANS (mean energy contribution from fat of 32-33% for males and 32-34% for females). The recommended limit for saturated fat was poorly adhered to with only 19% of males and 16% of females

adhering. The mean energy contribution from saturated fat was 13% (±3.3) for males and 14% (±3.7) for females. These findings are slightly higher than the 2008/09 NZANS which found a mean energy contribution from saturated fat of 12-13% for both males and females. Findings from this study and the 2008/09 NZANS exceed the recommended limit for saturated fat and trans-fat (<10% of total energy intake). In comparison with the 2008/09 NZANS, daily energy contribution from carbohydrates is lower and contribution from total fat is higher. This shift in energy contribution from carbohydrates to fats may be related to increased popularity of low carbohydrate/ketogenic style diet trends. Google Trends identified that 'Ketogenic' and 'low carbohydrate' diets were the third and fourth most googled diets between 2004-2019 respectively (Kamiński et al., 2020). Energy contribution from protein, alcohol, and saturated fat were similar between the 2008/09 NZANS and this research.

While the level of adherence RFGS and NRV gives insight into mean servings of each food group and energy contribution from macronutrients, they provide limited information about dietary quality of food choices and if participants are making good choices within food groups. For example, consumption of both white bread and other refined grain products would contribute to meeting RFGS for grain. Similarly, consumption of ice cream and other high sugar dairy products would contribute to meeting RFGS for dairy. This demonstrates that individuals may be meeting food and nutrition guidelines, however they may not make healthful choices within the food groups. Therefore, the findings of this research provide insight into the level of adherence to recommended food group servings and Nutrient Reference Values, however, they do not explore the dietary quality of food choices made by older adults in New Zealand.

3.5.8 Strengths and limitations of the study

This research had several strengths including the sample size, method of data collection and detailed instructions for participants, and the robust procedures and quality control measures utilised in the study. The large sample size of 330 participants is a key strength of the study as it provided more accurate mean values and enabled outliers to be identified, preventing skewed results. Another strength of the research was the method for collecting dietary data. Participants recorded all food and beverages eaten, including at least one weekend day, in a detailed estimated 4-DFR. Participants were provided with in-depth details outlining methods for estimating and recording accurate food records. This included providing training on estimating

portion sizes using common household measures, weighing food and beverages using kitchen scales, and provided with reference food picture portion sizes. Lastly, researchers involved in data collection and FoodWorks data entry were highly trained in nutrition. Researchers included Bachelor of Science qualified nutritionists and New Zealand Registered Dietitians.

There were also several limitations to the research including the age of the data, recent updates to food and nutrition guidelines, limited participant demographics, reliance accurate participant reporting, and limitations in nutritional analysis software used. Firstly, the data used were collected as part of the REACH project between 2018-19, meaning that the data were 3-4 years old at the time of analysis for this research. Additionally, the food and nutrition guidelines used to inform RFGS for data analysis were released in November 2020. This is after data collection was complete. The next limitation was the demographics of participants included in the research. Due to the convenience sample used most participants resided within Auckland's North Shore and surrounding areas. Therefore, data were not representative of the New Zealand population and results of the research cannot be applied outside of the study population. Another limitation of the research was the reliance on participant accuracy and honesty in 4-DFR reporting. As participant 4-DFR were self-recorded, under and over reporting may have occurred resulting in inaccurate dietary data. The final limitation was the database used in FoodWorks 4-DFR dietary analysis. The primary database used was the 2016 FOODfiles from Plant and Food (The New Zealand Institute for Plant & Food Research Limited & Ministry of Health, 2017). Plant and Food database tests for a comprehensive number of nutrients, however, some food items are missing selected nutrient values. Therefore, some nutrients could not be assessed and had to be excluded from this study, creating limitations in the nutrients analysed.

3.6 Conclusion

The findings of this research have identified an overall low level of adherence to New Zealand food and nutrition guidelines within the study population of community dwelling older adults aged 65-74y. Adherence to RFGS was low (<50%) for fruits, vegetables, grains, and dairy products. Overall, 25% of male and 19% of female participants adhered to fruit guidelines which was low compared with findings from the 2008/09 NZANS (60-64% male and 72-73% female adherence) and the 2021/22 NZHS (~60% total adherence). Twenty-four percent of male and thirty percent of female participants adhered to vegetables guidelines which was higher than the 2021/22 NZHS (~12% total adherence). Thirty-three percent of male and forty-

four percent of female participants adhered to grain guidelines, and dairy was the least adhered to RFGS guideline with only 11% of male and 1% of female participants adhering. Adherence to RFGS for grains, dairy, and protein were not assessed in the 2008/09 NZANS or 2021/22 NZHS and therefore could not be compared. Nutrient Reference Values were well adhered to (>50% of participants) except for calcium with only 49% adherence in males and 23% adherence in females. There was low adherence to AMDR for carbohydrate (30% of males and 17% of females) and total fat (42% of males and 31% of females). Adherence to the recommended limit for saturated fat was also low (19% of males and 16% of females). Mean energy contribution from total fat was higher, while mean energy contribution from carbohydrate was lower when compared with the 2008/09 NZANS. Overall, the low level of adherence to food and nutrition guidelines identified within this study population is of significant concern due to the association between poor nutritional status and undesirable health outcomes, especially in older adults.

Chapter 4. Final conclusions and recommendations

4.1 Research outcomes

The aim of this research was to determine the level of adherence to food and nutrition guidelines in community dwelling older adults living in New Zealand using data from the REACH study. The findings of this research have identified an overall low level of adherence to New Zealand food and nutrition guidelines within the study population of community dwelling older adults aged 65-74y. Adherence to RFGS was low (<50%) for fruits, vegetables, grains, and dairy products, with protein being the only RFGS with >50% adherence. Nutrient Reference Values were generally well adhered to with >50% adherence except for calcium with only 49% adherence in males and 23% adherence in females. Adherence to AMDR guidelines was low for carbohydrate (30% of males and 17% of females) and total fat (42% of males and 31% of females). Adherence to the recommended limit for saturated fat was also low at 19% of males and 16% of females. This research outcome suggests that there is potentially a nationwide issue regarding low adherence to food and nutrition guidelines. As poor nutritional status is directly associated with undesirable health outcomes, especially in older adults, further research should be considered. A positive finding of this research found that the study population of older adults adhered well to RFGS for protein foods. This meant that NRV and AMDR guidelines for protein were also well adhered to. Therefore, older New Zealanders are likely at a low risk of inadequate protein intake based on current recommendations. Further research should be completed to assess adherence to food and nutrition guidelines using a sample size which is representative of New Zealand older adults. Future research should also be considered to identify potential barriers which impact the ability for older adults to adhere to food and nutrition guidelines. As adherence to dairy guidelines was considerably low, further research investigating dairy intake in older adults in New Zealand would be beneficial. The findings of further research will provide a greater insight into nationwide adherence to food and nutrition guidelines in older adults and the barriers which impact on rates of adherence. These findings can be used to inform nationwide initiatives targeted to improve dietary intake of older adults to align with food and nutrition guidelines.

4.2 Research impact

This research has provided a greater insight into the levels of adherence to food and nutrition guidelines in community dwelling older adults. It has identified that within the sample of older adults analysed (n=330), there were low rates of adherence to food and nutrition guidelines.

This research indicates that there is potentially a nationwide issue with adherence to food and nutrition guidelines which needs to be investigated further. Further investigations into rates of adherence and barriers to adherence will advise on the need to nationwide interventions to promote adherence to guidelines.

4.2 Strengths

This research had several strengths including the large sample size, the dietary data collection methods, and the robust procedures and quality control measures utilised in the study. These strengths have assisted this research in giving insight into levels of adherence to food and nutrition guidelines in older community dwelling adults living in New Zealand. The first strength was the large participant sample size which gave viable data entries for 330 participants. The large sample size is a key strength as it provided more accurate mean values and enabled outliers to be identified, preventing skewed results. The next strengths was the 4-DFR method of dietary data collection. Participants recorded all food and beverages eaten, including at least one weekend day, in a detailed estimated 4-DFR. Prior to 4-DFR data collection, each participant was provided with detailed methods for recording accurate food records through an educational video. This included instructions on estimating portion sizes using common household measures, weighing food and beverages using kitchen scales, and provided with reference food picture portion sizes. This provided participants with the skills needed to record accurate food records and provide in-depth dietary data. Another key strength was the high skill level of the researchers completing data collection and data entry. Data collection and FoodWorks data entry was completed by highly trained researchers (qualified nutritionists and New Zealand Registered Dietitians).

4.3 Limitations

Limitations to the research include data age, recent updates to food and nutrition guidelines, participant demographics, reliance on accurate participant reporting, and limitations in nutritional analysis software used. The data used in this research were collected as part of the REACH project between 2018-19 meaning that the data were 3-4 years old at the time of analysis for this research. Further, the guidelines used to inform RFGS for data analysis were released in November 2020 which was after data collection was complete. A convenience sample was used for data collection, resulting in most participants residing within Auckland's North Shore and surrounding areas. Therefore, data were not representative of the New Zealand

population and results of the research cannot be applied outside of the study population. Accuracy of participant 4-DFR relied on the honesty and ability for participants to correctly record all food and beverage intake for 4 days. Accuracy of participant nutrient intake also relied on the accuracy of the nutrient database used for analysis of 4-DFRs. Another limitation of the study was the database used in FoodWorks 4-DFR dietary analysis itself. The primary database used was the 2016 FOODfiles from Plant and Food (The New Zealand Institute for Plant & Food Research Limited & Ministry of Health, 2017). Plant and Food test for a comprehensive amount of nutrients, however, some food items are missing selected nutrient values including vitamin D and specific polyunsaturated fatty acids. This meant that some nutrients could not be assessed and had to be excluded from this study.

4.4 Recommendations

The outcomes of this study highlighted a need for further research exploring dietary intake and adherence to food and nutrition guidelines in older adults.

1. Undertake similar research with a sample which is representative of the New Zealand older adult population demographics. This will provide insight into levels of adherence to food and nutrition guidelines which can be applied at a national level.
2. If recommendation 1 finds that there is a consistent issue with low adherence to food and nutrition guidelines nationwide, further qualitative research should be undertaken to identify barriers to adherence.
3. Use outcomes of recommendation 2 to inform the development of tools and resources which reduce barriers to adherence to food and nutrition guidelines in older adults.
4. Assess the dietary quality of older adults dietary intake against recommendations. This includes assessing types of grain, protein, and dairy foods consumed. This will give further insight into dietary quality of older adults in New Zealand.
5. Assess adherence to other food and nutrition guidelines including types of fat used in cooking and as a spread, consumption of red meat, physical activity levels, and consumption of processed foods and sugar sweetened beverages.

4.5 Final conclusion

This research has provided important insight into the dietary intake of older community dwelling adults compared with food and nutrition guidelines. Within the sample analysed, adherence to food and nutrition guidelines was generally low with <50% of participants adhering to recommended food group servings for all food groups other than protein foods.

This likely resulted in low adherence to Nutrient Reference Value guidelines for calcium and acceptable macronutrient distribution ranges for carbohydrates, total fat, and the recommended limit for saturated fat. The findings of this research have contributed to New Zealand health literature and identified that there is likely to be an issue with low adherence to food and nutrition guidelines in community-dwelling older adults living in New Zealand. There were several limitations in this research including age of the data and the convenience sample used. Therefore, it is highly recommended that further research is completed utilising a sample representative of the New Zealand older adult population. Further, if it is found that low adherence to food and nutrition guidelines is consistent throughout the New Zealand older adult population, barriers to adherence should be explored to inform intervention strategies.

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Appendices

Appendix A: REACH health and demographics questionnaire

Note: Only relevant questions for this research are included in this appendices.

The REACH Study – Researching Eating Activity and Cognitive Health

Please complete the following form. All the information you give us is in confidence and will be used only for the purposes of this study. If you need any help to complete the form please ask one of the research team.

What is your gender (please tick)?

- ☐ Male
- ☐ Female
- ☐ Gender diverse

What is your date of birth (day/month/year)?

_____

Which ethnic group(s) do you belong to? Tick whichever applies to you (you may tick more than one box)

- ☐ European
- ☐ Māori
- ☐ Pacific Peoples
- ☐ Chinese
- ☐ Indian
- ☐ Middle Eastern/Latin American/African
- ☐ Other Ethnicity *Please state which other ethnicity or ethnicities you belong to*

_____

What is your current living arrangement?

☐ Living alone

☐ Living with others

If living with others, how many others do you live with and what is their relationship to you (eg. Husband, wife, partner, son, daughter, grandson, granddaughter, flatmate, boarder, etc)

_____

_____

Are you?

☐ Married / cohabiting / civil union / de facto

☐ Divorced / separated

☐ Widowed

☐ Single

☐ Other, please describe

_____

Study Identification Number

What is your highest educational level (choose one)?

☐ No qualifications

☐ Primary school

☐ Secondary school

☐ Post-secondary certificate, diploma, or trade diploma

☐ University degree

Appendix B: REACH participant 4-DFR

Participant ID

MASSEY UNIVERSITY
COLLEGE OF HEALTH
TE KURA HAUORA TANGATA

The REACH (Researching Eating Activity and Cognitive Health) Study

4 Day Food Record

Thank you very much for taking part in the REACH Study. We are extremely grateful for your time, effort and commitment!

If you have any questions, please contact Owen Mugridge on (09)2136650; or email reachstudy@massey.ac.nz

All information in this diary will be treated with the strictest confidence. No one outside the study will have access to this.

Participant ID

What to do?

- Record all that you eat and drink on the following dates.

_____

_____

_____

_____

_____

- If possible record food at the time of eating or just after – try to avoid doing it from memory at the end of the day.
- Include all meals, snacks, and drinks, even tap water.
- Include anything you have added to foods such as sauces, gravies, spreads, dressings, etc.
- Write down any information that might indicate size or weight of the food to identify the portion size eaten.
- Use a new line for each food and drink. You can use more than one line for a food or drink. See the examples given.
- Include any supplements (brand name, type, number taken, etc)
- Use as many pages of the booklet as you need.

Describing Food and Drink

- Provide as much detail as possible about the type of food eaten. For example **brand names and varieties / types** of food.

General description	Food record description
Breakfast example – cereal, milk, sugar	1 cup Sanitarium Natural Muesli 1 cup Pam's whole milk 1 tsp Chelsea white sugar
Coffee	1 tsp Gregg's instant coffee 1 x 200ml cup of water 2 Tbsp Meadow fresh light green milk
Pasta	1 cup San Remo whole grain pasta spirals (boiled)
Pie	Big Ben Classic Mince and Cheese Pie (170g)

- Give details of all the **cooking methods** used. For example, fried, grilled, baked, poached, boiled…

General description	Food record description
2 eggs	2 size 7 eggs fried in 2tsp canola oil 2 size 6 eggs (soft boiled)
Fish	100g salmon (no skin) poached in 1 cup of water for 10 minutes

- When using foods that are cooked (eg. pasta, rice, meat, vegetables, etc), please record the **cooked portion** of food.

General description	Food record description
Rice	1 cup cooked Jasmine rice (cooked on stove top)
Meat	90g lean T-bone steak (fat and bone removed)
Vegetables	½ cup cooked mixed vegetables (Wattie's peas, corn, carrots)

- Please specify the **actual amount of food eaten** (eg. for leftovers, foods where there is waste)

General description	Food record description
Apple	1 x 120g Granny Smith Apple (peeled, core not eaten – core equated to ¼ of the apple)
Fried chicken drumstick	100g chicken drumstick (100g includes skin and bone); fried in 3 Tbsp Fern leaf semi-soft butter

- **Record recipes** of home prepared dishes where possible and the proportion of the dish you ate. There are blank pages for you to add recipes or additional information.

Participant ID

Recording the amounts of food you eat

It is important to also record the quantity of each food and drink consumed. This can be done in several ways.

- By using household measures – for example, cups, teaspoons and tablespoons. Eg. 1 cup frozen peas, 1 heaped teaspoon of sugar.
- By weight marked on the packages – eg. a 425g tin of baked beans, a 32g cereal bar, 600ml Coke
- Weighing the food – this is an ideal way to get an accurate idea of the quantity of food eaten, in particular for foods such as meat, fruits, vegetables and cheese.
- For bread – describe the size of the slices of bread (eg. sandwich, medium, toast) – also include brand and variety.
- Using comparisons – eg. Meat equal to the size of a pack of cards, a scoop of ice cream equal to the size of a hen's egg.
- Use the food record instructions provided to help describe portion sizes.

General description	Food record description
Cheese	1 heaped tablespoon of grated cheese 1 slice cheese (8.5 x 2.5 x 2mm) 1 cube cheese, match box size Grated cheese, size 10B

- If you go out for meals, describe the food eaten in as much detail as possible.
- ***Please eat as normally as possible - don't adjust what you would normally eat just because you are keeping a food record and be honest! Your food record will be identified with a number rather than your name.***

Participant ID

Example day

Time and place food was eaten	Complete description of food (food and beverage name, brand, variety, preparation method)	Amount consumed (units, measures, weight)
Example 7:55am At home	Sanitarium weetbix	2 weetbix
" "	Anchor Blue Top milk	150ml
" "	Chelsea white sugar	2 heaped teaspoons
" "	Orange juice (Citrus Tree with added calcium – nutrition label attached)	1 glass (275 ml)
10.00am In car	Raw Apple (gala)	Ate all of apple except the core, whole apple was 125g (core was ¼ of whole apple)
12.00pm At home	Homemade pizza (recipe attached)	1 slice (similar size to 1 slice of sandwich bread, 2 Tbsp tomato paste, 4 olives, 2 rashers bacon (fat removed), 1 Tbsp chopped spring onion, 3 Tbsp mozzarella cheese)
1.00pm At work	Water	500ml plain tap water
3.00pm At work	Biscuits	6 x chocolate covered Girl Guide biscuits (standard size)
6.00pm At home	Lasagne	½ cup cooked mince, 1 cup cooked Budget lasagne shaped pasta , ½ cup Wattie's creamy mushroom and herb pasta sauce, ½ cup mixed vegetables (Pam's carrots, peas and corn), 4 Tbsp grated Edam cheese
6.30pm At home	Banana cake with chocolate icing (homemade, recipe attached)	1/8 of a cake (22cm diameter, 8 cm high), 2 Tbsp chocolate icing
" "	Tip Top Cookies and Cream ice cream	1 cup (250g)
7.30pm At home	Coffee	1 tsp Gregg's instant coffee 1 x 300ml cup of water 2 Tbsp Meadow fresh blue top milk 2 tsp sugar

Participant ID

Date_____ DAY 1

Time and place food was eaten	Complete description of food (food and beverage name, brand, variety, preparation method)	Amount consumed

Appendix C: Food group components and serving sizes

Food item in 4-DFR	Serving size	Food group
Fruit		
Apples, pears, nashi pears	150 g	Fruit
Banana	150 g	Fruit
Citrus fruits e.g., orange, tangelo, tangerine, mandarin, grapefruit, lemon, lime	150 g	Fruit
Stone fruits e.g., apricots, nectarines, peaches, plums, lychees	150 g	Fruit
Avocado	37 g	Vegetables
Olives		
Strawberries, blackberries, cherries, blueberries, boysenberries, loganberries, cranberries, gooseberries, raspberries (fresh, frozen, canned)	150 g	Fruit
Dried fruit e.g., sultanas, raisins, currants, figs, apricots, prunes, dates	17 g	Sweet treats
All other fruit e.g., feijoa, persimmon, tamarillo, kiwifruit, grapes, mango, melon, watermelon, pawpaw, papaya, pineapple, rhubarb	150 g	Fruit
Vegetables		
Potato e.g., boiled, mashed, baked, jacket, instant, roasted	75g	Vegetables
Hot potato chips, French fries, wedges	89 g	Processed Foods
Kumara, taro, green banana, cassava e.g., boiled, mashed, baked, roasted	75g	Vegetables
Carrots	75g	Vegetables
Other root vegetables e.g., yams, parsnip, swedes, beetroot, turnips	75g	Vegetables
Peas, green	75g	Vegetables
Green beans, broad beans, runner beans	75g	Vegetables
Broccoli, cauliflower, Brussel sprouts, cabbage (all varieties)	75g	Vegetables
Salad vegetables e.g., lettuce, cucumber, celery, sprouts	75g	Vegetables
Green leafy vegetables e.g., spinach, silver beet, Swiss chard, watercress, puha, Whitlow, chicory, kale, chard, collards, Chinese kale, Bok Choy, taro leaves (palusami)	75g	Vegetables
Tomatoes (all varieties)	75g	Vegetables
All other vegetables e.g., corn, pumpkin, mushrooms, capsicum, peppers, courgette, zucchini, gherkins, marrow, squash, asparagus, radish, eggplant, artichoke	75g	Vegetables
Onions, leeks, garlic	75g	Vegetables

Food item in 4-DFR	Serving size	Food group
Meat and chicken		
Beef, lamb, hogget, mutton, pork, veal e.g., roast, steak, fried, chops, schnitzel, silverside, casserole, stew, stir fry, curry, BBQ, hamburger meat, mince dishes, frozen dinners	65 g	Protein
Chicken, turkey or duck e.g., roast, steak, fried, steamed, BBQ, casserole, stew, stir fry, curry, mince dishes, frozen dinners	80 g	Protein
Liver, kidney, other offal (including pate)	65 g	Protein
Sausages, frankfurters, cheerio's, hot dogs	78 g	Processed Foods
Ham, bacon, luncheon sausage, salami, pastrami, other processed meat	57 g	Processed Foods
Corn beef (canned), boil up, pork bones, lamb flaps, povi masima	65 g	Protein
Meat pies, sausage rolls	171 g	Processed Foods
Fish and seafood		
Fish fried in batter (from fish & chips shop)	100 g	Protein, Processed Foods
Albacore tuna, salmon, sardines, herring, kahawai, swordfish, carp, dogfish, gemfish, Alfonsino, rudderfish, anchovies	100 g	Protein
Mackerel, snapper, Oreo, barracouta, trevally, dory, trout, eel	100 g	Protein
Tuna (canned), hoki, gurnard, hake, kingfish, cod, tarakihi, groper, flounder	90 g	Protein
Crumbed fish e.g., patties, cakes, fingers, nuggets	65 g	Processed Foods
Green mussels, squid	100 g	Protein
Shellfish e.g., cockles, kina, oysters, paua, scallops, shrimp/prawn, pipi, roe	100 g	Protein

Food item in 4-DFR	Serving size	Food group
Eggs, nuts, soy and legumes		
Eggs – boiled, poached, raw	120 g	Protein
Eggs - fried, scrambled, egg based dishes including quiche, soufflés, frittatas, omelets	120 g	Protein
Nuts e.g., peanuts, mixed nuts, macadamias, pecan, hazelnuts, brazil nuts, walnuts, cashews, pistachios, almonds	30 g	Protein
Seeds e.g., pumpkin seeds, sunflower seeds, pinenuts, sesame seeds, tahini	30 g	Protein
Nut butters or spreads e.g., peanut butter, almond butter, pesto	30 g	Protein
Tofu, soybeans, tempeh	170 g	Protein
Beans (canned or dried) e.g., black beans, butter beans, haricot beans, kidney beans, cannellini beans, refried beans, baked beans, chilli beans	150 g	Protein
Peas and lentils e.g., chickpeas, hummus, falafels, split peas, cow peas, dahl	150 g	Protein
Vegetarian sausages / meat, vegetarian burger patty, textured vegetable protein	85 g	Protein
Cereals and grains		
Bran based cereals, muesli, porridges – e.g., rolled oats, oat bran, oatmeal, All Bran, Sultana bran	30 g	Grains
Weetabix, cornflakes or rice bubbles	34 g	Grains
Sweetened cereals e.g., Nutrigrain, Fruit Loops, Honey Puffs, Frosties, Milo cereal, Coco Pops	25 g	Grains
Other breakfast cereals e.g., Special K, Light and tasty	52 g	Grains
White rice	95 g	Grains
Brown rice	95 g	Grains
White pasta, noodles e.g., spaghetti, canned spaghetti, vermicelli, egg noodles, rice noodles, instant noodles	95 g	Grains
Whole meal pasta, noodles	95 g	Grains
Couscous, polenta, congee, Bulgur wheat, quinoa e.g., tabbouleh	95 g	Grains
Pancakes, waffles, sweet buns, scones, sweet muffins, fruit bread, croissants, doughnuts, brioche	60 g	Sweet treats
White bread and rolls including sliced and specialty breads such as foccacia, panini, pita, naan, chapatti, ciabatta, Turkish, English muffin, crumpets, pizza bases, wraps, tortilla's, burrito, roti, rewena bread	40 g	Grains
Whole meal or wheat meal bread and rolls including sliced and specialty breads	40 g	Grains
Whole grain or multi grain bread and rolls including sliced and specialty breads	40 g	Grains
Crackers e.g., crisp bread, water crackers, rice cakes, cream crackers, Cruskits, Mealmates, vitawheat	35 g	Grains

Food item in 4-DFR	Serving size	Food group
Dairy products and alternatives		
Cheese e.g., Cheddar, Colby, Edam, Tasty, blue vein, camembert, parmesan, gouda, feta, mozzarella, brie, processed	40 g	Dairy
Cottage cheese, ricotta cheese	134 g	Dairy
Cream, sour cream, cream cheese, cheese spreads		
Cow's milk including milk as a drink, milk added to drinks (e.g., milky coffees), milk added to cereal	250 g	Dairy, Fluids
Soy milk, coconut milk, rice milk, almond milk	250 g	Dairy, Fluids
Smoothies, milk shakes (made from milk, yoghurt, ice cream), milk shakes, flavoured milk	250 g	Dairy, Fluids
Milk based puddings e.g., rice pudding, custard, semolina, instant puddings, dairy food	129 g	Dairy
Yoghurt	200 g	Dairy
Ice cream	140 g	Dairy
Non-alcoholic drinks		
Hot chocolate, drinking chocolate, Cocoa, Ovaltine, Nesquik, Milo	250 g	Dairy, Fluids
Coffee (all varieties)	268 g	Fluids
Tea	250 g	Fluids
Herbal tea, fruit tea	250 g	Fluids
Low calorie cordials	250 g	Fluids
Cordials including syrups, powders e.g., Raro	250 g	Sugary drinks
Fruit and vegetable juices (all varieties)	262 g	Fluids
Sports drinks e.g., Powerade	255 g	Sugary drinks
Energy drinks e.g., Red Bull, V	258 g	Sugary drinks
Diet soft/fizzy drinks e.g., Sprite Zero, Diet Coke, Coke Zero	252 g	Fluids
Soft/fizzy drinks e.g., Sprite, Coke	258 g	Sugary drinks
Water including tap, bottled or sparkling water	250 g	Fluids
Alcohol		
Beer, lager, cider (all varieties)	332 g	Alcohol
Red wine	100 g	Alcohol
White wine	100 g	Alcohol
Port, sherry, liquors	100 g	Alcohol
Spirits e.g., gin, brandy, whiskey, vodka	29 g	Alcohol
Ready to drink alcoholic beverages	275 g	Alcohol

Food item in 4-DFR	Serving size	Food group
Miscellaneous foods and snacks		
Cakes, slices, pastries	40 g	Sweet treats
Non milk-based puddings e.g. pavlova, sweet pastries, fruit pies, trifle	95 g	Sweet treats
Biscuits, plain	16 g	Sweet treats
Biscuits, chocolate or cream filled	30 g	Sweet treats
Butter, ghee		
Margarine		
Vegetable oils		
Sugar (all varieties) added by you to food or drinks	5 g	Sweet treats
Jam, marmalade, honey, syrups, sweet spreads or preserves	10 g	Sweet treats
Marmite, vegemite		
Coconut cream		
Coconut oil		
Creamy dressings e.g., mayonnaise, tartar, thousand island, ranch dressing		
Light dressings e.g., French, Italian, Balsamic vinegar		
White sauce, cheese sauce, gravies		
Tomato sauce, barbeque sauce, sweet chilli sauce		
Pickles, chutneys, mustard		
Spices e.g., turmeric, ginger, cinnamon		
Soup, homemade or canned		
Muesli or cereal bar (all varieties)	45 g	Sweet treats
Potato crisps	40	Processed Foods
Sweet, lollies	35 g	Sweet treats
Chocolate (all other varieties)	25 g	Sweet treats