The relationship between nutritional adequacy and 24-month fracture occurrence in Māori and Non-Māori of advanced age.

A thesis presented in partial fulfilment of the requirements for the degree of Masters of Science in Nutrition and Dietetics.

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Abstract

Background

The life expectancy of both Māori and non-Māori is continually increasing with more New Zealanders expected to live into advanced age. Adults over the age of 80 experience greater health loss than any other age group, with chronic disease and associated disability increasing substantially with age. Osteoporosis and the morbidity associated with fractures, particularly hip fracture, are of critical concern for an ageing population and may diminish quality of life and independence for older people, thus placing an increased burden on health and disability support services. The role of nutrition in the maintenance of bone mineral density (BMD), bone integrity, and subsequent fracture prevention, particularly in octogenarians is unclear. The ability to meet adequate energy requirements decrease with increasing age and may compromise intake of nutrients related to bone health. Nutrients necessary for bone health including: protein, calcium, vitamin D, phosphorous, magnesium and potassium are modifiable factors. Achieving optimal bone nutrient intakes may influence potential for maintenance of good bone health in adults of advanced age. This study aims firstly to investigate food and nutrient intakes of Māori and Non-Māori octogenarians to establish an understanding of nutrient adequacy. Secondly, to investigate the energy and nutrient intakes of participants who experience a fracture compared with those non-fractured to identify nutrient specific risk factors for fracture in adults of advanced age.

Method

Comprehensive nutritional parameters were collected using two separate 24-hour multi-pass recalls. FOOD files were used to analyse food sources and nutrient intake. Face to face interviews were conducted to ascertain specific social, demographic, health and fracture information. Fracture occurrence was measured over a 24 month period following the 2 x 24-hour Multi Pass Recall's and included self-reported and hospitalised fracture occurrences. Hospitalisation data was obtained with permission from the participants. National Health Index New Zealand (NHI) numbers were used to identify fractures.

Results

There were 317 participants (113 Māori and 204 non-Māori), aged 80-90 years in this study. For men and women respectively the median energy intakes were 6,943kJ vs. 5,603kJ for Māori; and 8,203kJ vs. 6,225kJ for non-Māori; protein as a percentage of energy was 15.5% vs. 15.9% for Māori and 15.7% vs. 15.5% for non-Māori. The top foods contributing to energy were bread, butter and margarine for all Maori and non-Maori with beef and veal contributed the most protein for Māori men, bread for

Māori women and milk for non-Māori, men and women. Compared to the Estimated Average Requirement (EAR) intakes of calcium, vitamin D, magnesium and potassium were inadequate for all participants. Compared to an EAR of 1100mg for men and women, median calcium intakes were low, 559mg vs. 539mg for Māori and 748mg vs. 672mg for non-Māori, men and women respectively. The primary food groups contributing to calcium were milk, cheese and bread. Compared to the EAR (15 µg/day in men and women) and vitamin D intake from food was low (≤ 4 µg) for all participants. Compared to the EAR (350mg/day men and 265mg/day women), median magnesium intakes were 259 mg/day vs. 204mg/day for Māori and 271 mg/day vs. 238 mg/day for non-Māori, men and women respectively. The primary food groups contributing to magnesium were bread, breakfast cereals and fruit. A total of 18.6% of Māori and 20.6% of non-Māori sustained a fracture over a 24 month period. One in five Māori and non-Māori women sustained fractures. Among non-Māori women those who fractured were 1.1 times more likely to be financially insecure than non-fractured women (p=0.033). For Māori women who were fractured, inability to afford to eat properly was 3.3 times more likely (p=0.012), and previous fractures were 1.5 times (p=0.015) more likely than for non-fractured women. Fractured Māori women consumed significantly less vitamin D (2.0µg vs 3.0µg) (P=0.01) and magnesium (143.0mg vs 211mg) (P=0.033) compared to non-fractured Māori women.

Conclusion

Energy intakes were low for all participants and may have manifested the suboptimal intakes of calcium, vitamin D, potassium and magnesium prevalent in Māori and non-Māori, men and women. Fractures were more frequent in women than men, and both Māori and non-Māori sustained similar rates of fracture over the 24 month period. Magnesium and vitamin D intakes were significantly related to fracture occurrence in Māori women; this relationship diminished with further regression analysis. Increased intake of energy in adults of advanced age, with a focus on protein rich and nutrient dense foods, particularly calcium and magnesium, should be encouraged through consuming a variety of foods from the major food groups. Greater intakes of calcium can be achieved through higher consumption of milk and dairy products including yoghurt and cheese; and magnesium through increased green leafy vegetables, seafood, dairy, mushrooms, avocado, beans and bananas. Vitamin D intakes were minimal from food; however it is possible participants were receiving supplementary vitamin D and further investigation is warranted. For fractured Māori women, magnesium intake was significantly lower than those with no fractures. Promoting increased intakes of culturally acceptable foods such as vegetables and seafood may be advantageous to increase magnesium intakes.

Key Words:

Māori, non-Māori, fractures, nutrition adequacy, advanced age, protein, calcium, vitamin D, magnesium, potassium and previous fractures.

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Abbreviations

Abbreviation	Term	Abbreviation	Term
1,25 $(OH)_2D_2$	1a, 25-dihydroxyvitamin D_a, of Calcitrol	**ERAS**	Enhanced Recovery After Surgery.
25 (OH)D	25 hydroxyvitamin D	**FFM**	Fat Free Mass
25(OH)D D- 1-hydroxylase	25- hydroxyvitamin D D-1 hydroxylase	**FM**	Fat Mass
IU	International units	**IFN-g**	Interferon Gamma
kg	Kilogram	**IGF- I**	Insulin-like Growth Factor
L	Litres	**IHD**	Ischemic Heart Disease
µg	Micrograms	**IL1**	Interleukin 1
mg	Milligrams	**IL6**	Interleukin 6
ml	Millilitres	**LM**	Lean Mass
nmol/litres	Nanomol per litre	**NHANES**	National Health and Nutrition Examination Survey
AI	Adequate intake	**NZANS**	New Zealand Adult Nutrition Survey
AMDR	Acceptable Macronutrient Distribution Range	**NZHS**	New Zealand Health Survey
BMC	Bone Mineral content	**OECD**	Economic Co-operation and Development
BMD	**B**one mineral density	**PTH**	Parathyroid hormone
BMI	Body Mass Index	**QOL**	Quality of Life
CDV	Cardiovascular disease	**RR**	Relative Ratio
DALY's	Disability-adjusted life years.	**SD**	Standard Deviation
DXA	Dual energy X-ray absorptiometry	**TNFα**	Tumour Necrosis Factor alpha
EAR	Estimated Average Requirement	**eGFR**	Estimated Glomerular Filtration Rate

Glossary

Term	Meaning
Hazardous Drinking	Score eight of more on an Alcohol Use Disorders Identification test. A level considered to be detrimental to health.
PHARMAC	New Zealand government agency that decides which pharmaceuticals are to be publicly fund in New Zealand.
Regular Physical Activity	Participation in at least 30 minutes of exercise on five or more days of the week.
Mana	Prestige, authority, control, power, influence, status, spiritual power, charisma. *Mana* is a supernatural force in a person, place or object. *Mana* goes hand in hand with *tapu,* one affecting the other. The more prestigious the event, person or object, the more it is surrounded by *tapu* and *mana*.
Octogenarian	Adult aged between 80- 90 years.

1 Introduction

1.1 Introduction

New Zealanders are living longer with a greater proportion of older adults living into advanced age. It is expected that by 2051, 8% of New Zealanders with be over 85 years, compared to 1% in 2001 (Bascand, 2013). As health loss increases with age, subsequent outcomes including on-going disability, loss of independence and quality of life can make achieving increased health expectancy in line with life expectancy a challenging for older adults particularly in Māori (Ministry of Health, 2013f). The relative functional decline and increased occurrence of chronic health issues observed in older adults (Te Pou & Duncan, 2011), places greater demand on health services and expenditure, with services being accessed three to four times more by older adults than any other age group (Cornwall & Davey, 2004). Individuals living in the most deprived areas, frequently Māori (Harris et al., 2012; Salmond & Crampton, 1999; Salmond, Crampton, King, & Waldegrave, 2006), tend to experience greater health inequalities with limited access to health care, unmet health needs and higher occurrence of chronic disease (Harris et al.; Ministry of Health, 2012a).

Nutrition acts as a key modifiable factor for improved physiological and psychological wellbeing in older adults and thereby improving quality of life (Pirlich & Lochs, 2001). However, ageing is associated with decreased energy intakes, increased nutrient requirements and subsequent deficiencies in essential nutrients (Malafarina, Uriz-Otano, Gil-Guerrero, & Iniesta, 2013; Visvanathan, 2015). These deficiencies commonly manifest into chronic health conditions. Osteoporosis being one of which requires a lifelong approach for prevention, however, the detrimental effects of this disease predominantly fractures, are most debilitating for adults in advanced age (Brown, 2007; Brown, McNeill, Leung, Radwan, & Willingale, 2011). While treatment of osteoporosis and associated fractures requires a multifactorial approach including medical treatment, environment modification, medication/hormone therapy and supplementation (Brown, 2007; Flodin et al., 2014; Manuele et al., 2007; Murad et al., 2012); nutrition may be used at a primary (preventative) and secondary (treatment) level for prevention of osteoporosis and subsequent fractures.

With life expectancy of Māori increasing and more Māori predicted to reach advanced age, osteoporosis and fracture rates may increase (Brown et al., 2011). It is currently accepted that Māori experience significantly lower rates of hip fracture than non-Māori over 60 years, however less is known about the relationship between nutrient intake and fracture rate in adults over 85 years (Barber, Mills, Horne, Purdie, & Devane, 1995; Brown, 2007; Brown et al., 2011; Clarke & Khosla, 2010). The health of Māori has been improving over the last decade (Robson & Harris, 2007), however, disparities between Māori and non-Māori still exist and are a concern for Māori living into advanced

age. A focus on improved access to health care, and ensuring services are appropriate and responsive to Māori, will help improve health outcomes for Māori in the future (Ministry of Health, 2013g). The Māori Health Strategy: He Korowai Oranga (Ministry of Health, 2013a) and Positive Ageing Strategy (Rowe & Kahn, 1997) are two Government initiatives currently in place to promote successful ageing for Māori. Additionally, greater research and understanding of specific health risks for Māori adults over 85 years is required to provide this service to octogenarians (80 to 90 years). In order to use nutrition as a direct and efficient preventative tool for fractures in advanced age, we first must investigate and understand the current nutrient intakes and dietary adequacies in Māori and non-Māori, men and women.

1.2 Background

Osteoporosis is a common age-related degenerative disease affecting the bone mineral density (BMD) of sufferers globally, presenting a significant public health problem in many countries including New Zealand (Brown, 2007; Brown et al., 2011; Cummings et al., 1995; Sanders et al., 2009). Disparities in health between Māori and non-Māori have resulted in Māori having greater risk of common health conditions (Barber et al., 1995; Cunningham, New, & Ministry of Social, 2002; Dyall, Feigin, Brown, & Roberts, 2008; L. Ellison-Loschmann & N. Pearce, 2006; Lis Ellison-Loschmann & Neil Pearce, 2006; Kalafatelis, Fink-Jensen, & Johnson, 2006; Ministry of Health, 2013g; Sporle, Pearce, & Davis, 2002). However, for osteoporosis and associated fractures, European individuals particularly women have previously been at greater risk, due to a combination of genetic, hormonal and environmental factors (Barber et al., 1995; Brown et al., 2011).

Independent of health and socioeconomic factors, nutritional factors have an impact on the general wellbeing of older adults and progression of osteoporosis (Ministry of Health, 2013a). Overall energy requirements decrease with age parallel to increased requirements for some nutrients, making the intake for nutrient dense foods more important in older adults (Ministry of Health, 2012b; Morley, 2012a). As intake of total energy also decrease with age, it becomes increasingly difficult for older adults to meet both energy and nutrient requirements, which is a critical barrier to maintenance of good health and function (Chapman, MacIntosh, Morley, & Horowitz, 2002; Ministry of Health, 2012b; Morley, 2012a; Visvanathan, 2015). Additionally, hospitalisation secondary to fractures has catabolic effects on muscle and often results in additional muscle mass loss. Thus, the potential decreases in function can lessened the likelihood of fracture recovery with advancing age, particularly when suboptimal nutrition status is a contributing factor (Flodin et al., 2014). Dietary patterns and food preference also change with age, with the preference for carbohydrate foods being common both dietary diversity and ability to meet protein requirements for recovery are again impacted (Chapman

et al., 2002; Morley, 2001). The overall decrease in energy intake can be related to age associated physiological changes along with lifestyle and health status alterations. As a result, progressive weight loss and functional decline often initiate in adults over 70 years and pose a concern for overall health status and maintained independence of those living longer (Chapman et al., 2002). As little can be done to influence age-related physiological changes, food intake is a key modifiable factor to help influence health expectancy in older adults (Ministry of Health, 2013c).

Currently, nutrients of concern for adults over 70 years in New Zealand (Māori and non-Māori) include zinc, copper, calcium, vitamin D, magnesium, iodine, folate and B12 with borderline intakes of protein (Horwath, Campbell, & Busby, 1992; Ministry of Health, 2012c, 2013a, 2013c). Of these commonly inadequate nutrients protein, calcium, vitamin D and magnesium have been directly associated with bone health, additionally phosphorous and potassium play a significant role (Bischoff-Ferrari, Willett, Wong, & et al., 2009; Bonjour, 2011; Dawson-Hughes, 2015; Dawson-Hughes et al., 1990; Miggiano & Gagliardi, 2005a; Palacios, 2006b; Reid et al., 2008; I. R. Reid, 2015; Sanders et al., 2009; World Health Organisation, 1962). Both calcium and vitamin D have been extensively researched, with the consensus being that increased consumption of these nutrients by older adults would promote increased BMD and potentially decrease fracture risk (Bischoff-Ferrari et al., 2009; Chapuy et al., 1992; Tang, Eslick, Nowson, Smith, & Bensoussan, 2007). However, a recent meta-analysis and systematic review of this literature suggest that this isn't the case; that increase calcium intakes, through food and supplementation, with or without vitamin D, only resulted in marginal, non-lasting increases to BMD with limited clinical application for decreased fracture risk (Tai, Bolland, Reid, Grey, & Leung, 2015). Less is known about the remaining nutrients associated with bone health. In regards to phosphorous new research suggests that if calcium and phosphorous remain in normal ranges, increasing phosphorous intakes positively associate with BMD (Lee & Cho, 2015). Low magnesium intakes have also been linked to decreased BMD in women, without associated increased risk of fracture (Orchard et al., 2014). Additionally, increased intakes of potassium have been shown to help maintain BMD (Booth et al., 2003; Tucker et al., 1999).

1.3 Statement of Problem

Little is known of nutrient adequacy of adults of advanced age, particularly Māori living in New Zealand. Currently the New Zealand Adult Nutrition Survey (NZ ANS) investigates a handful of essential nutrients and their contributing food sources (Ministry of Health & Otago University, 2012). While helpful as a means of comparison, this survey fails to encapsulate adults living in advanced age, with the highest age group for non-Māori being generalised to over 70 years and for Māori over 50 years (Ministry of Health, 2012a). Additionally, the Mosgiel Study of Health and Nutrition in Old Age (NZ), Australian Longitudinal study of Ageing, UK National Diet and Nutrition Survey over 65 years and Newcastle 85+ Study provides some additional insight of dietary status and nutritional adequacy of older adults, however, less is known specifically for octogenarians (Adamson et al., 2009; Alam & Johnson, 1999; Horwath et al., 1992; Nowson, Sherwin, McPhee, Wark, & Flicker, 2003b).

While there is extensive research into the relationship between nutrient intake and fractures with older age and it is accepted that intakes of adequate energy, protein, vitamin D and calcium are essential (Bonjour, 2011; Miggiano & Gagliardi, 2005a; Palacios, 2006a; Price, Langford, & Liporace, 2012). Most of this research considers the relationship between supplementation with nutrients and BMD rather than dietary intake (Tai, Bolland, Reid, Leung, & Grey, 2015). Furthermore, fracture specific research commonly segregates into age groups of women over 50 years (Tang et al., 2007), or older men and women over 65 years (Bauer et al., 2013; Dawson-Hughes, Harris, Krall, & Dallal, 1997; Salovaara et al., 2010), less is known for adults living in advanced age particularly Māori. Adults aged 85 years and over represent the fastest growing proportion of older adults in New Zealand, therefore understanding current nutrient intakes of these octogenarians is imperative, if nutrition interventions are to be implemented to decrease the impact of osteoporosis and associated fractures.

This study will address the gap in the literature of contributing food groups and nutrient intakes of Māori and non-Māori living in advanced age (>80 years) and further explore New Zealand rates of fracture in this age group. A select number of nutrients related to bone health (protein, calcium, vitamin D, phosphorous, magnesium and potassium) will be investigated to determine their adequacy for New Zealand Māori and non-Māori, in advanced age and the relationship to fracture occurrence. This may result in a greater understanding of the influence dietary nutrient intakes have on future fracture occurrence in octogenarians. Findings extrapolated from this research may be of use to primary and secondary health practitioners, public health organisations, Māori health specialists, Orthopaedic and Gerontology specialists and Dietitians with relation to current knowledge, standard of practice and future nutrient based interventions for fractures.

1.4 Aim and Objectives

1.4.1 Aim

To investigate the nutrient and food group intakes of Māori and non-Māori, men and women, aged 80- 90 years in New Zealand and fracture occurrence 24 months post 2 x 24-hour multi-pass recall (MPR).

1.4.2 Objectives

1. To examine bone-related nutrient adequacy and food group intakes of Māori and non-Māori, men and women 80-90 years of age.
2. To assess the bone-related nutrient adequacy for Māori and non-Māori, men and women ages 80-90 years, who have sustained fractures over a 24 month period against non-fractured.

1.5 Structure of Thesis

This thesis includes six key chapters with accompanying abstract, references and appendices. Chapter one the Introduction outlines the context of this research concerning nutrient intakes and fracture risk, describing relevant background information and statement of the problem for New Zealand adults of advanced age. This chapter also outlines the purpose of this study, along with the specific aim and objectives. In Chapter two, current literature on health and nutritional status of an ageing population, body composition changes with age, fracture risk and nutrients of importance to bone are critically reviewed. Chapter three describes the methodology and research design of this current study. Followed by results in Chapter four and in-depth discussion of these findings along with the strengths and limitations of this study presented in Chapter five. Finally Chapter six outlines the study conclusion and recommendations.

2 Literature Review

2.1 Ageing in New Zealand

New Zealander's are living longer with a greater proportion of older adults living to an advanced age. As the population ages, what was once a classic population distribution pyramid shape is quickly becoming top-heavy (Bascand, 2012). This trend observed across western nations is believed to result from a combination of factors including decreased fertility rates, decreased infant and child mortality and increased survival of older adults (Bascand, 2012). New Zealand's top-heavy population depicted in (Figure 2.1) is a result of a gradual increase in mean age from 29 years in 1951 to 37 years in 2011-12 and the predicted increase up to 44 years by 2061.

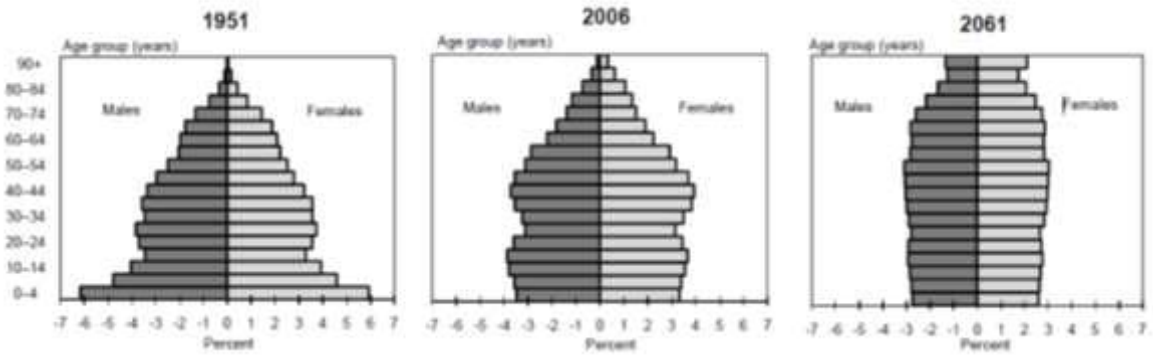

Figure 2-1 Estimated and Projected Age-Sex Distribution (total population) 1951-2061
Source: (Statistics New Zealand, 2009).

More specifically the New Zealand population of older adults aged over 65 has doubled since the 1980s, it currently accounts for 635,200 people and 14.3% of the total population (Statistics New Zealand, 2013). Increased growth is projected to continue, doubling again within the next 40 years, and resulting in a greater proportion of individuals over 65 years compared to those under 15 year by 2051 (Statistics New Zealand, 2009). By then 1,325,000 individuals aged over 65 years are projected to be living in New Zealand, just over one quarter of the total population (Bascand, 2013). Those aged over 85 years represent the fastest growing proportion of this over 65 year demographic group. With one in every four of the over 65 population estimated to be over 85 years, meaning the numbers of adults in advanced age are expected to increase from 1% in , to 8% by 2051 (see Figure 2-2).

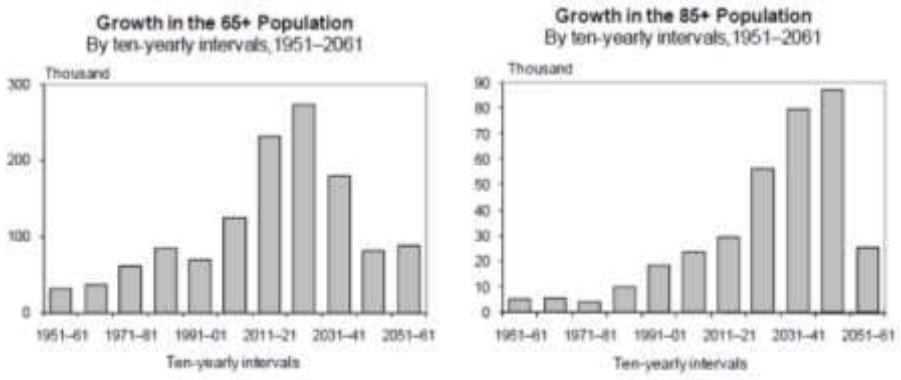

Figure 2-2 **Growth in 65+ and 85+ populations in ten year intervals from 1951-2061**

Source: (Statistics New Zealand, 2013).

This population shift presents economic pressure with the proportion of the population contributing to the working age group 15-64 years estimated to decline 8% by 2061 (figure 2-3). This demographic shift, defined by fewer people entering the workforce then exiting, is predicted to exert pressure on the labour force and result in higher productivity needed to support an ageing population (Statistics New Zealand, 2009). Labour force pressure may be relieved slightly by an expansion of the working age group, with more adults over 65 years staying in the workforce before they retire. Increased life expectancy and wellbeing in older adults have resulted in a greater proportion of adults over 65 years remaining in the workforce. The predicted contribution from this group is expected to increase from 3% to 10-18% between 2006 and 2061. Additional factors including increased eligibility for superannuation, greater flexibility in retirement age, changing attitudes of employers and employees to older workers are believed to contribute to this expanded working age (Bascand, 2012). Whether or not this predicted expansion is enough to counter increases in healthcare costs of an ageing population is not yet understood.

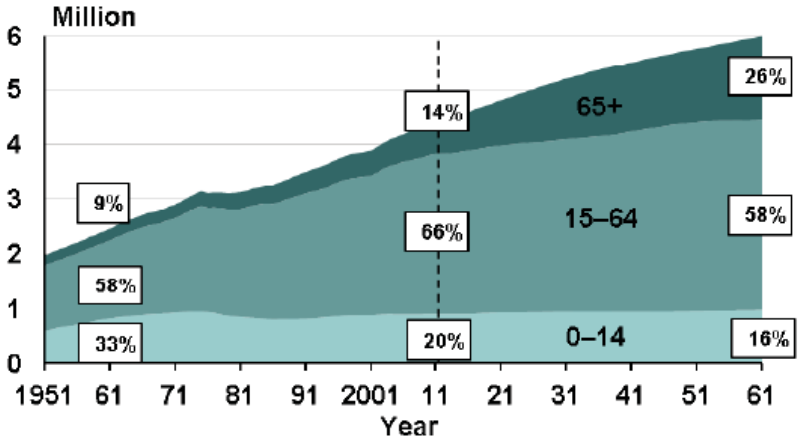

Figure 2-3 **New Zealand population age structure, mid-range projection 1951-2061**

Source: (Bascand, 2012).

Despite the idea of increased longevity being a good outcome, the prospect of an ageing population presents challenges, especially the associate financial burden of health care costs for older adults. Older age is associated with relative functional decline and increased chronic health issues (Te Pou & Duncan, 2011). Higher health service demand and expenditure has been observed with services being accessed 3-4 times more by older individuals (Cornwall & Davey, 2004). In 2010 adults aged over 85 years accounted for 1.3 % of the population, yet 10 % of total health expenditure. This expenditure is predicted to increase to 15 % by 2021, with over 85 year olds increasing to 2.3 % of the population (Ministry of Health, 2006a). In western societies, the proportion of government versus family financial support can become unbalanced for older adults, who have a greater reliance on pensions and health care and support services to cover health expense (Statistics New Zealand, 2009). A tendency to rely on the state for support in European countries is relatively common. A more positive family structure provides greater whānau support in Māori cultures, where supportive social and culture attitudes associate a relative status of mana for elders (Statistics New Zealand, 2009). Unfortunately, for predominantly Western cultures the contributions of older adults to family/society are recognised less, and government initiatives, including the Positive Ageing Strategy, are in place to help positively influence attitudes towards all older adults.

2.1.1 Life expectancy in Māori and non-Māori

A lack of uniform distribution in life expectancy exists between ethnic groups in New Zealand with non-Māori living longer than Māori (Bascand, 2013). While the average life expectancy of non-Māori (80.2 years men and 83.7 years women) is higher compared to Māori (72.8 years men and 76.5 years women), both Māori and non-Māori women tend to live longer than men, respectively (Bascand, 2012, 2013). This disparity between Māori and non-Māori life expectancy is decreasing with a 1.8 year reduction in the ethnic gap between 1997-2012 (Bascand, 2013). Contrary to this Māori men spend on average more of their shorter lives in good health compared to women. On average, Māori men have 85 % of their life spent in good health (10.3 years in poor health); and Māori women 84 % of life spent in good health (12.2 years in poor health) (Ministry of Health, 2013f). Two-thirds of the years gained in live expectancy will be spent in good health, however despite the narrowing gap in life expectancy between Māori and non-Māori; relative health expectancy in Māori people is much lower.

Independent of decreased fertility rates and decreased infant and child mortality, population growth is being driven by increasing life expectancy (Statistics New Zealand, 2006). Positive ageing is more attainable in older adults if a proportional increase in health expectancy occurs parallel to the predicted increase in life expectancy. As health loss increases with age, subsequent outcomes including disability, loss of independence and quality of life can result. Achieving this increased health

expectancy can be challenging, particularly for Māori where disproportionate health loss is observed (Ministry of Health, 2013f). While more Māori are reaching advanced age the proportion who do so in good health is lower than non-Māori.

The current average life expectancy for Māori is below a level or advanced age, however, those who do reach advanced age are predicted to experience 3% lower rates of good health than non-Māori (Bascand, 2013; Ministry of Health, 2013e). Meaning Māori will spend more of their gained years in poor health as current life expectancy is raising at a quicker rate than health expectancy, (Ministry of Health, 2013f). For Māori to achieve this proportionate increase in health expectancy and decreased the burden of disease, good health status may need to be maintained throughout life and this can only be achieved with decreased health disparities and greater health support for Māori (Marmot & Wilkinson, 2009).

2.2 Positive Ageing

The term 'Ageing in Place' describes an individual living in their residence of choice for as long as they are able. A key factor influencing the ability to age in place is access to services and or support required as their needs change with age (Dyson, 2001; Lianne, 2001; Office for Senior Citizens, 2015). Age-related changes including reduced vision, hearing, muscle strength, mobility, cognition and increased risk of falls and illness, which may affect an individual's independence within the home. The move from individual dwellings to residential care may occur at a time in an older person's life where their needs outweigh the opportunity for them to live independently (Lianne, 2001; Office for Senior Citizens, 2015).

Successful ageing is a term commonly accepted as the promotion of well-being in older adults as opposed to the negative connotation of ageing held by westernised countries in the past (Havighurst, 1963; Marmot & Wilkinson, 2009). Further definition of successful ageing describes a three-dimensional concept aimed at minimisation of disease and disability, maintenance of good physical and cognitive function along with continued engagement in social and productive activities in older adults (Rowe & Kahn, 1997). There is a direct link between successful ageing and the concept of 'Ageing in place'. The longer cognitive and physical function is maintained and disability avoided by older adults, the greater overall wellbeing and independence will be and, therefore, the likelihood of ageing in place greater. Both the Health of Older People Strategy (2002) and The New Zealand Positive Ageing Strategy (2001) support the notion of ageing in place to maintain quality of life while living in the community (Lianne, 2001; Ministry of Health, 2002b).

The small amount who are frail or vulnerable require increased care and support that spans an assortment of services (Dyson, 2001). Approximately one quarter of adults aged 65-74 years were dependent on assistance, (Ministry of Health, 2002a). The greatest incidence of fragility secondary to chronic illness and or disability aligns with the later years of life. With a greater proportionate amount of people living longer, irrespective of increases in health expectancy, demand for support services is expected to rise to meet the population demand; to address this government adopted the New Zealand Positive Ageing Strategy. The policy vision is to promote a society where people can age positively and where, older people are highly valued for their skills/ knowledge and are recognised as an integral part of families and community (Lianne, 2001; Office for Senior Citizens, 2015).

2.3 Health of older adults

As average life expectancy has increased in recent years, older adults represent the fastest growing of the age groups and the occurrence of health issues in the elderly has become a prevalent issue (Jiang et al., 2015). Older adults are an extremely diverse population group, ranging from fit and active people with relatively few chronic conditions, to those who are frail, dependent and suffer from chronic conditions and disabilities (Hickson, 2006). Decline in overall health, and body function are an expected part of ageing, observed alongside increased risk and prevalence of chronic disease. In New Zealand, prevalence of conditions become comparatively greater in older adults 75 years and over (Ministry of Health, 2015a).

The term 'Health' may be used concerning ageing, where a subjective use of good or poor health may indicate the extent of individual physiological or functional decline compared to norms for an individual of the same age (Ministry of Health, 2013g). Similarly, the use of “old old” versus “young old” to compare individuals within a similar age category may be utilised to depict health (Hoch et al., 1997). Good health is defined by the World Health Organisation as “a state of complete physical, social and mental well-being, not merely the absence of disease” (WHO, 2002). This closely aligns with the themes of successful ageing outlined prior (Rowe & Kahn, 1997). Similarly, an accelerated rate of decline in perceived wellness for older adults can be expected around 65 years (Rowe & Kahn, 1997). For those who have good self-reported health, social contact and positive health habits in their 60’s, it is expected they will have better health outcomes in their 70’s, than those with poor self-reported health. In the 2014/15 New Zealand Health Survey, an average 81.2% of older adults (over 75 years) report being in good health, with lower rates observed in Māori, and those residing in lower deprivation quintiles (Ministry of Health, 2015a).

Physical, physiological, psychological and cognitive, social, and environmental changes, all play a role in ageing and may impact on physical function and overall quality of life (Ministry of Health, 2013b).

The meaning of 'health' for older versus younger adults, and between cultures, can differ vastly based on individual beliefs (Khaw et al., 2008).

2.3.1 Health loss of older adults

With time, there is greater potential for exposure to health risk factors. The accumulative degenerative effects these have on individuals over a lifespan, influences the greater proportionate incidence of chronic health conditions observed in older adults (Khaw et al., 2008), and can be expressed as a measure of health loss. Health loss, is defined as the amount of healthy life lost, secondary to early death, illness or disability (Ministry of Health, 2013e). Health loss is expressed with relation to both disability-adjusted life years (DALYs), and health expectancy. DALYs integrates both fatal and non-fatal impacts to health, while health expectancy takes into account the healthiness of life lived (Ministry of Health, 2013e). Irreversible and modifiable conditions attribute to measures of health loss, and can shine a light on areas of potential intervention for health agencies.

In New Zealand, the Burden of Disease Injuries and Risk Factor Study 2006 -2016 (Ministry of Health, 2013e) explores health loss at a national level. Older adults (65 years and over), were found to experience greater health loss than the younger population. Although older adults only make up 12.2% of the population, they accounted for a third of total DALYs. There are various nutritional and lifestyle risk factors that jointly attribute to the development of chronic disease over time (WHO, 2002). Risk factors such as smoking, drinking, physical activity, fruit and vegetable intakes and obesity are reported in the New Zealand National Health Survey. Collectively, it is believed that health risk factors attributed close to a third of total health loss in 2006 or 300 000 DALYs. A total of 31 risk factors were considered, and broken into five clusters: physiological (high blood pressure, cholesterol, glucose and low bone mineral density), substance use (tobacco, alcohol and illicit drugs), diet and BMI, injury, and low physical activity to determine their proportionate contribution. Diet and BMI attributed 11.4% of proportionate loss when considered together. Individually, dietary factors (high sodium, low fruit and vegetable and high saturated fat intakes) contributed 3.8%, and low physical activity 4.2% (Ministry of Health, 2013f).

2.3.2 Factors Influencing Health

Socioeconomic status namely income for elderly exerts the greatest independent influencer of health in older adults, with low income and poor health going hand in hand (American Psychological Association, 2015; Kahn & Pearlin, 2006). Lower socioeconomic status is associated with increased all-cause mortality (Bassuk, Berkman, & Amick, 2002), higher incidence of stroke (Horner, Swanson,

Bosworth, & Matchar, 2003; Kapral et al., 2012), cardiovascular events, progressive chronic kidney disease (Go, Chertow, Fan, McCulloch, & Hsu, 2004; Jafar, Islam, & Poulter, 2006), lower self-reported quality of life and smaller social networks with subordinate quality of social interaction (Kaplan et al., 2008).

Paid employment predominantly determines income. A New Zealand adult becomes eligible for superannuation at 65 years of age and older adults commonly have lower incomes than their younger counterparts. Despite this over 90% of adults over 65 years still live with their spouse, either in a home they own, or in a house owned by a family trust or relative (Ministry of Health, 2002a). Work cessation in older adults can be gradual with an observed decrease to part-time paid work, voluntary unpaid work and childcare common for those over 65. This gradual progression allows continued contact with social networks, community, and regular activity, and can positively affect health independent of income (Ministry of Health, 2002a). Additionally, societal engagement is associated with better health, lower risk of disease, and increased survival (Greenwood, Muir, Packham, & Madeley, 1996; Kawachi et al., 1996). The maintenance of good family and social support systems increases the likelihood of older adults to gain access to doctor and community services.

Maintenance of good physical condition becomes increasingly difficult for older adults secondary to physiological and cognitive changes. Age-related changes influence older adults metabolic functionality, impacting nutrient absorption, storage, utilisation, and excretion, along with the functional ability to prepare and consume foods (Ministry of Health, 2013b; Visvanathan, 2015). Cognitive and mental decline with age, can have a marked impact on appetite, food choice and eating habits, with dementia being strongly associated nutritional risk (Ikeda, Brown, Holland, Fukuhara, & Hodges, 2002). Similarly, depression in older adults has serious outcomes for health. Increased risk of death, disability, anxiety and subsequent cognitive and functional decline, have been associated with depression (Rodda, Walker, & Carter, 2011).

Smoking and hazardous drinking are two influencing factors that are comparatively less prevalent in older adults. In comparison to the national average of 15.5 %, smoking rates in elderly are lowest of all age groups, with only 4% of adults >75 years smoking at least once daily (Ministry of Health, 2013g). Rates of hazardous drinking are greatest in youths and subsequently decreases with increasing age. As few as 2% of adults >75 years were classified as drinking at a level detrimental to health, compared to the national average of 15.4%; therefore, hazardous drinking is less of a concern for this age group (Ministry of Health, 2013g).

Preventative measures, both dietary and physical activity are two modifiable factors that can have marked effect on the pace of health decline and mortality rates of older adults. In the Health Loss in New Zealand report physical activity was observed at its lowest in adults over 75 years, with 38% participating in regular physical activity, having decreased 12% compared to adults 65 to 74 years (Ministry of Health, 2013e) which suggesting potential room for exercise interventions. In the same report approximately three-quarters of deaths reflected poor diet, while the remaining quarter reflected inadequate physical activity (Ministry of Health, 2013e). The importance of nutrition and physical activity is, therefore, imperative not only in the prevention of chronic disease, but also in minimising frailty and maintenance of independence in older adults. To achieve this, an array of age and culturally appropriate food and nutrition, physical activity, and support services are necessary (Kuczmarski & Weddle, 2005).

2.4 Māori Health

Globally, the health status of indigenous people varies. It is influenced by factors including distinctive historical, social and political conditions; however, these conditions usually result in poorer health for indigenous people (Bramley, Hebert, Jackson, & Chassin, 2004). While health disparities are unnecessary and unjust, disparities in Māori health, comparative to non-Māori, have been evident since colonisation (Dulin, Ephens, Alpass, Hill, & Stevenson, 2011; L. Ellison-Loschmann & N. Pearce, 2006; Harris et al., 2012). With a greater proportion of New Zealanders reaching advanced age, increased life expectancy could be attributed to the better health status of older adults, but this is not necessarily the case for Māori (Ministry of Health, 2013f). Rather, it is believed that of all New Zealand ethnic groups reaching advanced age, both Māori and Pacific populations will experience the greatest amount of age-related morbidity. The occurrence of disparity for Māori involves an intricate mix of factors including socioeconomic status, lifestyle factors, availability of healthcare, and discrimination (L. Ellison-Loschmann & N. Pearce, 2006). These findings have prompted a call for health services to be culturally appropriate and responsive and, with improved access for Māori (Lis Ellison-Loschmann & Neil Pearce, 2006).

Health inequalities exist amongst all ethnic groups in New Zealand; however, are most distinct between Māori and Europeans (non-Māori) (Harris et al., 2012). Health disparities for Māori are evident for exposure to health risk factor and prevalence of health conditions, both of which have been associated with greater barriers to health care experienced by Māori. In the 2014/15 National Health survey Māori adults over 70 years' experienced higher rates of coronary heart failure, type 2 diabetes, gout, asthma, anxiety and depressive disorders compared to non-Māori (Ministry of Health, 2015a). In the last New Zealand Health Loss Report, Māori had higher rates of health loss than non-

Māori across all ages including older adults (Ministry of Health, 2013e). Additionally, cost and lack of transport were reported as barriers to visiting the GP, getting a medical centre appointment within 24 hours, and filling prescriptions (Ministry of Health, 2013g).

Deprivation may be considered with regard to health disparities between Māori and non-Māori (L. Ellison-Loschmann & N. Pearce, 2006). In New Zealand Māori and those residing in the lowest deprivation quintile, experience proportionally greater occurrence of psychological disorders including depression and anxiety (Ministry of Health, 2015a). More than half of the Māori population (56%) are believed to live in areas ranked in deciles 8 to 10 (Quintile 4 to 5) (P. L. Dulin, Stephens, Alpass, Hill, & Stevenson, 2011). The New Zealand Deprivation Index (NZDep) categorically scales deprivation based on neighbourhood decile scores 1-10; one being the least deprived and ten being the most. Additionally, deprivation may be depicted in quintiles associated with the NZDep2006 scale utilised in the 2008/09 New Zealand Adult Nutrition Survey; one being the least deprived and five being the most (Ministry of Health, 2012b; Winnard et al., 2012). Analysis of the decile index reported differences in life expectancy between Māori and non-Māori. The least deprived decile (1-7) showed disparities in life expectancy between groups as Maori were living 5.8 years and 5.3 years less than non-Maori for men and women respectively. In the most deprived deciles (8–10), this comparative gap between cultural groups grew to 8.2 years for men and 10.1 for women.

The Māori view of health is one of overall wellness and utilises holistic health models. The Te Whare Tapa Whā model describes the four fundamental foundations for Māori health as being: Whānau (family health), Hinengaro (mental health), Tiana (physical health) and Wairau (spiritual health). Additional models, Te Wheke and Te Pae Mahutonga, are also used as they illustrate the importance of social, emotional, physical and spiritual aspects of health (Rochford, 2004). Modern New Zealand primary care services lack consistent acknowledgement of the taha Wairau (spiritual dimension) of Māori well-being and, therefore, have been less successful in catering to Māori needs (Durie, 1999).

In New Zealand, older Māori maintain greater social and community contact in older age, with higher proportional rates of unpaid work, including childcare, community work and contact with the marae, (Ministry of Health, 2002a). For Māori, this is particularly important as involvement with whānau, marae and community not only contributes to positive ageing but also makes up a large aspect of Māori culture (Waldon, 2003).

To achieve the best health outcome for Māori New Zealand's the Māori Health Strategy: He Korowai Oranga was developed by the Health and Disability sector. The strategy provides an overarching framework of considerations for Māori health and wellbeing so initiatives are specific to meeting the

needs of Māori communities. The overall aim of He Korowai Oranga is to produce Pae Ora (Healthy Future. Elements of Wai Ora (Healthy Environments), Whānau Ora (Healthy Families) and Mauri Ora (Healthy Individuals) are the basis of its framework (Ministry of Health, 2013b). To make Primary Health Care more accessible to Māori, there are increasing numbers of Māori Hauora (health care providers) being established to run culturally specific services (L. Ellison-Loschmann & N. Pearce, 2006).

2.5 Osteoporosis, Fractures and Falls

2.5.1 Osteoporosis

One of the perceived issues associated with increasing life expectancy, that is disproportionate to health expectancy, is the burden of degenerative conditions including osteoporosis, (Edelstein & Barrett-Connor, 1993). Ageing, body mass index (BMI), and body composition all impact on bone health due to their influence on bone mineral density (BMD) (Jiang et al., 2015). Osteoporosis has traditionally been an indicator for fracture risk, however, low BMD is now also considered as a strong predictor of all-cause mortality (von der Recke, Hansen, & Hassager, 1999).

Bone is a living tissue made up of, organic matrix (collagen), bone cells (osteoblasts and osteoclasts) and bone minerals (WHO, 2003). During childhood and adolescence, the bones that constitute the human skeleton undergo continual growth and remodelling (Matkovic & Visy, 2015; Office of the Surgeon, 2004). The first three decades of life is dedicated to the growth of bone, with the accrual of peak bone mass occurring around 30 years of age (Compston, 2004; Poole & Compston, 2006). Higher peak bone mass is associated with the lessened impact of age-associated bone loss, and lower relative risk of fracture in advance age (Poole & Compston, 2006). Bone and total body calcium loss are accelerated with age as bone minerals, and the collagen matrix degradation occurs quicker than it can be remodelled or replaced (Ministry of Health, 2013c; WHO, 2002).

There is accelerated bone loss observed in postmenopausal women around 50 years of life, and men over 70 years (Brown, 2007). This silent and rapid bone loss constitutes the progression towards osteoporosis and is believed to provide an increasingly significant public health burden as the population ages (WHO, 2002). Irrespective of BMD the longer individuals live, the higher their chance of developing osteoporosis and associated fractures (Brown, 2007). It is imperative that osteoporosis prevention is lifelong, starting with measures to achieve adequate calcium intake, vitamin D exposure and physical activity in youth not just in later life.

2.5.1.1 Classification and Causation

Osteoporosis can be classified three separate ways based on causal factors: age-associated post-menopausal, idiopathic and secondary. Age-associated, post-menopausal is most common and pertains to the accelerated loss of bone observed post-menopause (WHO, 2003); while, the age-association describes the later onset of osteoporosis found in men over 70 years (Manuele et al., 2007). Hormones, including oestrogen in women and testosterone in men, decrease with age which in turn promotes bone loss (Mundy & Guise, 1999; Prince, 1994; Turner, Lawrence, & Spelsberg, 1994).

Idiopathic osteoporosis is a less common with no apparent etiological reasoning. In women, it is defined by low areal BMD, or fractures, in otherwise healthy pre-menopausal women (Cohen et al., 2009). Similarly, in men, idiopathic osteoporosis is defined by one or more fractures alongside low BMD before 65-70 years of age (Gennari & Bilezikian, 2013; Willson, Nelson, Newbold, Nelson, & LaFleur, 2015). Despite the absence of aetiology, it is theorised that both genetic factors and family history have a role to play in idiopathic osteoporosis (Cohen-Solal, Baudoin, Omouri, Kuntz, & De Vernejoul, 1998; Gennari & Brandi, 2001).

Secondary osteoporosis occurs as a consequence of certain disease states and treatments. Gastrointestinal disorder (Coeliac and Crohn's disease), metabolic disorders (haemophilia, anorexia, and chronic renal disease) and endocrine disorders (thyrotoxicosis and type 1 diabetes). Subsequently common drugs used in therapy of medical conditions including anticonvulsants, glucocorticosteroids, gonadotropin-releasing hormone agonists and oestrogen antagonists, all pose a risk of secondary osteoporosis (Brown, 2007).

Lifestyle factors, including physical activity and smoking, also have subsequent effects on BMD and fracture risk. Regular weight wearing exercise, including activities like walking, having been found to be beneficial in retention of bone mineral density throughout the life span (Huang, Himes, & McGovem, 1996). Likewise, physical activity is beneficial in fracture prevention through improved muscle function (up to 200% in octogenarians), co-ordination and balance (Deutz et al., 2014; Karlsson, Nordqvist, & Karlsson, 2008). Conversely, smoking has the opposite effect on BMD and bone health (WHO, 2003). Greater rates of BMD degradation (2% greater loss of BMD, per decade)(Law & Hackshaw, 1997), and subsequent increased risk of fractures, are both higher for smokers (Kanis et al., 2004). A combination of poor nutrition, sedentary behaviours, smoking, and hormonal imbalance, throughout lifespan affects peak BMD accrual and, therefore, increases the risk of osteoporosis in older life.

2.5.1.2 Diagnosis

Single and dual energy X-ray absorptiometry (SXA and DXA) is the recommended measure for diagnosis of osteoporosis. SXA, examines both mineral density and area and volume, for appendicular sites (wrist and heel), and DXA, for other locations (hip and spine) (Brown, 2007; Jiang et al., 2015). The World Health Organization definition of osteoporosis is a BMD 2.5 or more standard deviations below the normal, age-matched peak BMD. Prevalence measures of osteoporosis in New Zealand have previously been based on self-recall of fracture or previous osteoporosis diagnosis from a doctor. Findings from the New Zealand Health Survey identified 70,000 New Zealand individuals to report having osteoporosis. Nearly a third (20,000) were diagnosed secondary to fracture. The remainder were diagnosed by other means with relatively few receiving recommended DXA scan (Ministry of Health, 2008), therefore, it is believed that the prevalence of osteoporosis is much greater than that reported.

2.5.1.3 Morbidity

The main cause of both morbidity and mortality, accompanying the loss of BMD, is the increased occurrence of fractures. Health loss associated with osteoporosis and osteoporotic fractures is consistent throughout national and international reports on osteoporosis specific burden of disease (Begg, Viss, Barker, Stanley, & Lopez, 2008; P. Brown, R. McNeill, W. Leung, E. Radwan, & J. Willingale, 2011; Keene, Parker, & Pryor, 1993; Ministry of Health, 2013f; Strom et al., 2011; Willson et al., 2015). As osteoporosis is a silent disease, it is not until fractures occur that individual morbidity and associated quality of life begins to decrease. In New Zealand, osteoporosis contributed to 82% of fracture-related health loss in older women, and 64% of older men, and was estimated to account for 10% of all injury-related health loss in adults over 50 years (Ministry of Health, 2013f; Otago University & Health, 2012). Osteoporotic fractures can be either incidental or silent and occur anywhere through the body, most commonly in the hip, wrist or spine (Brown, 2007). Hip fractures, in particular, incur the greatest contribution to health loss, with marked impact on morbidity and mortality (Pasco et al., 2005). Short term morbidity (6 weeks to 6 months, post fracture) can be expected for all fractures, when individuals experience decreased mobility, confidence independence and restriction in activities of daily living. However, prolonged morbidity may extend >1 year, post-fracture, with increased age and hip fractures (Pasco et al., 2005). Strategies for prevention, treatment and management of fractures is integral in decreasing morbidity duration, and is further discussed in the Chapter 2.8.2 Fracture Hospitalisations.

2.5.2 Falls

Falls are serious at any age, yet fracturing, secondary to falls, is more likely with advancing age. One in three older adults in community-living, are likely to fall one, or more times annually (Campbell, Borrie, & Spears, 1989; S. R. Lord, Ward, Williams, & Anstey, 1993; Tinetti, Speechley, & Ginter, 1988). The relationship between falls risk, fractures and osteoporosis are of key concern to older adults due to the silent nature of the condition (Karlsson et al., 2008). Where fracture occurs as a result of a fall, the likelihood of secondary falls consequently increases post fracture due to deconditioning (Bliuc, Alarkawi, Nguyen, Eisman, & Center, 2015). The frequency of falls in older adults can be influenced by any number of the following factors: dwelling type, age, gender, frailty and level of independence. While rates of fracture are comparatively higher in women than men, it is the opposite for falls. An Australian study has observed average fall rates for older adults, as 2.8 falls/person/year in men, and 1.5 falls/person/year for women (Lord, Menz, & Tiedemann, 2003a), with likelihood of falls by men being 1.5 times more likely than for women (Murray, Cameron, & Cumming, 2007). Those found to fall most frequently are considered to be in the middle of the spectrum of care. Fall rates are least for the frailest (limited mobility) and the most independent (Lord et al., 2003a). Supplementary factors of fall risks in this cohort, not mentioned above, included incontinence, psychoactive medication, slow reaction times and a previous fall history (Lord, H. B. Menz, & A. Tiedemann, 2003b).

Falls in nursing homes are around three times more common than in the community (Lord et al., 2003a; Soriano, DeCherrie, & Thomas, 2007), with the incidence of falls in nursing homes equating to 1.5 falls/bed/year (Rubenstein, Josephson, & Robbins, 1994). Falls incidence in hospitals, however, is found to be higher again, with 3.4 falls/person/year in geriatric rehabilitation wards, and a staggering 6.2 falls/person/year in psychiatric wards (Nyberg, Gustafson, Janson, Sandman, & Eriksson, 1997). For those specifically in the rehabilitation settings, risks are greater secondary to carpet flooring, confusion, vertigo, stroke, cognitive impairment, being an amputee, sleep disturbance and medications (Vieira et al., 2014).

In New Zealand, falls in adults aged over 65 years are common for those in residential care, hospitals and community–dwellings. New Zealand ACC data of accidents during 2000-02 found that falls accounted for fifty percent of ACC claim costs, and three-quarters of injury-related hospitalisation in older adults (> 65years). Deconditioning commonly accelerate with advancing age (Anton et al., 2015; Rolland et al., 2008), therefore, strategies to address fall prevention in community-dwellings, residential care and hospitals are imperative in the prevention of fracture amongst octogenarians.

2.5.3 Fracture

Incidental or silent fractures are both linked to poorer outcomes for older adults, and cause significant pain, suffering, disability and occasionally, premature mortality (Brown et al., 2011; Kanis, Odén, McCloskey, Johansson, Wahl, Cooper, et al., 2012). As osteoporosis affects the skeleton, systemically fractures can occur anywhere throughout the body; however, fracture of the hip, spine, wrist and shoulder are most common, with hip or neck of femur (NOF) fractures having the greatest impact on morbidity and mortality. For those who survive hip fracture, many require long-term care, and incur the highest rates of premature deaths with one in five passing away within the 12 months post fracture (Brown, 2007; Brown et al., 2011). Secondary to the primary fracture, some concerning secondary outcomes may result including, chronic pain, deformity, multiple hospitalisation, loss of independence, potential need for long-term care, and decreased quality of life (Brown, 2007; Orive et al., 2015).

Decreased BMD, related to osteoporosis is the predominant risk factor associated with fractures; however, any number of additional factors may exacerbate risk. These include: previous fractures, increasing age, poor self-rated health, smoking history, weight change, height, and low socioeconomic status (Brennan et al., 2009; Brown, 2007; Compston, 2015; Ensrud et al., 2003; Holloway et al., 2015; Kanis et al., 2004; Melton Iii, Atkinson, Cooper, O'Fallon, & Riggs, 1999). Risk of fracture is believed to increase with any degree of BMD loss (Bliuc et al., 2015; Johnell & Kanis, 2005; Marshall, Johnell, & Wedel, 1996; Richards et al., 2008), with every SD decrease in BMD, the associated risk of hip fracture increases 2.6 times for fractured hip, and 1.6 times for any other form of fracture (Johnell & Kanis, 2005; Marshall et al., 1996). Age irrespective of BMD was determined as a risk in findings from the Dubbo Osteoporosis Epidemiology Study which looked at individuals over 60 years. In this study, 54 % of fractures occurred in non-osteoporotic older adults (12% normal BMD, 42% osteopenia). Considering previous fractures, The Women's Health Initiative Observational Study and Clinical Trials, identified initial wrist fractures to be associated with subsequent increased risk of secondary fracture at various sites including hip, vertebral, upper and lower extremities in post-menopausal women (Crandall et al., 2015). Additionally, after sustaining a vertebral fracture, the risk of sustaining a secondary fracture within the next 12 months is believed to increase four-fold (Melton Iii et al., 1999).

Globally, osteoporosis is believed to cause 8.9 million fractures annually. A recent systematic review investigated the country-specific risk of hip fracture, and the 10-year probability of a major osteoporotic fracture (Kanis, Odén, McCloskey, Johansson, Wahl, Cooper, et al., 2012). Country based findings for the ten-year probability of fracture, stratified for men and women, can be seen in figure 2.4, with colour classifications descriptors displayed in Table 2.5. New Zealand is shown to be at a

comparatively lesser risk of fracture on a global level. Women are classified at a moderate risk level (200-300/100 000), and men low risk (<100/100 000) for 10-year probability of fractures. Despite New Zealand's comparatively low ranking, the burden of osteoporosis and osteoporotic fracture is still substantial at a societal level. In New Zealand, almost 100,000 osteoporotic fractures occur annually and it is believed this number will increase to over 115,000 by 2020.

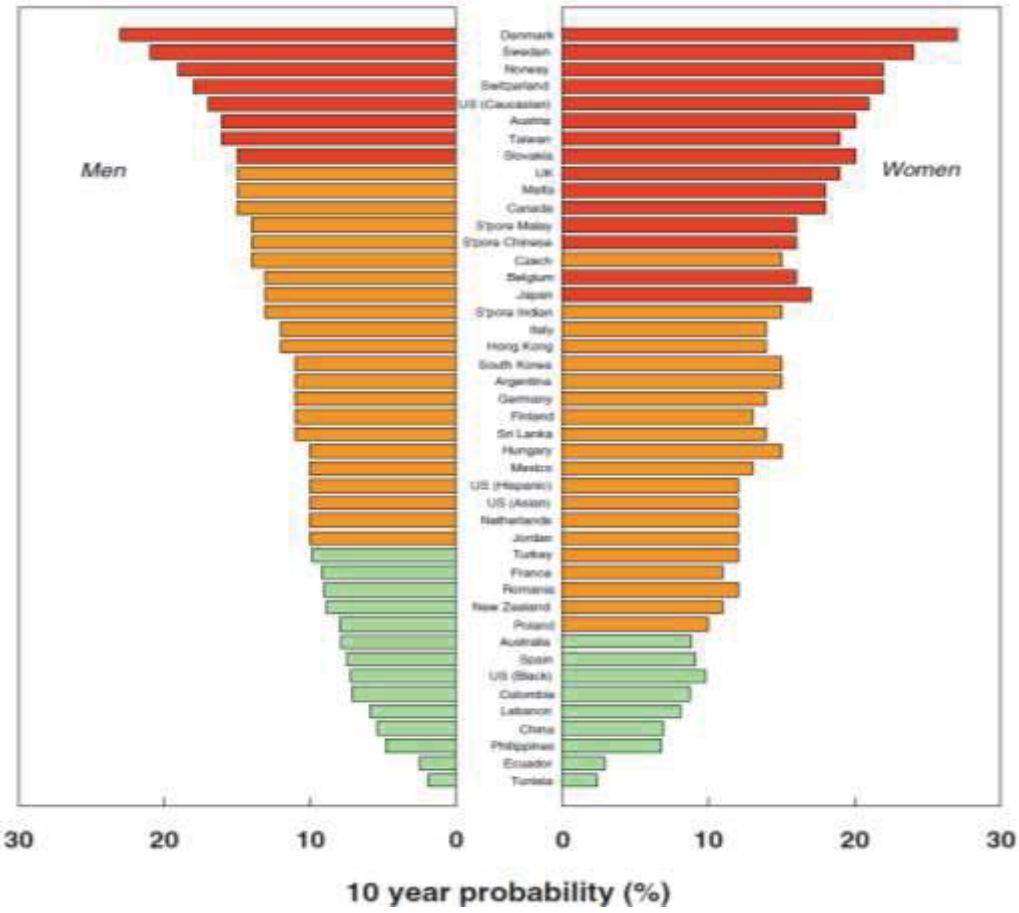

Figure 2.4 Global ten-year probability of major fracture (%) in men and women aged > 65 years. ***Source: (Kanis, Odén, McCloskey, Johansson, Wahl, Cooper, et al., 2012)***

Table 2. 5 Categorisation and colour coding, for fracture rates/100,000 and 10 year fracture probability. ***Source:(Kanis, Odén, McCloskey, Johansson, Wahl, Cooper, et al., 2012)***

		Incidence /100,000			FRAX probability (%)	
Colour	Category	Women	Men	Men and women	Men	Women
Red	High	>300	150+	>250	>15	>15
Orange	Moderate	200–300	100–150	150–250	10–15	10–15
Green	Low	<200	<100	<150	<10	<10

Internationally, European men and women experience a higher incidence of fracture, and therefore increased risk, compared to other ethnic groups (Kanis, Odén, McCloskey, Johansson, Wahl, & Cooper,

2012). Similarly, in New Zealand osteoporosis prevalence has historically been higher in Europeans than Māori, Pacific and Asian ethnicities. A study that looked at rates of fracture in a sample of 84,000 New Zealanders found Māori individuals only represented 4% of osteoporotic fractures, with an exponentially greater 92% experienced by Europeans (Brown, 2007). A less drastic ethnic dispersion was observed in an additional study of Māori and non-Māori, men and women, aged over 60 years. Rates of hip fracture per 100,000 people were as follows: for Māori men 197 and women 516; and non-Māori men 288 and women 827 (Barber et al., 1995). This research showed that at the time, age-specific hip fracture rates were rising in New Zealand for everyone but Māori men; and that non-Māori experienced a higher incidence of hip fracture than Māori.

Due to the accumulative effect of age-associated risk factors for fractures, adults of advanced age should be considered at greatest risk of fracture, particularly those of European descent, both in care and dependent, and for those with severe cognitive impairment (Benzinger et al., 2015; Norton et al., 1999; Taylor et al., 2004). Lifelong measures focused on decreasing the impact of modifiable risk factors, may help to preserve function and lessen the burden of fracture in older adults.

2.6 Hospitalisation

2.6.1 General hospitalisation

Numbers of hospital admissions increase for older adults, particularly those of advanced age. The increased complexity of health conditions, experienced with ageing, is believed to correlate with the increased rate of hospitalisation and, therefore, increased health expenditure observed for older adults (Anton et al., 2015). Age-related morbidity and mortality, are seen to increase as conditions including chronic disease, dementia, disability, mental illness and addiction are common in this group (Te Pou & Duncan, 2011). The resultant risk of falls is the greatest threat for adults over 85 years. Between 2000 and 2001, 89 % of patients in rehabilitation wards were aged over 65 years, with those over 85 years occupying a disproportionately higher number of beds compared to their younger counterparts. This as, bed numbers in those over 85 years were double that of those for 75 and 84 years and seven times greater than those for 65 -74 year olds (Ministry of Health, 2002).

Within New Zealand, disproportionate rates of hospital admission are observed with age as well ethnicity. Between 2012-13, 31.5 % of publicly funded hospital admissions were for older adults (>65years), with the greatest rates of admission being observed in men and women over 85 years (Ministry of Health, 2015b). Additionally, previous findings from LiLACS NZ discovered that 42 % of participants had been admitted to hospital in the last 12 months, with half of those admitted, readmitted at a later date (Kerse & LiLACS NZ, 2014). These findings are similar to New Zealand data

on medical and surgical admissions between 2000-2001, which reported 53% of adults over 85 years had been admitted at this time (Ministry of Health, 2002a). Furthermore, hospitalisation rates for Māori, have been consistently higher than non-Māori over the last decade non-Māori over the last decade (Ministry of Health, 2015b). Consequently, Māori and non-Māori adults of advanced age are overrepresented in hospitalisation data and this representation is only expected to increase with an ageing population.

Increased length of stay is also observed with increasing age (Levant, Chari, & DeFrances, 2015). Any functional declines advance dramatically during these admissions (Graf, 2006). As the length of stay increases for older adults, so too does the cost of hospital admissions and total health expenditure (Blakely et al., 2014). The average length of stay for New Zealand between 2009/10 was 7.9 days; 6.2 and 8.2 days for Māori and non-Māori respectively (Ministry of Health, 2012b).. Health expenditure in adults >65 this group was seen to rise from 29 %-40% between 1951 and 2002, and is predicted to increase to 63 % by 2050/51 (Bryant, Cheung, McHugh, Teasdale, & Tobias, 2004). Therefore, efforts to assist the health of older adults and strategies to decrees length of hospital stays are integral to lessen the burden of health expenditure associated with an ageing population.

2.6.2 Fracture Hospitalisation.

Musculoskeletal and circulatory conditions contribute the greatest number of hospital admissions in New Zealand older adults (Ministry of Health, 2002a). Age-associated frailty increases the risk of falls in older adults and represents the leading cause of injury-related mortality and morbidity in adults over 85 years In New Zealand. Recent falls frequency data released from LiLACS NZ for Māori and non-Māori over 80 years, found that over one-third (37%) of individuals had fallen in the previous 12 months, of those who fell one in five were hospitalised secondary to falling (Kerse & NZ, 2014). Falls were the leading cause of death secondary to injury in adults over 85years 2003-2007. Falls accounted for 80.2% of all injury resulting in death for older adults; an increase of 2.9% from 77.3% between 1998-2003 (Otago University & Health, 2012). Falls also generated the greatest proportion of injury resulting in hospitalisation for adults over 85years (2005-2009), with 87.0% of injury-related hospitalisations due to falls (Otago University & Health, 2012).

Falls and subsequent hospitalisation due to fracture of any nature are of concern for adults of advanced age. However, morbidity associated with hip fracture impacts greatly on both an individuals' quality of life, and at an economic level (Brown, 2007; Brown et al., 2011; Kanis, Odén, McCloskey, Johansson, Wahl, Cooper, et al., 2012; Orive et al., 2015). In 2007, the annual cost of hip fracture care was NZ$105 million alone, and contributed to the NZ$325,000 spent daily on treating fractures caused by osteoporosis (Brown, 2007). The average length of stay for osteoporotic fractures in, particularly

hip fracture (14 days), are substantially higher than the average length of hospital stay, and these fractures often require additional rehabilitation and outpatient care. A hip fracture requires twice as many acute days as average general admissions. Over two-thirds of hip fracture sufferers require additional admittance to rehabilitative care; on average 22 days of additional care (Brown, 2007).

Between 1998 and 1999, rehabilitation wards accounted for 20% of total health expenditure and were the second highest contributor to disability support services expenditure (Ministry of Health, 2002a). The average cost of treatment for a hip fracture is estimated to be close to $24,000 per person (Brown, 2007). In contrast to hip fractures, hospitalisation due to vertebral or other fractures, on average require fewer days in the hospital (11 days) and fewer outpatient visits. Therefore, the cost of vertebral fracture care is approximately half that required for hip fractures ($12, 500) (Brown, 2007). Hip fractures are severe in nature and have marked effects on mobility and quality of life, therefore, most will require hospital care, conversely, 92% of vertebral fractures remaining undetected or misdiagnosed (Finnern & Sykes, 2003).

Fracture Liaison Services (Office for Senior Citizens, 2015), and the Enhanced Recovery After Surgery (ERAS) program (White, Houghton-Clemmey, & Marval, 2013) are two DHB based initiatives that have been implemented to decrease fracture occurrence, enhance recovery and lessen the burden of fractures. Fracture Liaison services have been adopted in all New Zealand DHB's and aim to minimise the risk of secondary fractures, via hospital-based screening post admission for fragility fracture, implementing preventative treatments (DXA bone scan, prescription of calcium supplementation, vitamin D and bisphosphonates) and liaising with GP services (Office for Senior Citizens, 2015) . Conversely, ERAS is an accelerated care pathway developed to improve the care of elective surgical patients, however, is yet to be fully integrated into all New Zealand DHB's. The ERAS multidisciplinary team approach aims to improve quality of treatment, decrease length of stay and deliver better patient outcomes (White et al., 2013). Both approaches are delivered at a secondary care level, and therefore, primary care preventative approaches are still necessary to provide accessible tools for the promotion of bone health, and decreased individual and economic burden of fractures.

2.7 Ageing and Body Composition

The greatest proportion of adults with BMI >30 is observed in adults aged 64-74 years (38%). These rates decreased after that to 26% of adults in advanced age (Ministry of Health, 2014). This BMI decrease is in line with the considerable changes in body composition that occur with ageing, with an inevitable loss of lean mass, and relative increase in fat mass is observed over time (WHO, 2003). This age-related decline in muscle mass is termed sarcopenia, the gradual decrease of lean body mass (skeletal muscle and bone) and the proportional increase of fat, observed independent of the catabolic effects of conditions like cachexia and malnutrition (Rolland, Van Kan, Gillette-Guyonnet, & Vellas, 2011). Consequences of this are decreased strength, decline in physical function, and frailty, which can subsequently impair mobility and balance (Deutz et al., 2014; Rolland et al., 2008).

Sarcopenia like osteoporosis is understood to have both genetic, mechanical and environmental aspects (Janssen, Heymsfield, & Ross, 2002; Ministry of Health, 2013b). While causation is debated, sarcopenia is primarily believed to be a natural process of ageing (encapsulating hormonal, neural, and metabolic and cytokine effects); and further influence by factors including reduced physical activity, illness, disease or malnutrition (Cruz-Jentoft et al., 2010; Hickson, 2006; Roubenoff & Hughes, 2000). Conversely, because the capacity to participate in physical activity diminishes with the progression of sarcopenia, this further influences the subsequent decline of mean muscle mass (LMM) (Hickson, 2006). The consequences of this for elderly are the commonly observed declines in gait, walking speed, flexibility, functional and aerobic capacity (Fielding et al., 2011). Such declines have marked effects on individual's wellbeing, notably the association between negative effect of gait and balance, and increased risk of falls and subsequent fracture.

Muscle mass is affected systematically, despite the majority of consequences pertaining to skeletal muscle loss, both respiratory and cardiac muscles and immune function may be compromised (Watsford, Murphy, & Pine, 2007). Increased expression of pro-inflammatory cytokines has been associated with sarcopenia (Yeh & Schuster, 1999). Acute phase proteins, signal breakdown of muscle and fat at the tissue, and are stimulated by increased pro-inflammatory cytokines (TNFα, IL1, IL6, serotonin and IFN-g) REF. Increased concentration of pro-inflammatory cytokines is synonymous with ageing; secondary to higher concentrations of catecholamine, glucocorticoids and decreased production of sex and growth hormones (Hickson, 2006). This resultant systemic inflammation has been associated with muscle loss in disease states (de Godoy, Donahoe, Calhoun, Mancino, & Rogers, 1996; Hickson, 2006). A proposed relationship between INFα, IL1β and muscle wasting suggests cytokine interference with myogenic differentiation. Subsequently, the ability of stem cells to transformation into functional muscle fibers decreases and muscle wasting results (Langen, Schols, Kelders, Wouters, & Janssen-Heininger, 2001).

Lean muscle mass (LMM) is further compromised when older adults are hospitalised. As protein stores are primarily decreased by sarcopenia (Fielding et al., 2011), malnutrition and sarcopenia are believed to intensify each other. An inadequate oral intake in hospital (Cerri et al., 2015), promotes gluconeogenesis as a primary source of energy, further breaking down Lean Mass (Desborough, 2000; Krenitsky, 2012; Roubenoff & Hughes, 2000). Muscle breakdown is further exacerbated if admission is due to fracture or trauma, as stress response secondary to surgery is believed to contribute to catabolic effects of muscle (Desborough, 2000; Krenitsky, 2012). The potential outcome of clinical malnutrition and sarcopenia is a vicious cycle of disease, complications and re-hospitalisation, further worsened by increased length of hospital stays (Vandewoude, Alish, Sauer, & Hegazi, 2012; Volkert, 2011).

BMI is understood to be an important indicator of bone tissue structure (Bredella et al., 2011; J. J. Park et al., 2010; Wilsgaard et al., 2009), and predictor of risk of osteoporotic fractures, independent of BMD in older adults (Cummings et al., 1995; Porthouse et al., 2004). Risk of hip fracture increases close to two-fold in older adults with a BMI of 20 kg/m^2 compared to a BMI of 25 kg/m^2 (De Laet et al., 2005), whereas a BMI of 30 kg/m2 compared to is associated with a lessor 17% reduction in the risk of hip fracture. Therefore, it has been suggested that a BMI below 23kg/m^2, or above 30kg/m^2 in this age group, prompts the need for dietary interventions (high energy/protein and nutrient dense or calorie reduction respectively) and exercise interventions that facilitate synthesis and maintenance of lean muscle mass (LMM) (Porter Starr & Bales, 2015). Weight maintenance, rather than loss, is advised for those adults with a BMI > 30kg/m^2, who are over than 79 years or who suffer from chronic illness or disability (Porter Starr & Bales, 2015). Many studies have considered the correlation between BMI or weight and bone mineral density (BMD), with conclusions that obesity (BMI>30) protects against osteoporosis (Reid, 2002). This idea is challenged by the definition of obesity being a measure of total body fat percentage, irrespective of mass muscle contribution. It is now believed individuals with a BMI >30.5kg/m^2 and high percentage of body fat comparative to muscle mass could be at similar risk of osteoporosis as those with low BMI >18.5kg/m^2 (L. J. Zhao et al., 2008). Although studies have further investigated the various other factors influencing BMD, results are notably inconsistent.

2.7.1 Lean Mass, Fat Mass and Bone

The components of body weight or body composition include lean mass (LM), fat mass (FM), fat-free mass (FFM) and bone mineral content (BMC). While these components are known to change with age (Jiang et al., 2015), to which extent is due to the influence of a combination of factors, including

gender and ethnicity. Consequently, researchers have explored the relationship between ageing, ethnicity and body composition on parameters of BMD.

Body FM steadily increases up to 75 years, and then stabilisation or steady declines after 75 years and simultaneous fat redistribution that results in increased central adiposity (E. Rush et al., 2007; E. C. Rush, Freitas, & Plank, 2009). Prior to this increased FM, declining FFM (muscle, organ tissue, skin and bone) begins between 40-50 years, with resultant reductions in skeletal muscle and BMD (Baumgartner, Stauber, McHugh, Koehler, & Garry, 1995; Forbes & Reina, 1970; Kyle, Genton, Slosman, & Pichard, 2001; Novak, 1972). At this time body mass plays a direct role in bone turnover; as women with lowered proportionate BMD exhibit greater rates of bone loss during menopause (>50 years) (Shapses & Riedt, 2006).

LM losses, as low as 10% in formerly healthy adults are associated with increased infection rate, regressed immunity, and increased mortality (Broadwin, Goodman-Gruen, & Slymen, 2001; Landers, Hunter, Wetzstein, Bamman, & Weinsier, 2001). Normal declines in muscle mass are expected around five percent yearly after 40 years (Greenlund & Nair, 2003), increasing to one to two percent yearly after 50 years (Rolland et al., 2008). Therefore, the retention of muscle mass is believed to be of importance to older adults as it promotes maintenance of physical strength, immune function, stability and potentially BMD.

While it is accepted that both FM and LM impact BMD (J. Park et al., 2012; Zhu, Hunter, James, Lim, & Walsh, 2015), individual influence of LM or FM is debatable, some agree LM has a greater impact on BMD and reduction of fracture risk (Douchi et al., 2003; Hsu et al., 2006; Moseley et al., 2011); others believe FM, independent of LM is the stronger determining influence on BMD (Edelstein & Barrett-Connor, 1993; K. G. Lee et al., 2012; Makovey, Naganathan, & Sambrook, 2005). The contributing role each body composition factor has on BMD is said to differ slightly, as both LM and FM have mechanical elements and FM alone exerts a hormonal effect on bone. FM and LM exert a proportional degree of mechanical loading to bone, which therefore contributes to BMD (Ho-Pham, Nguyen, & Nguyen, 2014; Riggs, 2000; R. Zhao, Xu, & Zhao, 2015). Bone loss is said to be two to four times faster in the absence of oestrogen (post-menopause) (WHO, 2003). While the effects of both oestrogen and testosterone on BMD have been investigated in older men and women, it is believed that oestrogen has the greater effect and contribution to BMD in men is relatively modest (Ho-Pham et al., 2014). It is understood that low oestrogen levels impair skeletal responses to mechanical loading in elderly women (R. Zhao et al., 2015)**.** Leptin is also believed to be a contributing factor, due to the positive relationships between serum leptin and BMD in pre- and post- menopausal women. Leptin is believed to both; inhibit osteoclast activity while also promoting osteoblast maturation from stromal cells and inhibiting

adipocyte maturation (Gordeladze, Drevon, Syversen, & Reseland, 2002; Nuttall & Gimble, 2000). While mechanical and hormonal factors are known to play a role, the proportional effects depend on individual characteristics including age, gender and physical activity.

2.8 Nutrition

2.8.1 Nutrients of concern for older adults

Alterations in individual ability to metabolise, absorb, store and utilise nutrients are altered with advancing age, subsequently, requirements are altered along with the ability of adults in advanced age adults to access, prepare and consume a variety of foods (Ministry of Health, 2013c). Factors such as sensory changes, sarcopenia, food skills and knowledge, polypharmacy, altered gastrointestinal and immune function, oral health, and dentition present challenges for older adults to maintain nutritional status. Attaining good nutritional status in older age is an integral factor in health ageing, as poor nutritional status is associated with a range of issues including reduced, mobility, quality of life, self-care, participation in usual activities, and increased pain, discomfort, anxiety and depression(Keller, Østbye, & Goy, 2004; Kvamme, Olsen, Florholmen, & Jacobsen, 2011). Various factors contribute to the attainment of overall good nutrition in older adults. These include: prevention of malnutrition, the risk of chronic disease/ disability, support for physical function and mental health (Ministry of Health, 2002b).

The most recent New Zealand population based data on nutritional adequacy for Māori and non-Māori is provided by the 2008/09 New Zealand Adult Nutrition Survey (Ministry of Health & Otago University, 2012). This data is however limited for older Māori people, as the upper age category is 51 years and over, due to the limited proportion of population represented in the 71 years and over category (Ministry of Health, 2012b). Furthermore, the range of nutrients included in the survey is not extensive; however, provides a bench mark on which to compare the nutritional status of New Zealander octogenarians (Ministry of Health, 2012b).

Acceptable Macronutrient Distribution Ranges (ADMR) are used to guide macronutrient consumption for adequate nutrient intakes, while maximising health outcomes (Ministry of Health, 2006b). Currently, ADMR ranges for older adults are consistent across age groups. These consist of ranges for protein 15-25% of energy, carbohydrate 45-65% of energy, and fat 20-35% of energy. Findings for average intake of energy, protein, carbohydrate, and fat intake for adults of over 75 years were documented in the Adult Nutrition Survey 08/09, and are depicted in Table 2.6.1.

Table 2.8-1
Mean Macronutrient intake of New Zealand Adults >75 years from the 2008/09 NZANS.

	Energy	**Protein**		**Carbohydrate**		**Fat**	
	Median intake (kJ/day)	*Median intake (g/day)*	*Percent contribution to energy (%)*	*Median intake (g/day)*	*Percent contribution to energy (%)*	*Median intake (g/day)*	*Percent contribution to energy (%)*
Women	5569	57.7	16	169	48	51	33
Men	7477	72.7	16	213	48	63	31

Source:(Ministry of Health, 2012b)

The recommended intakes of some nutrients change with age and decreased vital organ function, making it increasingly difficult for adults of advanced age to keep nutrients in balance (Ministry of Health, 2013c). A systematic review of observational cohort and longitudinal studies investigated the habitual dietary intake of adults over 65 years and aimed to extrapolate the key nutrient deficiencies that posed concern for public health. Of a total twenty nutrients, the six that presented key concern included vitamin D, thiamine, riboflavin, calcium, magnesium, and selenium (Ter Borg et al., 2015). Marian and Sacks (2009) suggest a range of micronutrients have been identified of key importance to adults in ageing, these include: Vitamin A, C, D, E, B12, folate, calcium, magnesium, iron, and selenium (Marian & Sacks, 2009). Therefore, consumption of a variety of nutrient dense foods is key to the reduction of nutrition risk of older adults, and promotion of healthy ageing.

2.8.2 Nutrition and Bone Health

Many of the nutrients that have been associated with the general health of older adults have a role in bone health. Epidemiological studies have found nutrients of importance to bones, are commonly set to levels for optimal overall health not necessarily bone health (Palacios, 2006a). Good bone health throughout the lifespan is of interest, for both individuals and public health agencies, to decrease rates of osteoporosis and associated morbidity and mortality. The incidence of osteoporosis increases with age (Brown et al., 2011), and it is believed that one in two women, and one in three men, will sustain an osteoporotic fracture over their lifespan (Jones et al., 1994). Essential minerals for bone, sodium, potassium, calcium, and magnesium are of key concern to older adults, as it becomes increasingly difficult to maintain these within a homeostatic range. Age-related decline in renal function is the predominant issue for mineral balance where the ability to either conserve or excrete appropriate concentration of minerals decreases. This impaired renal function may also be exacerbated by other physiological co-morbidities or polypharmacy (Ministry of Health, 2013b).

The majority of literature, and government agencies, promote regular weight-bearing exercise, and adequate intakes of calcium, protein, vitamin D, and vitamin D exposure as the main preventative of

Osteoporosis (Ahmed et al., 2013; Cornwall & Davey, 2004; Ministry of Health, 2013c; Nguyen, Center, & Eisman, 2010b; Sanders et al., 2009; WHO, 2003; World Health Organisation, 1962). Other key nutrients are understood to play an important role at various levels of bone metabolism, including phosphorous, magnesium, potassium, silicon, boron, copper, iron, zinc, and vitamin A, E, K, C (Barbagallo, Belvedere, & Dominguex, 2009; Goulding, 2002; R. P. Heaney, 2015; Miggiano & Gagliardi, 2005b; Palacios, 2006a; Price et al., 2012). Dietary patterns that include foods high in calcium, potassium, magnesium; moderate protein (1-1.2g/kg/day protein); low in sodium and which contain fruit, and green leafy vegetables have been associated with good bone health (Zhu & Prince, 2015). Conversely, compromised bone health, and increased risk of fracture, has been associated with smoking, caffeine, and excessive alcohol consumption (Huang et al., 1996).

2.8.2.1 Energy

When older adults achieve adequate energy and macronutrient intake, micronutrient requirements are likely to be met (Ministry of Health, 2013d). Energy requirements are based on individual characteristics of gender, age, height, weight, and body composition. With increasing age there are decreasing energy needs (Ministry of Health, 2013d; Roberts & Dallal, 2005). These are caused by reductions in muscle mass and resultant alterations in basal metabolic rate (BMR), and reduced physical activity (Ministry of Health, 2013d). Simultaneously, with decrease energy requirements, age-associated nutrient requirements increase (Chapman et al., 2002; Visvanathan, 2015).

Food intake of adults in advanced age, energy consumption commonly decreases and this can be attributed to age-associated physiological changes, altered lifestyle, and health status. These decreased intakes could be seen in findings from the 2008/09 NZANS, where adults over 71 years of consumed 7477kJ/day for men and 5569 kJ/day for women. Intakes were, 18.1% and 15.8% lower for men and women respectively, than the national median intake (9161 kJ/d for men and 6449 kJ/d for women).

Decreased appetite and oral intake is common in older adults and termed ‘anorexia of ageing’. This anorexic state is most evident when weight reduction occurs in adults over 70-75 years, independent of health status deterioration (Chapman et al., 2002). The multifactorial reasons for declining intake involve both central and peripheral mechanisms. Shifts in hormone production can influence satiety factors and decreased feeding drive (Chapman et al., 2002; Malafarina et al., 2013). Age-associated changes in taste and smell are said to alter the hedonic qualities of food therefore individual preference, and early satiation is believed to occur secondary to mechanical changes within the stomach (Morley, 2001, 2012b). Cholecystokinin levels increase and testosterone levels decrease with age. This may promote premature satiation and lower appetite (Chapman et al., 2002; Morley, 2001).

Cytokines are largely anorectic so, for older adults with mild inflammatory disorders and/or a high percentage of body fat, may promote an anorexic state (Langen et al., 2001; Morley, 2001). Additionally, dysphagia, chewing difficulties, polypharmacy, financial insecurities, and inability to access or prepare food, are potential barriers that decrease the likelihood of reaching adequate energy intake (Drewnowski & Evans, 2001).

Dietary restrictions based on food preference may further decrease individual ability to attain adequate nutrients. Dietary patterns and preference foods change with age. With a preference for carbohydrate foods being common, both dietary diversity, and ability to meet macronutrient needs are impacted (Chapman et al., 2002; Morley, 2001). Greater dietary variety and nutrient density are therefore required to achieve optimal nutritional status and decrease the incidence of morbidity and mortality associated with poor nutritional status following The New Zealand Nutrition Guidelines for older adults helps with achieving this goal. Consuming three meals and two snacks a day, including foods from the four main food groups, can help increase appetite and achieve nutrient requirements (Ministry of Health, 2013d).

2.8.2.2 Protein

Protein is extensively found throughout the human body. Because of its role in every cell, the main properties of protein are both structural and functional. All protein is made up of varied long chain combinations of 20 different amino acids (Ministry of Health, 2013c). Protein is required for several body functions including enzyme, hormone, and antibody synthesis (Chernoff, 2004). Therefore, it is not uncommon to see increased health issues for older adults with inadequate protein intakes. Problems such as lower immune function, lengthened recuperation periods, skin frailty, and poor healing commonly lead to longer hospital stays (Chernoff, 2004; Deutz et al., 2014). Foods found to be rich in protein include milk and milk products, meat, fish, poultry and eggs, nuts, legumes, bread, cereal, and cereal based food along with meat alternative (soy protein) (Ministry of Health, 2013g).

Inadequate protein intake results in greater losses of muscle and in turn, higher risk of degenerative conditions. As functional decline is linked to poorer health outcomes in elderly, the maintenance of lean muscle mass through diet and exercise is of key importance in this age group (Deutz et al., 2014). While it is accepted dietary protein is important for bone health, whether adequate intakes correlate with long-term decreased fracture risk is yet to be determined (Darling, Millward, Torgerson, Hewitt, & Lantham-New, 2009). Decreased protein intake however has been linked to, reduced neck of femur BMD, low serum IGF-I, poor physical performance and is common in patients experiencing fracture (Bonjour, 2011). Dietary protein intake in community-dwelling older adults is predominantly inadequate, increasing the risk of subsequent lean muscle mass loss, functional decline, and decreased

independence (Houston et al., 2008). Ensuring adequacy of protein intake in elderly limits the risk of age-related immune function deficiency, and degenerative conditions including osteoporosis and sarcopenia (Bonjour, 2011; Deutz & Wolfe, 2013; Thomas, 2007; B. T. Wall & L. J. C. van Loon, 2013). As these degenerative conditions impact significantly on quality of life, understanding the role protein has in optimal health, prevention, and treatment are imperative for older adults (Deutz et al., 2014).

2.8.2.2.1 Metabolism

Older adults experience age-related changes concerning protein metabolism that are reflected by increased protein recommendations in this age group. Greater splenic excretion, attenuated anabolic response to ingested protein (E. Gaffney-Stomberg, K. L. Insogna, N. R. Rodriguez, & J. E. Kerstetter, 2009), greater incidence of pro-inflammatory and catabolic conditions including sarcopenia (Deutz et al., 2014), make achieving optimal protein requirements difficult for older adults.

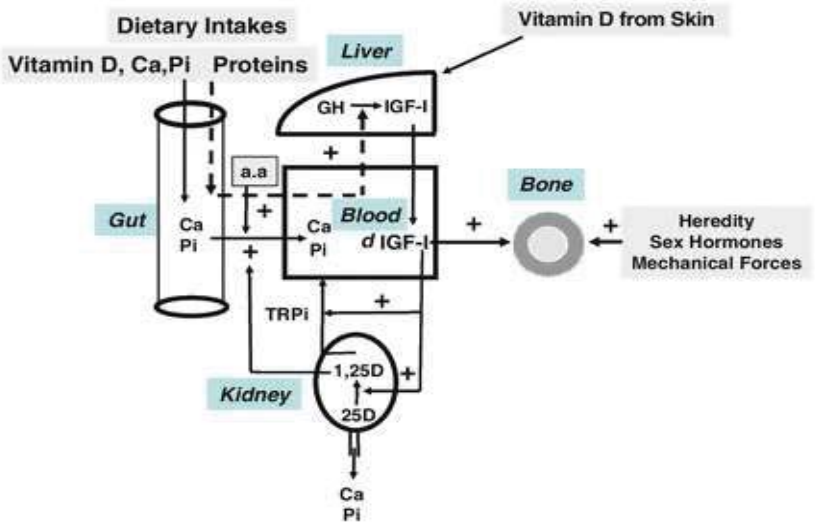

Figure 2-4 Role of dietary protein on calcium and phosphate.
Source: (Bonjour, 2011)

For the growth and maintenance of healthy bones both mechanical loading and adequate protein play a role (Miggiano & Gagliardi, 2005a). There is a dynamic interaction between dietary protein, calcium–phosphate economy, and bone metabolism. Protein intakes stimulate the production of insulin-like factor I (IGF-I), which in-conjunction with vitamin D metabolism and calcium phosphate, positively promotes attenuation of age-related bone losses (Bonjour, 2011), see Figure 2-4. Additionally, mechanical loading of skeletal muscle acts together with amino acids and IGF-I to positively influence

muscle mass and strength (Palacios, 2006a). The amino acid arginine is believed to apply a positive effect on IGF-1 production in bone forming cells. When serum IGF-1 is low, in response to decreased protein intake or malnutrition, bone loss results and this increases the risk of frailty fractures (Bonjour, 2011)

2.8.2.2.2 Recommendations

It is recommended that New Zealanders aged over 71 years consume between 15-25% of their total daily energy intake from protein or 0.94g/kg and 1.07g/kg for women and men respectively (NHMRC, 2006). Dietary protein contributed the least to energy for adults over 71years adults in the 2008/09 NZANS, with on average 16.0% of energy coming from protein for men and 16.7% for women (Ministry of Health, 2012b). the top foods contributing to protein intake for men and women were: bread, milk, beef and veal, fish/seafood and poultry (Ministry of Health & Otago University, 2012). While current protein intakes fall within the ADMR range of current dietary protein recommendations (NHMRC, 2006), they are at the lower end of the scale and believed to be too low to promote optimal health for adults of advanced age (Deutz et al., 2014). It is suggested however, that the nitrogen balance studies traditionally used to determine protein requirements do not sufficiently account for internal shifts of protein stores, and gradual losses observed in older adults, therefore cannot accurately estimate needs (Walrand, Guillet, Salles, Cano, & Boirie, 2011).

Findings from the PROT-AGE study, suggest that current recommendations aren't high enough for older adults over 65 years to maintain health, support recovery from illness, maintain muscle mass and functionality, due to the physiological considerations of ageing (Deutz et al., 2014). A recent review of protein requirements by the ESPEN Expert group outlines updated recommendations for protein intake of individuals over 70 years (Deutz et al., 2014). Conclusions were that protein intake of 1.0 to 1.2g/kg/day was necessary for healthy older adults to allow for appropriate calcium metabolism and nitrogen balance, without renal impairment (Estimated Glomerular Filtration Rate (eGFR), >30), with increases up to 1.2 to1.5g/kg/day needed for elderly suffering from acute or chronic disease. Secondary, to new protein targets, evenly distributed protein intake throughout the day was recommended to support maximum protein absorption and synthesis; with regular exercise required to help maintain and build muscle mass (Deutz et al., 2014). This data supports the idea that although an average New Zealander currently achieves adequate protein intake, this may not be sufficient enough for the maintenance of optimal health in ageing. Short-term studies have shown beneficial effectiveness of protein intakes between 1.6 to 1.8 g/kg/day for optimal muscle and bone health. However, little is known about long-term safety and efficacy (Gaffney-Stomberg, Insogna, Rodriguez, & Kerstetter, 2009).

Protein intake and bone mineral density were investigated in 615 adults (224men, 391 women) ranging from 68 to 91 years, over four years, corrected for age and gender (Hannan et al., 2000). On average, participants consumed 68g of protein/day contributing 16% to their total macronutrient intake (Hannan et al., 2000). This is similar to intakes currently observed in New Zealand older adults (Ministry of Health, 2013a). In a study by Hannan et. Al. (2000) low protein intake has been associated with increased risk of spinal and femoral fracture. Femoral and spinal fractures were significantly more frequent in 25% of individuals who consumed lowest levels of total protein, and where animal protein contributed least to total protein (Hannan et al., 2000).

Investigations into the impact of high quality on optimal human health were explored at the 'Protein Summit 2.0' (Paddon-Jones et al., 2015; Rodriguez, 2015). Two main themes about optimal protein intake included: meeting protein threshold (25-30g/meal) at meal times throughout the day, and ensuring adequate high-quality animal protein was consumed due to the anabolic properties of leucine (Paddon-Jones et al., 2015). Both animal and plant based proteins contain amino acids essential for good health; however, it is the higher proportion of leucine contained in animal protein that has significance for sarcopenia in older adults.

Adequate intake of high quality protein, evenly distributed throughout the day alongside physical activity is important in stimulating the anabolic effect of protein and the maintenance of lean muscle mass. In order to achieve the proposed protein recommendations for optimal health of older adults (1-1.2 g/kg/day), protein should be consumed at each meal (Deutz & Wolfe, 2013).

2.8.2.3 Calcium

Calcium has various roles it is essential in cardiac and neurotransmitter function, development and conservation of bone and teeth. Adequate intakes of calcium through the life span aid in ensuring the integrity of bone by promoting accrual of optimal bone mineral density prior to 30 years (Clarke & Khosla, 2010; Heaney, 2002). Factors affecting the accrual of peak bone mineral density include delayed puberty, anorexia nervosa and exercise-associated amenorrhea (WHO, 2003). Elderly at high risk of fracture are commonly observed to have low calcium intake and vitamin D deficiency, therefore, it is believed adequate intake of calcium in conjunction with optimal vitamin D levels is essential to the prevention of bone loss and fracture in advanced age (Zhu & Prince, 2015).

2.8.2.3.1 Metabolism

Serum calcium concentrations are tightly control by the endocrine system influencing calcium metabolism at three points; intestinal absorption, renal excretion and bone exchange (Bacon, Gamble, Horne, Scott, & Reid, 2009). Negative calcium balance relation to decreased calcium absorption and serum vitamin D (1, 23-dihyroxy vitamin D or 1, 25-(OH) 2D) are common anomaly observed in osteoporotic women. Hypocalcaemia and hypercalcemia are more frequently observed in older adults as they more commonly suffer from disease states that interrupt calcium homeostasis (Dawson-Hughes, 2015). The metabolism of calcium and phosphorous are under careful control by the endocrine system. Tight regulation of serum calcium levels is achieved by actions of parathyroid hormone (PTH), vitamin D, phosphorous and calcitonin. When serum calcium levels are low, parathyroid hormone (PTH) stimulates the release of calcium and phosphate from bones and up-regulates 1α hydroxylase in the kidney allowing an increase in calcitriol and upregulation of calcium absorption in the intestine. Calcitriol also works directly on the nephron of the kidney to increase calcium reabsorption via the proximal convoluted tubule and on the bone to promote calcium and phosphate release. PTH also works directly in the kidney to stimulate calcium reabsorption, this time, promoting the distal convoluted tubule (Mundy & Guise, 1999). Conversely, when serum calcium levels are high calcitonin is released from the parafollicular cells of the thyroid gland and works to counter the action PTH has and decrease serum calcium levels (Figure 2-5).

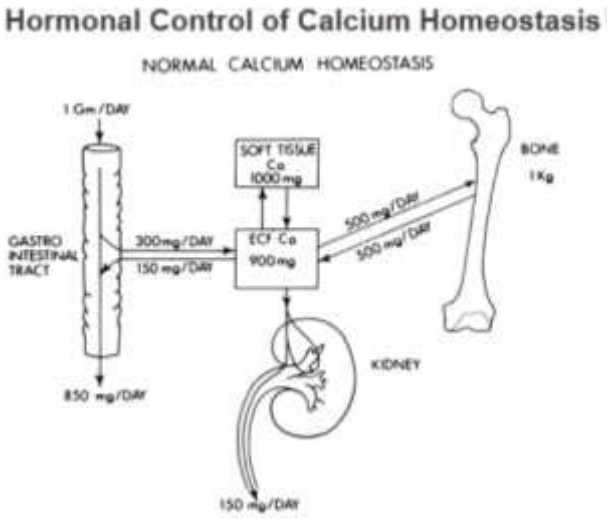

Figure 2-5 **Calcium balance and hormonal control of calcium homeostasis**

Source:(Mundy & Guise, 1999)

The integrity of bone is determined by a combination of factors comprised of genetics (60%), sex hormones (20%) and nutritional intake (20%) (Warren, 2010). Calcium intake along with intestinal absorption decreases with relation to age (Gallagher et al., 1979) and factors affecting absorption are in part related to specific nutrient consumption and endocrine (hormonal) influences (Lytras & Tolis, 2007). Additionally, calcium intake is seen to be habitually low in older adults and this decreases the chance of attaining optimal calcium requirements. Only up to one third (20%-30%) of ingested calcium is able to be absorbed (Andon, Peacock, Kanerva, & De Castro, 1996; Mundy & Guise, 1999); this being considered pertains to our current dietary recommendations for calcium of 1100mg adults over 70 years (Ministry of Health, 2006b; NHMRC, 2006). Physiological factors, nutrient type, timing of supplements and some medications can contraindicate individual ability to maintain calcium balance which elicit a negative influence on calcium stores.

Nutrients including phytates (in whole grains), iron (meat, liver, raisins) and oxalates may all work to impair calcium absorption if consumed together (Andon et al., 1996). Bioavailability of calcium can additionally be lowered by the presence of atrophic gastritis in octogenarians, deterioration of the gastric mucosa results in lower excretion of gastric acid, intrinsic factor and pepsin that can ultimately decreases the bioavailability of numerous nutrients (Ministry of Health, 2013b; WHO, 2002). Additionally adverse effects to calcium balance can occur due to increased urinary calcium excretion with high intakes of sodium, protein and caffeine (Goulding, 2002; WHO, 2002).

2.8.2.3.2 Recommendations

Limited consensus on optimal intake of calcium is evident, as there has been turbulence calcium requirements exhibited throughout the literature over the last 50 years. AN initial WHO report in 1962 suggested that throughout the world calcium intakes of 300-1000mg were consistent with adequate bone health thus initial (World Health Organisation, 1962). As evidence suggests individuals with relatively low habitual calcium intakes did not exhibit significantly higher rates of fracture or suffer from poor bone health (Hegsted, Moscoso, & Collazos, 1952; Pathak, 1958; Walker, 1956). Levels have since increased based on the growing pool of evidence that suggested, firstly as a result of calcium balance studies that intake below 1000mg-1500mg could not adequately replace losses (Heaney & Recker, 1983; Heaney, Recker, & Saville, 1977). Finally, that fracture rates could be reduced with supplementation of vitamin D and calcium together (Chapuy et al., 1992; Dawson-Hughes et al., 1997).

Secondary to the accelerated bone loss is observed post-menopausal (>50 years) for women and over 70 years for men (Clarke & Khosla, 2010), in 2002 the FAO and WHO recommend intake for postmenopausal women was increased to 1300mg/day (WHO, 2003). Therefore, the NHMRC recommendations for calcium in women over 50 and men over 70 years are 1300mg/day (EAR

1100mg/day) (Ministry of Health, 2006b). Internationally levels vary with American and Canadian levels of adequacy being set at 1200 mg/day for women over 50 years (National Academy Press, 2010) and the United Kingdom consistent for all adults over 50 years at 700 mg/day (Department of Health, 1998; Theobald & British Nutrition Foundation, 2005).

The 2008/09 NZANS found the mean intake of calcium to be lower than the recommended level (RDI); this result is in line with finding from similar nutritional adequacy surveys conducted internationally. Mean intake of calcium for New Zealand women was found to be 745mg/day and for men 919mg/day (University of Otago & Ministery of Health, 2011). Comparatively similar results have been found in Canada with 78% of the adult population not meeting the RDI for calcium (Ahmed, Arcand, Schermel, & L'Abbe, 2015). Foods rich in calcium are predominantly dairy based including milk and milk products, to a lesser degree salmon, almonds, sesame seed and green leafy vegetables (spinach and kale) (Price et al., 2012). Milk and dairy foods offer an inexpensive, bioavailable source of calcium and play a critical role in bone health as it also offers a source of vitamin D, potassium, magnesium and other bio factors (Möller, Scholz-Ahrens, Roos, & Schrezenmeir, 2008).

2.8.2.3.3 Supplementation

Oral calcium supplementation is a separate means of getting calcium into the diet when habitual intakes are low, and dietary intake of milk and milk products is restricted secondary to lactose intolerance or when osteoporotic risk is high (Ministry of Health, 2013b; Sanders et al., 2009). The previous consensus on appropriate supplementation was that levels between 500-1000mg daily were safe for most individuals, as habitual intakes of calcium are low and consistently provide close to half of optimal calcium requirements (Ministry of Health, 2012c; Sanders et al., 2009). However, currently a unanimous consensus on optimal calcium intake and the extent to which inadequate intakes impact pathogenesis of osteoporosis is not evident (Reid, 2015). Limited evidence supporting the effectiveness of calcium supplementation for fracture prevention and the increased incidence of gastrointestinal side effects and cardiovascular events, provide contraindications for routine calcium supplementation for prevention of fractures (Bischoff-Ferrari et al., 2005; Reid, 2015; Tai, Bolland, Reid, Leung, et al., 2015). Where calcium is supplemented it should be with vitamin D. However, a food first approach is recommended as foods rich in calcium are commonly high in other essential nutrients for bone health.

2.8.2.4 Vitamin D

Vitamin D is a fat- soluble vitamin which predominantly plays the role of a hormone influencing various body systems and functions (Ministry of Health, 2013d). It relation to bone health vitamin D maintains phosphate and calcium homeostasis. Deficiency of vitamin D results in demineralisation of the skeleton (Goulding, 2002). Older adults occur greater risk of vitamin D deficiency with age as, the ability to metabolise serum vitamin D from sun exposure through the skin decreases (Bischoff-Ferrari et al., 2004). Vitamin D requirements are predominantly meet through sun exposure however foods including oily fish and a good vitamin D source (salmon, mackerel, swordfish and tuna), with lesser being provided by egg yolk, liver and cheese may also contribute (Price et al., 2012).

2.8.2.4.1 Metabolism

Both vitamin D from the sun (D3 or Cholecalciferol) and nutrient intake as contribute to vitamin D status. Once vitamin D is produced through the skin or intestinally absorbed vitamin D appears as 25-hydroxyvitaminD (25(OH) D) in the blood, also known as serum vitamin D. In the kidneys 25(OH)D is converted to the biologically active form calcitriol or 1,25 dihydroxyvitamin D (1,25(OH)2D) (NHMRC, 2006).Vitamin D assists in the maintenance of serum calcium concentrations (Goulding, 2002), described in more detail In the section 2.7.3.1 Calcium Metabolism.

Vitamin-D deficiency is believed to play a role in the decreased rate of calcium absorption observed in in adults over 60 years, with relative malabsorption being observed in octogenarians (Bullamore, Wilkinson, Gallagher, Nordin, & Marshall, 1970). Adequate serum vitamin D at levels of 80nmol/L is considered optimal for allowing intestinal absorption of calcium (Heaney, 2005). Sun exposure in advanced age is believed to be of more importance for adequate serum vitamin D levels. However, older adults are less able to synthesis vitamin d through the skin (Bischoff-Ferrari et al., 2004), as irrespective of individual levels of serum vitamin D (25-OHD) adequacy, muscle tissue biopsies suggest that older adults have decreased vitamin D receptors present. This is of key concern for older adult ability to achieve adequate serum vitamin D levels becomes very difficult, as sun exposure is the predominant source of vitamin D, followed by diet and supplementation (Binkley, 2013; Heaney & Holick, 2011; Uusi-Rasi et al., 2015; Zhu & Prince, 2015).

2.8.2.4.2 Recommendations

Serum vitamin D is a measure of total body vitamin D status. Serum vitamin D (25-OHD) levels are categorised by a system including; vitamin D deficiency <25nmol/L (sever <12.5nmol/L and mild to moderate deficiency ≤25nmol/L), below recommended levels ≥25 and <50nmol/L, equal to or above recommended levels and high ≥125nmol/L (Ministry of Health, 2006b). Levels may vary secondary to

factors including latitude, altitude, air pollution, clothing coverage, sunscreen use and skin pigmentation (Faustino R. Pérez-López et al., 2012).

The 2008/09 New Zealand Adult Nutrition Survey found two-thirds of New Zealanders (68.1 %) had adequate vitamin D levels, with close to one-quarter (27.1 %) falling below recommended levels and few (1.7 %) with high vitamin D levels. One-fifth (4.9 %) were considered to have inadequate vitamin D levels (Ministry of Health, 2012c).

Despite the majority of New Zealand adults having adequate serum 25-OHD levels, with research suggesting that 80nmol/L is optimal for calcium absorption and prevention of osteoporotic fracture. Alongside, additional research suggesting a range of 95-127nmol/L is beneficial in preventing most fractures, those individuals with serum vitamin D levels between 50-80nmol/L, within the adequate range may still be at risk for bone health.

To achieve adequate vitamin D levels, it is recommended that individuals spend between 10 to 20 minutes a day with their skin exposed to UV light (without sunscreen). For octogenarians who are in residential care, obese, using anticonvulsant or antiretroviral medications have low sun exposure, malabsorption syndromes or aged skin, dietary intake via food or supplementation is required (F. R. Pérez-López et al., 2012). In adults over 70 years, intake requirements increase from 600IU to 800IU or 20mcg daily (NHMRC, 2006; Faustino R. Pérez-López et al., 2012).

Serum vitamin D levels of equal to or greater than 50nmol/L are considered adequate by the New Zealand Ministry of Health (Ministry of Health, 2012c) and levels that fall below 25nmol/L have been associated with poor health. The current Institute of Medicine (IOM) recommendations for serum vitamin d (25-OHD) state that 20ug/ml (63.6nmol) is adequate to maintain good bone health, However, some believe that these levels are not adequate and rather 30ug/ml (95.4nmol) is more appropriate (Heaney & Holick, 2011). Both proposed levels 20 and 30ug/ml fit within the New Zealand recommended a range of serum 25OHD adequacy of 50nmol/L- 124nmol/L (16-39ng/ml) however the proposed 25nmol/L (7.8ug/ml) cut off for good bone health falls far short.

Previous research supports this reasoning, Heaney (2005) outlines that serum vitamin D (25OHD) levels of approximately 80nmol/L have been associated with optimal intestinal absorption of calcium, minimizing age-related hyperthyroidism and reduction of osteoporotic fractures. Trivedi et al. (2003) found that serum 25-OHD levels of 21-29ug/ml (67-92nmol/L) resulted in decreased incidence of major osteoporotic fractures by 33 % (Trivedi, Doll, & Khaw, 2003). Further, to this meta-analysis of fracture reduction studies considering vitamin d did not show reproducibility for most fractures when

serum 25-OHD was below 30ug/ml (95nmol/L) and for the remaining 40ugml (127nmol/L) (Bischoff-Ferrari et al., 2009; Bischoff-Ferrari et al., 2005; Heaney & Holick, 2011).

2.8.2.4.3 Supplementation

Reaching these serum concentrations in adults especially elderly is difficult and where unattainable, prescription of vitamin D supplementation (2000IU orally) on top or oral intake and sunlight exposure has been suggested (Heaney, 2005). In New Zealand supplementation of 50,000IU cholecalciferol monthly is the current PHARMAC subsidised supplement alternately supplements approved by Medsafe are considered a safe secondary supplement. In New Zealand, there are three approved oral vitamin D medications and four over the counter vitamin D options (Ministry of Health, 2012c).

2.8.2.5 Other Nutrients

Despite the emphasis of osteoporosis, and fracture prevention interventions being focused on protein, calcium, and vitamin D (Sanders et al., 2009), several other vitamins and minerals play a role in bone health. In addition to the above phosphorus, magnesium, and fluoride have traditionally been associated with bone health. However, both traditional and emerging nutrients associated with bone health are commonly recommended at levels inadequate for bone health, rather for the maintenance of general health and therefore may be inadequate. It is the result of recent clinical trials and epidemiological studies that have brought to light the importance of these additional nutrients in the bone metabolism, the promotion of bone mass, and prevention of bone loss and fractures. The evidence suggests that nutrients including zinc, copper, manganese, vitamin K and C, have a crucial role to play in the maintenance of bone health, and prevention of fracture (Palacios, 2006b). However, further research is required to determine optimal RDI for bone health (Palacios, 2006b). Additional nutrients including iron, thiamine, boron, copper, riboflavin, niacin, folate, vitamin B6, and B12 have been addressed in various studies; however, further research is required to determine the extent of their role, and adequate levels required for good bone health. When considering foods rather than individual nutrients, there is are several foods including dairy products, green leafy vegetables, fruit and other vegetables, legumes and whole grains, animal protein, and nuts and seeds found to be beneficial to bone (Palacios, 2006b), see Table 2.7.5.

Table 2.7.5
Food Sources providing essential nutrients for bone health.

Food Source	Nutrients Provided
Dairy foods	Calcium, protein, vitamin D, phosphorus, potassium, magnesium, and zinc.
Green Leafy Vegetables (Spinach, bok choy, broccoli, and kale)*	Calcium, magnesium, potassium, boron, vitamins K, A, and C. Promoted an alkaline environment.
Fruits and vegetables*	Magnesium, boron, vitamins K, A, and C. Promotion of alkaline environment
Legumes and whole-grain	Phosphorus, potassium, magnesium, manganese, zinc, copper, and vitamin K.
Beef, fish, or poultry,	Protein, zinc, magnesium, copper, phosphorus, manganese, and iron.
Nuts and seeds	Protein, zinc, magnesium, copper, phosphorus, manganese, and iron.

*Promote alkaline environment: Decreased reliance on skeletal nutrients to maintain acid balance.

2.8.2.5.1 Phosphorous

Older adults risk compromising bone mineral homeostasis and bone integrity when serum phosphate levels are low (Penido & Alon, 2012). Conversely, as older adults experience a relative level of age-related renal impairment (Rifkin, 2008), high dietary intakes of phosphorus may result in hyperphosphatemia that can result in secondary hyperparathyroidism (SHPT), renal osteodystrophy, vascular calcification and increased morbidity and mortality (Block et al., 2004; Mohammed & Hutchison, 2008). The consensus is that calcium intake should be proportionately higher than phosphorous (J.-P. Bonjour, Kraenzlin, Levasseur, Warren, & Whiting, 2013; Lee & Cho, 2015). High phosphorous have controversially been considered detrimental to bone health when the ratio of Ca: P (calcium to phosphorous) is low (Kemi, Karkkainen, & Lamberg-Allardt, 2006; Kemi et al., 2009). However, the evidence to suggest detrimental effects to calcium balance from high phosphorous intake limited (Heaney, 2000; Rafferty & Heaney, 2008). Rather, it is suggested that while calcium and phosphorous remain within normal range, higher phosphorous intakes may be beneficial for bone, with increased BMD and decreased osteoporosis risk exhibited in these conditions (Lee & Cho, 2015).

It is recommended that both men and women, over 70 years consume 580mg phosphorus per day, see Table 2.7-1, from a range of phosphorous-rich foods, meat, seafood, poultry, eggs, dairy products, nuts and legumes, see Table 2.7.5 (Kalantar-Zadeh et al., 2010; Palacios, 2006b). As phosphorous is abundant in protein foods, where protein intakes are adequate, so too should phosphorous intake, and therefore, risk of either suboptimal or excessive intakes varies for

individual population groups (Heaney, 2015). Incidental intake of phosphorous may occur and be underreported in adults who consume high intakes of cola-based non-alcoholic beverages and is an additional consideration for individuals with renal impairment (Kalantar-Zadeh et al., 2010).

2.8.2.5.2 Magnesium

Dietary intakes of adults >65 years are estimated to be close within a range of 225-280mg/day for most western countries (Price et al., 2012; WHO, 2002). These intakes appear to be optimal for health as no clear signs of deficiency are prevalent. However, a question around adequacy for bone health arises for intakes averaging less than the prescribed RDI (Price et al., 2012). Current dietary recommendations (RDI) for magnesium in adults >71 years are 420mg/day for men and 320mg/day for women (EAR: 350mg/day, 265mg/day, respectfully) (Ministry of Health, 2006b).

Recent studies, however, suggest that magnesium intakes may play a key role in muscle strength, bone mineral density and subsequent risk of fractures in women. Magnesium has multiple roles in the body. However, it is particularly integral for adequate nerve and muscle function with magnesium resulting in poor physical performance in elderly adults (Veronese et al., 2014). Decreased muscle function, therefore, may aid decreased BMD secondary to decrease muscle tension exerted on bone and accelerated sarcopenia secondary to decreased physical function (Ferrucci, 2002). Long term magnesium deficiency is also implicated in attenuated oxidative stress and secondary inflammation (Y. Huang, Wahlqvist, Kao, Wang, & Lee, 2015) w which may have a role in facilitating the ageing process, frailty, subsequent falls and fracture risk (Barbagallo et al., 2009).

Magnesium from both dietary and supplement sources have been found to correlate positively with BMD in older white adults the same relationship. However, the same was not observed in those of black ethnicity (Ryder et al., 2005). Low magnesium intakes have also been associated with decreased BMD in women, with no subsequent increase risk of fracture (Orchard et al., 2014). The research concluded that an increase of 100mg magnesium daily correlated with a two percent increase in overall body BMD (Ryder et al., 2005). Additional, research investigating magnesium intake in postmenopausal women found that those consuming a high daily intake of magnesium (422.5mg/day) compared to low (206.5mg/day) were again associated with an increase in whole body BMD (Orchard et al., 2014). It is believed that and increase in current intakes, or daily supplementation of 250mg of magnesium would be beneficial in reducing fracture risk particularly in osteoporotic women (Price et al., 2012). In a study of osteoporotic living in Israel investigated the use of a daily 250mg supplement and found significant increase in bone mineral density compared to the control group. In order to achieve adequate dietary intakes of magnesium, a diet rich in green leafy vegetables, whole grains,

nuts (including almonds, peanuts and cashews), seeds, lentils, kidney beans, avocado, banana, yoghurt and dried fruit is recommended (Price et al., 2012).

2.8.2.5.3 Potassium

Intakes of potassium are commonly inadequate, particularly in populations with relatively low, fruit and vegetable intakes. The proposed benefit of potassium for bone health is its conjoint role with magnesium, in buffering acid load that occurs secondary to intakes of meat, fish, poultry, grains and legumes (Tucker et al., 1999; Wachman & Bernstein, 1968). Lifetime exposure to poorly buffered acid load may result in gradual loss of BMD (Booth et al., 2003; Tucker et al., 1999). There is relatively less data on the benefit of potassium for bone health in comparison to calcium, vitamin D and magnesium (Tucker et al., 1999). However, increased intakes of potassium have been shown to help maintain BMD (Booth et al., 2003; Tucker et al., 1999).

Current EAR for adult >71 years are 3800mg/d men and 2800mg/d for women (NHMRC, 2006). Maintaining adequate potassium intake and status is important in older adults due to its role in cardiovascular (Lai, Leu, Yeh, Chang, & Pan, 2015) and bone health (Bernstein et al., 2002). To achieve adequate intakes, older adults may benefit from increased intake of potassium-rich foods including, green leafy vegetables, beans, avocado, banana, potato and pumpkin (C. Palacios, 2006).

3.1.1 LiLACS NZ – Te Puāwaitanga O Ngā Tapuwae Kia Ora Tonu

LiLACS NZ is a longitudinal, cross-sectional, cohort study of those living to advanced age, in the Bay of Plenty and Lakes District Health Board regions of New Zealand. Two cohorts of statistically equal size, Māori aged 80-90 and non-Māori (NZ European, English, Scottish, other Europeans: 98.5%; Pacific, Asian, Middle Eastern, South African: 1.5%) aged 85 years were included to allow equal exploratory power. Participants living within the regions born between January 1st, 1920 and December 31st, 1930 for Māori and between 1st January and 31st December 1925 for non-Māori were deemed eligible. To gain the most robust sample of eligible older adults various recruitment avenues were utilised. The New Zealand electoral rolls (Māori and non-Māori) were utilised alongside primary health care and general practice database lists. Other recruitment avenues included word of mouth, Whānau and community networks.

At baseline LiLACS NZ recruited a total of 937 participants: 421 Māori (n= 172 men and 257 women) and 516 non-Māori (n=236 men and 274 women). Written informed consent was obtained before the commencement of the interview process. At baseline detailed demographic, anthropometric and physical health markers were collected, via standardised interviews undertaken at the participant's home or site of choice by LiLACS NZ trained interviewers. Annual follow-up of participants was completed to assess health status and function within these two cohorts. At 12 month follow-up (Wave 2) the standard questionnaire was utilised, alongside detailed dietary assessments using (2 x 24-hour Multi Pass Recall (MPR)) to provide detailed examinations of dietary intake (nutrients and food groups). At 24 month follow-up (Wave 3), the standard questionnaire was administered with no nutritional assessment. For those who found the standard questionnaire too burdensome, a brief questionnaire including; age, gender, living arrangements, functional status and the main cause of disability was completed.

A total 660 participants contributed to the Wave 2 data collection. Of these 578 (216 Māori, mean age 83) and (362 non-Māori, mean age 86) completed the nutritional assessment (Hayman et al., 2012). Those eligible for this study must have completed both nutritional assessments and the physical component of the health survey to identify those who have fractured vs non-fractured, resulting in a total of 317 participants included in this study. Ethical approval was gained for LiLACS NZ through the Northern X Regional Ethics Committee of New Zealand in December 2009 reference number (NTX/09/09/088). Funding for Wave 2 was provided by the Health Research Council of New Zealand and Ngā Pae o Te Māramatanga (New Zealand's Māori Centre of Research Excellence (CoRE).

This study is a sub-study of LiLACS NZ to investigate the energy, nutrient and food group intakes of Māori and non-Māori participants who have sustained fractures over a 24 month period. Information for this study was collected over a two-year period Wave 2 (baseline) gathered from 2011-2012 and Wave 3, 2012-2013. Wave 1 (contributing some baseline demographics: gender, ethnicity, lifelong occupation and income) gathered from 2010-2011 where not collected in Waves 2 or 3.

3.1.2 Participant Recruitment

Both Māori and non- Māori participants from whom self-reported or were hospitalised secondary to fractures over a 24 month period, with available dietary recalled data were included for analysis. Fracture occurrence was measured over a 24 month period following baseline dietary 24 hour MPR collection. Hospitalisation data was obtained with permission to use participants National Heal Index New Zealand (NHI) number. Fracture data from Wave 2 and Wave 3 each provided 12 months' worth of fracture occurrence and non-occurrence. Total fractures occurrence over 24 months was determined by combining data from these two Waves (2 and 3). Demographic, anthropometric, health, exercise and nutritional data was analysed for these individuals and depicted in Table 3.1-1.

Table 2.8-1
Data ascertained from LiLACS NZ Wave 1 and 2 (baseline) and 3 standardised interview, nursing assessments and 24 hour multi pass dietary recalls.

Wave 1 & 2	Wave 3
General information: ethnicity, gender and age.	General information: age
Occupation , Education, Income, NZ deprivation index, Living situation	Financial: cost of living and food security.
Financial: cost of living and food security.	Physical health- Including fractures occurrence and exercise.
Physical health- Including fractures occurrence and exercise.	Body composition: weight, height, BMI and any observed weight loss of gain.
Medical history: smoking, osteoporosis and fractures.	Hospitalisation: general and due to fractures
Body composition: weight, height and BMI.	
Hospitalisation: general and due to fractures Family medical history: fracture	
Nutrition assessment: 2x 24 hour multi pass dietary recall (MPR).	
Medication and supplement use.	

3.1.3 Data collection

3.1.3.1 Demographic Information

Demographic information regarding age, gender, marital status, living situation, deprivation status, education and occupation were included. Marital status was categorised into four separate parameters: never married, married/partnered, a widower and separated/divorced. Living situation categorised into three separate parameters: living alone, with partner/ spouse/child and with other.

Occupation was based on lifetime occupation of individual or spouse, whichever fell into the highest categorical occupation. Lifetime occupation was determined and assigned to one of three separate classifications. The classification were as follows: professionals (legislators, administrators, managers, professionals, agriculture and fishery workers), tech and trades (technicians, trades and associate workers), and clerks, factory and other (clerks, service and sales workers, plant and machine operators and assemblers and elementary occupation).

Education was based on highest level attained using an adapted version of the 2006 New Zealand Census questions (Statistics New Zealand, 2006). Descriptive data was presented into five separate education categories; primary/none, secondary/no qualification, secondary qualification, trade/occupation and tertiary.

Socioeconomic deprivation areas are reported within LiLACS NZ in accordance with the to the New Zealand Deprivation Index, an index scale of 1-10, ten representing the most deprived and one the least deprived areas or residences (Salmond et al., 2006). For the purpose of this research the 10 point decile indicator of deprivation was categorised into the quintile classification. The index is a scale from 1- 5, five indicating the areas with greatest deprivation, while one represents the least (White P, Gunston J, Salmond C, Atkinson J, & Crampton P, 2008) . This new categorisation is depicted in Table 3.1-2. Income was based on predominant source of income at the given time, self-selected from nine categorical choices including: NZ Superannuation, Other Superannuation, Other Pension, Tribal trust / land, Inheritance, Investment, Salary/ Wages, Support from family and other financial support. Secondary self-reported markers for income were also considered, including participant's financial security and ability to afford eating properly. Financial security was based on a selection of responses including; Unable to make ends meet, I have just enough and I am comfortable. While affordability of eating properly was based on a selection of response's including; always, sometimes, never and unknown.

Table 2.8-2
Categorisation of NZ deprivation decile points into quintile equivalents.

Decile	Quintile	Deprivation equivocal
1-2	1	Least deprived
3-4	2	
5-6	3	
7-8	4	
9-10	5	Most deprived

3.1.3.2 Anthropometric measures

Height (cm), weight (kg), BMI (kg/m^2) and change in weight (± 0.1-5%, 5- 10%, >10%) were determined. Weight and height measurements were attained following protocol guided by the 2008/09 New Zealand National Nutrition Survey (Ministry of Health, 2012b). BMI classifications and breakdown were based on the World Health Organisation classifications depicted in Table 3.1-3 (World Health Organization, 2006). Change in body weight (increase and decease) was determined by the combination of 2 x 12 month weight change data for Wave 2 (Wave 1 to Wave2) and Wave 3 (Wave 2 to Wave 3). Weight was not calculated for any individual who did not provide a weight at one or more of the three weight measures required. Weight change was expressed as a %age weight change for individuals who experienced greater than 0.1kg (+ or -) weight change.

Table 2.8-3
World Health Organisation BMI classifications for adults >18 years.

Classification	BMI (kg/m^2)
Under weight	<18.5
Normal	18.5-24.99
Overweight	25.0-29.99
Obese	>30

Source: (World Health Organization, 2006)

3.1.3.3 Physical and Health Measures

Long-term health conditions and risk factors (smoking, weight change and alcohol consumption) were obtained. For the purpose of this study osteoporosis diagnosis, fracture occurrence and family history of hip fractures (maternal and paternal) were included. Osteoporosis, previous fractures and family

history of fractures was self-reported with osteoporosis requiring a previous diagnosed by a doctor. Patients were asked to self-reported prescribed medications, over the counter medications (OTC), nutritional supplements and natural/herbal products or traditional medicines. Medication brand, dose strength and frequency were recorded and coded by interviewers on a separate table.

Physical activity was assessed using the Physical Activity Scale for Elderly (PASE) Criteria (Washburn, Smith, Jette, & Janney, 1993). PASE provides a measure of participation in exercises specifically to increase muscle strength endurance, and light, moderate, strenuous sport and recreational activities. All activities were based on measure of frequency: (never (0 Days), seldom (1-2days), sometimes (3-4 days) and often (5-7days). Likewise leisure activities including walking outside were measured using the PASE criteria and included a measure of duration: (< 1 hour, 1-2 hours, and 2-4 hours and >4 hours).

3.1.3.4 Dietary Assessment

Nutritional parameters for both Māori and non-Māori participants were attained through completion of 2x 24 hour multi pass recalls (MPR) collected on separate days. 24 hour MPR has been deemed appropriate for use in both general and elderly populations and has previously been validated and utilised within the New Castle 85+ studies (Adamson et al., 2009; Collerton et al., 2007). The 24-hour MPR was first developed by the US department of Agriculture and since been validated and utilised for national nutrition surveys in the United Kingdom, United States and New Zealand (Ministry of Health, 2012b)(University of Otago and Ministry of Health, 2011).The standard for this study was set based on the methods of this previous research mentioned above predominantly the New Castle 85+ study. In order to adequately describe an individual's habitual dietary intake more than one day of recall is required (Ministry of Health, 2013).The standard outlines completion of 2x 24h MPR, taken a week apart, each on different days (preferably one week day one weekend day) and separate occasions (Collerton et al., 2009).

This method uses a number of passes to ensure the accuracy of recalling dietary intake of the previous day. The 24h MPR is structured and administered as follows with a total three passes required. Within pass one (quick list): participants are asked to recall and document all food and drink consumed over the last 24 hours (midnight to midnight). Following this the interviews provides an initial prompt around possible consumption of forgotten foods such as snacks, sweets and drinks (tea, coffee, soft drink and alcohol) and secondary standardised prompting by the interviewer to extract any additional items missed to be added to the list. In pass two (detailed record): the interviewer take the participant through each listed food item and gains additional detail including, time, occasion and context of

eating, weight or serving size, food brand and cooking methods. Finally pass three (review): a final review for food and drink recalled with the participant to identify any missing items, recipes were coded and analysed by dieticians on entry.

The United Kingdom Photographic Atlas of Food Portion Sizes was utilised as a tool to help participants make accurate recalls of food portions consumed during their 24h recall. Secondary to piloting the tool amongst Māori and Non-Māori participants adaptations were required to ensure inappropriateness of the tool to represent foods available to participants in their local setting. Foods including avocado, beetroot, kumara, pumpkin, stewed rhubarb, mussels and pipis, muffins and scones, tomato sauce, kiwifruit, grapefruit, pears and grapes were incorporated as a result. All interviewers/ nurses were given relevant training, resources and feedback by the nutrition team to ensure consistency of interviews was achieved and where required interviews were completed in Māori language by Māori nurses.

Following the completion of all 24hr MPR data, qualified nutritionists and dietitians quality checked all food recall entries. Coded estimated weight for individual foods, food ingredients and photographic foods were documented onto a record form. Nutrient intakes for all food and drinks recorded by the participants were calculated using the FOOD files 2010 electronic food composition database (New Zealand) (Xyrus software Pty Ltd 2007). Total energy, protein and micronutrients: calcium, vitamin D, phosphorous, magnesium and potassium were examined using FOOD files. Nutrient Intakes were assessed for adequacy using the Australia and New Zealand Nutrient Reference Values (Ministry of Health, 2006b).

In order to determine nutrients by food groups, food items captured within the 24 hour recall were allocated to one of 33 different food group categories, encapsulating all food and beverage. These food groups were derived from the 2008/09 New Zealand Adult Nutrition Survey (Table 3.4) (Ministry of Health, 2012b). Foods contained in mixed dishes were classified based on their recipe break down as provided by recipes from participants. In the absence of recipes, generic recipes (description matched) or dish assignment to nearest food group was assigned. Foods contained in mixed dishes were classified based on their recipe break down as provided by recipes from participants. In the absence of recipes, generic recipes (description matched) or dish assignment to nearest food group was assigned.

Table 2.8-4

Food group classifications from the, 2008/09 New Zealand Adult Nutrition Survey.

Food Group	Examples of food items included
Grains and pasta	Rice (boiled, fried, risotto, sushi, salad), flour, pasta/noodles, bran, cereal-based products and dishes (pasta and sauce, lasagne, pasta salad, noodle soup, chow mein).
Breakfast cereals	All types (muesli, wheat biscuits, porridge, puffed/flaked/extruded cereals).
Biscuits	Sweet biscuits (plain, chocolate coated, fruit filled, cream filled), crackers
Cakes and muffins	All cakes and muffins, slices, scones, pancakes, doughnuts, pastry.
Snack bars	Muesli bars, wholemeal fruit bars, puffed cereal bars, nut and seed bars.
Fats and oils	Canola, olive, sunflower and vegetable oils, dripping, lard.
Snack foods	Corn chips, popcorn, extruded snacks (burger rings etc.), grain crisps.
Alcoholic beverages	Wine, beer, spirits, liqueurs and cocktails, ready-to-drink alcoholic sodas (RTDs).
Pies and Pastries	All pies including potato top, pasties, savouries, sausage rolls, quiche with pastry.
Soups and stocks	All instant and homemade soups (excluding noodle soups), stocks and stock powder.
Savoury and sausage condiments	Gravy, tomato and cream-based sauces, soy, tomato and other sauces, cheese sauces, mayonnaise, oil & vinegar dressings, spreads
Bread	All types of bread (rolls, pita, focaccia, and garlic), bagels, crumpets, sweet buns.
Bread-based dishes	Sandwiches, filled rolls, hamburgers, hotdogs, pizza, nachos, doner kebabs, wontons, spring rolls, stuffing's.
Puddings and desserts	Milk puddings, cheesecake, fruit crumbles, mousse, steamed sponges, sweet pies, Pavlov, meringues.
Milk	All milk (cow, soy, rice, goat and flavoured milk), milkshakes, milk powder.
Dairy products	Cream, sour cream, yoghurt, dairy food, ice-cream, dairy-based dips.
Cheese	Cheddar, edam, specialty (blue, brie, feta, etc.), ricotta, cream cheese, cottage cheese, processed cheese.
Butter and margarine	Butter, margarine, butter/margarine blends, reduced-fat spreads.
Sugar and sweets	Sugars, syrups, confectionery, chocolate, jam, honey, jelly, sweet toppings and icing, ice-blocks, artificial sweeteners.
Non-alcoholic beverages	All teas, coffee and substitutes, hot chocolate drinks, juices, cordial, soft drinks, water, powdered drinks, sports and energy drinks.
Eggs and egg dishes	Poached, boiled, scrambled and fried eggs, omelettes, self-crusting quiches, egg stir-fries.
Other meat	Venison, rabbit, goat, liver (lambs fry), pâté (liver), haggis.

Beef and veal	All muscle meats (steak, mince, corned beef, roast, schnitzel, etc.), stews, stir-fries.
Lamb and mutton	All muscle meats (chops, roast, mince, etc.), stews, stir-fries, curries.
Sausage and processed meat	Sausages, luncheon, frankfurters, saveloys/cheerio's, salami, meatloaf and patties.
Pork	All muscle meats (roast, chop, steak, schnitzel, etc.), bacon, ham, stews, stir-fries.
Poultry	All chicken, duck, turkey and mutton-bird muscle meats and processed meat, stews and stir-fries.
Fish and Seafood	All fish (fresh, frozen, canned, battered, etc.), shellfish, squid, crab, fish/seafood dishes (casseroles and fritters), fish/seafood products.
Vegetables	All vegetables (fresh, frozen, canned) including mixes, coleslaw, tomatoes, green salads, legumes and pulses, legume products and dishes (baked beans, hummus, tofu), vegetable dishes.
Potatoes, kumara and taro	Mashed, boiled, baked potatoes and kumara, hot chips, crisps, hash browns, wedges, potato dishes (stuffed, scalloped potatoes).
Fruit	All fruit, fresh, canned, cooked and dried.
Nuts and seeds	Peanuts, almonds, sesame seeds, peanut butter, chocolate/nut spreads, coconut (including milk and cream), nut-based dips
Supplements providing energy	Meal replacements, protein supplements (powders and bars).

Source: (Ministry of Health, 2012b)

3.1.3.4.1 Nutrient investigation

Nutritional parameters were selected based on their relationships to bone health, particularly fractures in older adults described within the literature review chapter of this thesis. Nutrients depicted in Table 3.1-5, and include energy, protein, calcium, vitamin D, phosphorous, magnesium and potassium. Dietary supplements were considered as anything a participant believed to supplement their diet, these include a range of oral supplements including vitamins and minerals and others such as fish oil and spirulina. Participants were asked to recall both 12 month exposures (alongside, prescription medicine, non-prescription medicine an herbal medicine use) and daily intake in the 2x 24 hour MPR's.

Table 2.8-5
Nutrients investigated from LiLACS NZ's Wave 2, 24 hour MPR.

Nutrients	
Macronutrients	**Micronutrients**
Energy- total (kJ and kcal) per day	Calcium (mg/day, mg/1000kcal)
Protein- total, calculated from total nitrogen (g)	Vitamin D (µg/day, µg/1000kcal)
Protein –total % energy	Phosphorous (mg/day, mg/1000kcal)
Protein – g/kg	Magnesium (mg/day, mg/1000kcal)
	Potassium (mg/day, mg/1000mg)

3.1.3.4.2 Nutrient Intake

The Australia and New Zealand Nutrient Reference, EAR values for protein and micronutrients (calcium, vitamin D, phosphorous, magnesium and potassium) were be used to determine adequacy of nutrient intakes firstly for Māori and non-Māori and secondly for fracture subgroups (fracture vs non-fracture) (Ministry of Health, 2006b). No EAR was established for energy, it is possible to estimate baseline energy requirements using the Schofield equation or NHMRC energy tables however the PASE Criteria was used to ascertain physical activity rather than the Physical Activity Levels (PAL) required for these calculations. The EAR for protein intake in adults over 70 is as follows: men 65g/day and 0.86g/kg and women 46g/ day and 0.75g/kg. ADMR ranges for all macronutrients are displayed in Table 3.1-6. EAR and UL upper level values for micronutrient analyses in this study (calcium, vitamin D, phosphorous, magnesium and potassium) are displayed in Table 3.1-7.

Table 2.8-6

The Nutrient Reference values for Australia and New Zealand, Acceptable Macronutrient Distribution ranges for all older adults (>70years).

Nutrients	Average Macronutrient Distribution Range
Protein	15- 25% of energy
Carbohydrate	45- 65% of energy
Fat	20- 35% of energy

Source: (Ministry of Health, 2006b)

Table 2.8-7

Estimated average requirements (EAR) and upper levels (UL) Micronutrients for older adults by gender.

	Estimated Average Requirements (EAR)		Upper Level (UL)	
Nutrients	Men	Women	Men	Women
Calcium (mg)	1100	1100	2500	2500
Vitamin D (µg)	15	15	80	80
Phosphorous (mg)	580	580	3000	3000
Magnesium (mg)	350	265	350	350
Potassium (mg)	3800	2800	-	-

Source:(Ministry of Health, 2006b)

3.1.4 Statistical Analysis

Statistical programs used for the analysis of data included IMB SPSS statistics package version 21 (IMB corporation, New York, USA) and Microsoft Excel 2010. Participant numbers varied by Waves (12 month periods) and survey question as those within the greater LiLACS study can opt to complete a shorter survey where deemed too burdensome (excluding variables required for this study), therefore overall participant totals do not always equal the sum of two waves.

The variables were tested for normality using the Kolmogorov-Smirnov and Shapiro Wilk test and homogeneity using the Levene's test. Non-normally distributed data was log transformed to obtain normality. Normally distributed data is expressed as mean ± SD and geometric means [95% CI]. While data non-normally distributed has been expressed as median [25th, 75Th percentiles]. A *P* value less than 0.05 was considered to be significant. Statistical significance of data was determined by performing Mann Whitney U tests on non-parametric data, independent t- tests on parametric data

and Chi-Square or Fishers Exact test (2-tailed) on counts (Fishers exact test where cell counts were <5).

For variables that showed statistically different variables between groups, effect size was calculated to provide an objective measure of the importance of the effect by using the following formulas: Mann-Whitney U test, effect size= Z/√n; for independent t-test, √t^2/ (t^2+DF). An effect size value of 0.10 indicated small effect, a value of 0.3 indicated a medium effect and >0.5 indicated a large effect. Multivariate Logistic analysis was use for regression analysis on nutrient values. Variables associated with fractures *p* <0.05 after univariate analysis were included in the bivariate logistic regression model controlling for age, gender, NZ Deprivation Index, BMI, previous fracture in Māori, with the addition of light physical activity in non-Māori. A *P*-value of <0.05 was considered as statistically significant.

4 Results

4.1 Participants

This study comprised of a total 317 participants (113 (44.9%) Māori; 204 (55.1%) non-Māori), who self-reported, or were hospitalised secondary to fractures within LiLACS NZ Wave 2 and Wave 3 face to face interviews. A total of 63 (23.7%) participants reported sustaining a fracture over a 24-month period (Wave 2 and Wave 3), 24 (38.1%) being men and 39 (61.9 %) women. Of those who experienced a fracture over the 24 month period, one third (33.3%) were Māori and two-thirds (66.6%) non-Māori. For Māori 13.7% of men and 22.5 % of women self-reported fracture within the 24 month period, compared to non-Māori, 17.3% of men and 23.6% of women, Table 4.1-1.

Table 4.1-1

Prevalence of fractures for Māori and non-Māori, by gender.

		Māori			Non- Māori		
	Total Study Cohort	Men	Women	Total Māori	Men	Women	Total non-Māori
Participants (Wave 2-3)	*n=243*	*n=39*	*n= 48*	*N=87*	*n=79*	*n=77*	*n=156*
Fractures occurring within 1st 12 months (Wave 2-3), n (%)	39 (16.0)	5 (12.8)	6 (12.5)	11 (12.6)	11 (13.9)	17 (22.1)	28 (17.9)
Participants (Wave 3-4)	*n=165*	*n=20*	*n= 29*	*n=49*	*n=48*	*n=68*	*n=116*
Fractures occurring in the following 12 months (Wave3-4), n (%)	30 (18.2)	2 (10.0)	9 (18.8)	11 (22.4)	6 (12.5)	13 (19.1)	19 (16.4)
Participants (Waves 2-4)	*n= 317*	*n= 51*	*n=62*	*n= 113*	*n= 98*	*n=106*	*n= 204*
Total number of individuals with fractured, occurring over the 24 month period, n (%)	63 (19.8)	7 (13.7)	14 (22.5)	21 (18.6)	17 (17.3)	25 (23.6)	42 (20.6)

*****Total does not equal sum of 1st and 2nd 12month period where individuals experienced a secondary fracture.

Cohort totals: Numbers are based on individuals who provided 2x 24 hour dietary recalls, these numbers varied per 12 month period (wave) based on individual capacity to complete survey section. Where individuals have only provided recalls in either the 1st or 2nd 12 month period the overall total for the 24 months is less than the sum of the two 12 month periods (waves).

4.2 Māori Participants

4.2.1 Demographic and Lifestyle characteristics

The overall demographic breakdown of Māori participants, by gender and fracture occurrence is depicted in Table 4.2-1 and 4.2-2. More women than men were represented in this cohort, 55% and 45% respectively. All Māori participants were aged over 80 years, ranging from 80-90 years, with a median age of 82 years for men, and 84 years for women (U= 1705, P=0.044, r=0.20). There was a two-year difference between women and men, with a median age of 84 years and 82 years respectively. Of the Māori participants over 93% had been married at some point with 40% still married and a half (50%) widowed. Marital status differed significantly between men and women, as women were 1.8 times more likely than men to be married compared to those widowed (x2=14.1, p=0.001). Māori men and women most commonly worked as Clerks, factory workers and other (64.6%), occupation breakdowns were similar for both genders however 10% more men had trades as their predominant lifetime occupation. Nearly half of men and women had a secondary level of education non-qualified (45.5%), one quarter (28.6%) were primary school education, and less than 12% of participants had trade or tertiary qualifications.

Just over half, 54.7% of participants were living alone, with NZ superannuation being the predominant source of income for most (92.6%) Māori, men and women. A high percentage of participants lived in the most deprived quintile 4 and 5 (28.4% and 27.4% respectively). Participants residing in each quintile decreased as the level of deprivation decreased, with very few Māori living in quintile one (6.3%) classified as least deprived. Deprivation status varied based on gender, nearly a third (29.0%) of women resided within quintile 5, while only 25.5% of men did, with slightly more men (35.5 %) living in quintile 4, making this the main deprivation level for Māori men. Financial security was similar in both men and women, with over 95 % of participants stating they didn't have enough money to make ends meet. This finding didn't appear to affect directly financial accessibility to food with over 90% (94.4% men and 91.5% women) stating that they can always afford to eat properly.

Age, marital status, occupation, education, deprivation status, income and financial security didn't differ between those who had fractured and those non-fractured, for both men and women. However Māori women's ability to afford to eat properly changed significantly between those fractured and non-fractured (x2=13.6, p=0.015). Non-fractured women were 1.5 times more likely always to have enough money to eat properly compared to those with fractures.

Table 4.2-1

Demographic and Lifestyle measures of Māori in advanced age, by gender and fracture occurrence.

	Men				Women			
	Total Men	Fracture	Non-fracture	P-value	Total Women	Fracture	Non-fracture	P-value
Age (years) [a] Median (25^{th}- 75^{th})	82 (81-84)	82 (81-84)	82 (81-84)	0.66[1]	84 (81-86)	85 (83-87)	84 (81-86)	0.15[1]
Marital Status, n (%)	*n=50*	*n=7*	*n=43*	0.65[4]	*n=60*	*n=14*	*n=46*	1.00[4]
Never Married/Partnered	4 (8.0)	0 (0.0)	4 (9.3)		3 (5.0)	0 (0.0)	3 (6.5)	
Married/Partnered	13 (26.0)	3 (42.9)	10 (23.3)		31 (51.7)	7 (50.0)	24 (52.2)	
Widow/Widower	30 (60.0)	3 (42.9)	27 (62.8)		25 (41.7)	7 (50.0)	18 (39.1)	
Separated	1 (2.0)	0 (0.0)	1 (2.3)		0 (0.0)	0 (0.0)	0 (0.0)	
Divorced	2 (4.0)	1 (14.2)	1 (2.3)		1 (1.6)	0 (0.0)	1 (2.2)	
Living Situation, n (%)	*n=33*	*n=6*	*n=27*	0.51[4]	*n=42*	*n=10*	*n=32*	0.13[4]
Living alone	21 (63.6)	3 (50.0)	18 (66.6)		20 (47.6)	6 (60.0)	14 (43.7)	
Living with partner/spouse /child	9 (27.3)	3 (50.0)	6 (22.2)		22 (52.4)	4 (40.0)	18 (56.3)	
Living with others	3 (9.1)	0 (0.0)	3 (11.2)		0 (0.0)	0 (0.0)	0 (0.0)	
Occupation, n (%)	*n=51*	*n=6*	*n=44*	0.85[4]	*n=62*	*n=14*	*n=48*	1.0[4]
Professional	13 (25.5)	1 (14.3)	12 (27.3)		18 (29.0)	4 (28.6)	14 (29.2)	
Trades and Techs	7 (13.7)	1 (14.3)	6 (13.7)		2 (3.2)	0 (0.0)	2 (4.2)	
Clerks, Factory, other	31 (60.8)	5 (71.4)	26 (59.0)		42 (67.8)	10 (71.4)	32 (66.6)	
Education, n (%)	*n=50*	*n=7*	*n=43*	0.73[4]	*n=62*	*n=14*	*n=48*	0.60[4]
Primary/None	16 (32.0)	4 (57.1)	12 (27.9)		16 (25.8)	2 (14.3)	14 (29.2)	
Secondary/ No qualification	21 (42.0)	2 (28.6)	19 (44.2)		30 (48.4)	7 (50.0)	23 (47.9)	
Secondary/ Qualification	8 (16.0)	1 (14.3)	7 (16.3)		8 (12.9)	3 (21.3)	5 (10.4)	
Trade/ Occupational	2 (4.0)	0 (0.0)	2 (4.6)		3 (4.8)	1 (7.2)	2 (4.5)	
Tertiary	3 (6.0)	0 (0.0)	3 (7.0)		5 (8.1)	1 (7.2)	4 (8.3)	

[a] Median (25^{th}- 75^{th}), [b] Mean ± SD (range)

*significant finding *p*= <0.05, ** *p*= <0.01, *** *p*= <0.001

[1] Mann- Whitney U, [2] Independent t –Test, 4 Chi-Square –Fishers Exact Test reported.

Table 4.2-2

Deprivation and income measures of Māori participants in advanced age, by gender and fracture occurrence.

	Men				Women			
	Total Men	Fracture	Non-fracture	P-value	Total Women	Fracture	Non-fracture	P-value
Income, n (%)	*n=35*	*n=3*	*n=32*	1.00[4]	*n=46*	*n=7*	*n=39*	1.00[4]
NZ Superannuation	33 (94.2)	3 (100)	30 (93.8)		42 (91.2)	7 (100)	35 (89.6)	
Other Superannuation	0 (0.0)	0 (0.0)	0 (0.0)		0 (0.0)	0 (0.0)	0 (0.0)	
Other Pension	0 (0.0)	0 (0.0)	0 (0.0)		2 (4.4)	0(0.0)	2 (5.2)	
Tribal trust / land	0 (0.0)	0 (0.0)	0 (0.0)		0 (0.0)	0 (0.0)	0 (0.0)	
Inheritance	0 (0.0)	0 (0.0)	0 (0.0)		0 (0.0)	0(0.0)	0 (0.0)	
Investment	1 (2.9)	0 (0.0)	1 (3.1)		2 (4.4)	0 (0.0)	2 (5.2)	
Salary/ Wages	1 (2.9)	0 (0.0)	1 (3.1)		0 (0.0)	0(0.0)	0 (0.0)	
Support from family	0 (0.0)	0 (0.0)	0 (0.0)		0 (0.0)	0 (0.0)	0 (0.0)	
Other financial support	0 (0.0)	0 (0.0)	0 (0.0)		0 (0.0)	0(0.0)	0 (0.0)	
Deprivation (2006 quintile), n (%)	*n=51*	*n=7*	*n=44*	0.37[4]	*n=62*	*n=14*	*n=48*	0.54[4]
1	3 (5.9)	1 (14.3)	2 (4.5)		4 (6.5)	0 (0.0)	4 (9.2)	
2	9 (17.6)	2 (28.5)	7 (15.9)		9 (14.5)	2 (14.2)	7 (14.6)	
3	8 (15.7)	0 (0.0)	8 (18.2)		17 (27.4)	7 (50.0)	10 (20.8)	
4	18 (35.3)	3 (42.9)	15 (34.1)		14 (22.6)	3 (21.4)	11 (22.9)	
5	13 (25.5)	1 (14.3)	12 (27.3)		18 (29.0)	2 (14.3)	16 (33.3)	
Financial Security, n (%)	*n=36*	*n= 3*	*n=33*	1.0[4]	*n=45*	*n=6*	*n-=39*	0.25[4]
Unable to make ends meet	35 (97.2)	3 (100)	32 (96.9)		43 (95.0)	5 (83.3)	38 (97.4)	
I have just enough	1 (2.8)	0 (0.0)	1 (3.1)		2 (5.0)	1 (16.7)	1 (2.6)	
I am comfortable	0 (0)	0 (0.0)	0 (0.0)		0 (0)	0 (0.0)	0 (0.0)	
Can you afford to eat properly, n (%)	*n=36*	*n=3*	*n=33*	1.0[4]	*N=45*	*n=6*	*n=39*	0.02*[4]
Always	34 (94.4)	3 (100)	31 (94.0)		43 (95.6)	4 (66.7)	39 (100)	
Sometimes	1 (2.8)	0 (0.0)	1 (3.0)		2 (4.4)	2 (33.3)	0 (0.0)	
Never	1 (2.8)	0 (0.0)	1 (3.0)		0 (0)	0 (0.0)	0 (0.0)	
I don't know	0 (0)	0 (0.0)	0 (0.0)		0 (0)	0 (0.0)	0 (0.0)	

*significant finding p= <0.05, ** p= <0.01,*** p= <0.001

[1] Mann- Whitney U,[2] Independent t –Test ,[4] Chi-Square –Fishers Exact Test reported.

4.2.2 Anthropometric Characteristics

The overall anthropometric characteristic of Māori participants, by gender and fracture occurrence, is depicted in Table 4.2.-3. Both Māori men and women had a median BMI, which fell within an overweight BMI range (25.0 to 29.9kg/m^2), with no significant difference between the two genders. Categorical BMI breakdown (underweight, normal, overweight and obese) differed significantly between men and women (x2=7.765, p=0.03). Men were more likely than women to be underweight then within healthy a healthy weight range, overweight or obese (RR= 6.4, 2.0, 5.2 respectively) and to be overweight rather than obese (RR=1.6). Women were 2.4 times more likely than men to be a healthy weight than obese. Both Maori, men and women experienced a median weight loss over the 24month period (-2.5kg men and -2kg women), 44.4% of men and 48.4% of those who's weight changed experienced greater the five percent weight loss at this time.

Median BMI, weight change (n) and weight change (%) did not differ significantly in Māori men and women who fractured over the 24 months. The majority of fractured women were overweight (62.5%) with BMI breakdown differing significantly between fractured women and non-fractured (x2=6.531, p=0.03). Non-fractured women were 7.6 and 3.9 times more likely than fractured women to be within a healthy weight range then overweight or obese, respectively. Median BMI of fractured men was within a healthy weight range; there was no significant difference for men the opposite trend to women was observed here with more men being a healthy weight then overweight.

Table 4.2-3

Anthropometric measures of Māori participants in advanced age, by gender and fracture occurrence.

	Men				Women			
	Total Men	*Fracture*	*Non-fracture*	*P*-value	*Total Women*	*Fracture*	*Non-fracture*	*P*-value
Weight (kg)[a] Median (25^{th}-75^{th})	75 (70-85)	65 (61-70)	77 (71-85)	0.25[1]	66 (59-78)	72 (63-87)	65 (59-76)	0.20[1]
Height (cm)[b] Mean ± SD	166 ± 5	167 ±5	166 ± 5	0.83[2]	155 ± 5	153 ± 4	155 ±5	0.37[2]
	n=37	*n=5*	*n=32*		*n=45*	*n=8*	*n=37*	
BMI (kg/m²)[a] Median (25^{th}-75^{th})	28 (26-30)	24 (21-26)	28 (26-30)	0.21[1]	29 (24-32)	29 (29-35)	28 (23-32)	0.18[1]
BMI ≤ 18.5 kg/m²	1 (2.9)	0 (0.0)	1 (3.1)	0.62[1]	0 (0.0)	0 (0.0)	0 (0.0)	0.03*[4]
BMI >18.6-24.9 kg/m²	5 (14.7)	1 (50.0)	4 (12.5)		14 (31.1)	0 (0.0)	14(37.8)	
BMI >25-29.9 kg/m²	19 (55.9)	1 (50.0)	18 (56.3)		13 (28.9)	5 (62.5)	8 (21.7)	
BMI ≥30 kg/m²	9 (26.5)	0 (0.0)	9 (28.1)		18 (40.0)	3 (37.5)	15 (40.5)	
	n=25	*n=2*	*n=23*		*n=31*	*n=5*	*n=26*	
Weight Change in the last 24 months (kg) Median (25^{th}-75^{th})[a]	-2.5 (-4.5 – 0.5)	3 (-1- 7)	-3 (-5 -0)	0.41[1]	-2 (-6 – 0)	-2 (-2 -2)	-3 (-7 – 0)	0.13[1]
Increase n, (%)				1.0[4]				0.43[4]
0.1-5%	3 (12.0)	0 (0.0)	3 (13.0)		6 (19.4)	1 (20.0)	5 (19.2)	
>5%	2 (8.0)	0 (0.0)	2 (8.8)		1 (3.2)	1 (20.0)	0 (0.0)	
>10%	1 (4.0)	1 (50.0)	0 (0.0)		1 (3.2)	0 (0.0)	1 (3.9)	
Decrease n, (%)								
0.1-5%	8 (32.0)	1 (50.0)	7 (30.4)		8 (25.8)	1 (20.0)	7 (26.9)	
>5%	8 (32.0)	0 (0.0)	8 (34.8)		10 (32.3)	2 (40.0)	8 (30.8)	
>10%	3 (12.0)	0 (0.0)	3 (13.0)		5 (16.1)	0 (0.0)	5 (19.2)	

[a] Median (25^{th}- 75^{th}), [b] Mean ± SD

*significant finding *p*= <0.05, ** *p*= <0.01,*** *p*= <0.001

[1] Mann- Whitney U,[2] Independent t –Test ,[4] Chi-Square –Fishers Exact Test reported.

4.2.3 Physical and Health characteristics

The physical and health characteristics of Māori participants, by gender and fracture occurrence, are depicted in Table 4.2-4 and 4.2-5. Over 90% of men and women were taking prescription medications, and less than 10% was consuming herbal/traditional medicines with little difference between the two. Use of nutritional supplement differed significantly between men and women (x2=4.804, p=0.028); women were 2.9 times more likely than men to take dietary supplements, comparatively, men had a slightly higher intake (+8.7%) of OTC medicines.

Proportionally more women than men had been previously diagnosed with osteoporosis (20.0% and 5.7%, respectively); similarly, women reported a family history of hip fractures in both parents more frequently than men. More than one third of Māori men and women had experienced a previous fracture in their lifetime (43.2% and 33.3%, respectively). Very few participants currently smoked with over 90 % of men and women being smoke-free throughout their lifetime. Nearly half of men and two thirds of women abstained from alcohol consumption (47.8% men and 64.3% women), and less than 20% of Māori consuming alcohol frequently (4+ times weekly), with no significant difference between proportionate intakes of men and women.

Walking was the most popular form of activity with over 80% of participants walking (off their property) at least 1 to 2 times per week. Men tended to walk more frequently with the greatest proportion walking 5 to 7 times per week, compared to women who predominantly walked 1 to 2 times a week. Men maintained a significantly higher level of involvement at a strenuous exercise level (x2=5.068, p=0.023); women were 1.1 times more likely not to participate in strenuous exercise at all compared to men. Finally, one out of every ten Māori, men and women, participated in a weekly exercise to help increase muscle strength and endurance (10.9% and 10.8% respectively).

There was no difference in medication, OTC, supplement and herbal/traditional medicine use, osteoporosis, previous fractures, family history and smoking or alcohol intake between fractured and non-fractured Māori, for both men and women. Previous fractures in non-Māori women was the only variable to differ significantly between fractured and non-fractured individuals, where fractured women were 3.3 times more likely to have had a previous fracture compared to non-fractured Māori women (x2=7.788, p=0.012).

Table 4.2-4

Lifestyle characteristics of Māori, by gender and fracture occurrence.

	Men				Women			
	Total Men	Fracture	Non-fracture	P-value	Total Women	Fracture	Non-fracture	P-value
Do you currently take:								
Prescribed Medication	43 (93.5)	3 (100)	40 (93.0)	0.64[3]	53 (94.6)	9 (100)	44 (93.1)	0.44[3]
Non Prescribed Medication	16 (35.5)	0 (0.0)	40 (71.4)	0.54[4]	15 (26.8)	1 (11.1)	14 (29.8)	0.42[4]
Nutritional Supplements	4 (8.7)	1 (33.3)	3 (7.0)	0.24[4]	14 (25.5)	3 (33.3)	11 (23.9)	0.68[4]
Herbal/ Traditional Medicines	4 (8.7)	0 (0.0)	4 (9.3)	1.0[4]	4 (7.3)	1 (11.1)	3 (6.5)	0.52[4]
Have you ever been told by a Doctor that you have osteoporosis	*n=35*	*n=3*	*n=32*		*n=45*	*n=6*	*n=39*	
Yes	2 (5.7)	0 (0.0)	2 (6.2)	1.0[4]	13 (28.8)	5 (83.3)	8 (20.5)	1.0[4]
No	33 (94.3)	3 (100)	30 (93.8)		32 (71.1)	1 (16.7)	31 (79.5)	
Have you had a previous fracture?	*n=37*	*n=3*	*n=34*	0.57[4]	*n=45*	*n=6*	*n=39*	0.01[4*]
Yes	16 (43.2)	2 (66.7)	14 (41.2)		15 (33.3)	5 (83.3)	10 (25.6)	
No	21 (56.8)	1 (33.3)	20 (58.8)		30 (66.7)	1 (16.7)	29 (75.4)	
Family history of fracture:								
Mother, n (%)				0.25[4]				0.44[4]
Yes	1 (3.6)	0 (0.0)	1 (3.7)		4 (10.3)	1 (20.0)	3 (8.8)	
No	27 (96.4)	1 (100)	26 (96.2)		35 (89.7)	4 (80.0)	31 (91.2)	
Age (years) Median, (25th-75th)[a]	65 (65-65)	-	65 (65-65)	-	82 (65-83)	83 (83-83)	74 (65-82)	1.0[1]
Father, n (%)				0.43[4]				0.16[4]
Yes	0 (0.0)	0 (0)	0 (0)		1 (2.7)	0 (0)	1(2.9)	
No	30 (100)	2 (100)	28 (100		37 (97.3)	4 (100)	33 (97.1)	
Age (years) Median, (25th-75th)[a]	-	-	-	-	70 (70-70)	-	70 (70-70)	-
Do you currently or have you ever smoked cigarettes?	*n=48*	*n=4*	*n=44*	0.30[4]	*n=58*	*n=10*	*n=48*	1.0[4]
Never	44 (91.6)	3 (75.0)	41(93.2)		54 (93.1)	10 (100)	44 (91.7)	
Current	4 (8.4)	1 (25.0)	3 (6.8)		4 (6.9)	0 (0.0)	4 (8.3)	
Past	0 (0.0)	0 (0.0)	0 (0.0)		0 (0.0)	0 (0.0)	0 (0.0)	

Alcohol intake	*n=46*	*n=3*	*n=43*	1.0[4]	*n=56*	*n=9*	*n=47*	0.28[4]
Never	22 (47.8)	2 (66.7)	20 (46.5)		36 (64.3)	6 (66.7)	30 (63.8)	
Monthly or less	8 (17.4)	0 (0.0)	8 (18.6)		9 (16.1)	0 (0.0)	9 (19.1)	
2-4x per month	3 (6.5)	0 (0.0)	3 (7.0)		2 (3.5)	0 (0.0)	2 (4.3)	
2-3x per week	5 (10.9)	0 (0.0)	5 (11.6)		3 (5.4)	1 (11.1)	2 (4.3)	
4 + per week	8 (17.4)	1 (33.3)	7 (16.3)		6 (10.7)	2 (22.2)	4 (8.5)	

[a] Median (25^{th}- 75^{th}), [b] Mean ± SD (range)

*significant finding *p*= <0.05, ** *p*= <0.01,*** *p*= <0.001, Statistical tests: [1] Mann- Whitney U,[2] Independent t –Test ,[4] Chi-Square –Fishers Exact Test reported.

Table 4.2-5

Exercise participation over the last 7 days in Māori, by gender and fracture occurrence.

How often have you?	Men				Women			
	Total Men	Fracture	Non-fracture	P-value	Total Women	Fracture	Non-fracture	P-value
Walked outside your home or yard for any reason.	*n=34*	*n=3*	*n=31*	0.32[4]	*n=46*	*n=7*	*n=39*	1.0[4]
Never (0days)	3 (8.8)	0 (0.0)	3 (9.6)		3 (6.5)	0 (0.0)	3 (7.7)	
Seldom (1-2day)	6 (17.6)	1 (33.3)	5 (16.3)		18 (39.1)	3 (42.8)	15 (38.5)	
Sometimes (3-4days)	4 (11.8)	1 (33.3)	3 (9.6)		9 (19.6)	1 (14.4)	8 (20.5)	
Often (5-7days)	21 (61.8)	1 (33.3)	20 (64.5)		16 (34.8)	3 (42.8)	13 (33.3)	
Hours spent walking	*n=33*	*n=3*	*n=30*	1.0[4]	*n= 44*	*n=7*	*n=37*	0.72[4]
No exercise	3 (9.1)	0 (0.0)	3 (10.0)		3 (6.8)	0 (0.0)	3 (8.1)	
<1 hour	18 (54.5)	2 (66.7)	16 (53.3)		31 (70.5)	5 (71.4)	24 (64.9)	
1-2 hours	7 (21.2)	1 (33.3)	6 (20.0)		7 (15.9)	1 (14.3)	6 (16.2)	
2- 4 hours	3 (9.1)	0 (0.0)	3 (10.0)		1 (2.3)	1 (14.3)	1 (2.7)	
>4 hours	2 (6.1)	0 (0.0)	2 (6.7)		3 (6.8)	0 (0.0)	3 (8.1)	
Engaged in light sport or recreational activities.	*n=36*	*n=3*	*n=33*	0.62[4]	*n=45*	*n=6*	*n=39*	0.68[4]
Never (0days)	15 (41.7)	1 (33.3)	14 (42.4)		20 (44.4)	4 (66.7)	16 (41.0)	
Seldom (1-2day)	10 (27.8)	2 (66.7)	8 (24.2)		10 (22.2)	1 (16.7)	9 (23.1)	
Sometimes (3-4days)	5 (13.9)	0 (0.0)	5 (15.2)		8 (17.8)	0 (0.0)	8 (20.5)	
Often (5-7days)	6 (16.7)	0 (0.0)	6 (18.2)		7 (15.6)	1 (16.7)	6 (15.4)	
Engaged in moderate sport or recreational activities.	*n=34*	*n=3*	*n=31*	1.0[4]	*n= 45*	*n=6*	*n=39*	1.0[4]
Never (0days)	22 (64.7)	2 (66.7)	20 (60.6)		40 (89.0)	6 (100)	34 (87.2)	
Seldom (1-2day)	9 (26.5)	1 (33.3)	8 (24.2)		2 (4.4)	0 (0.0)	2 (5.8)	
Sometimes (3-4days)	0 (0.0)	0 (0.0)	0 (0.0)		2 (4.4)	0 (0.0)	2 (5.8)	
Often (5-7days)	3 (8.8)	0 (0.0)	3 (15.2)		1 (2.2)	0 (0.0)	1 (1.2)	
Engaged in strenuous sport or recreational activities.	*n=36*	*n=3*	*n=33*	1.0[4]	*n=45*	*n=6*	*n=39*	1.0[4]
Never (0 days)	32 (88.8)	3 (100)	29 (87.6)		45 (100)	6 (100)	39 (100)	
Seldom (1-2day)	1 (2.8)	0 (0.0)	1 (3.1)		0 (0.0)	0 (0.0)	0 (0.0)	
Sometimes (3-4days)	1 (2.8)	0 (0.0)	1 (3.1)		0 (0.0)	0 (0.0)	0 (0.0)	

Often (5-7days)	2 (5.6)	0 (0.0)	2 (6.1)		0 (0.0)	0 (0.0)	0 (0.0)	
Exercise specifically to increase muscle strength and endurance	*n=35*	*n=3*	*n=32*	1.0[4]	*n=45*	*n=6*	*n=39*	1.0[4]
Never (0days)	34 (97.1)	3 (100)	31 (96.9)		41 (91.2)	6 (100)	35 (89.7)	
Seldom (1-2day)	1 (2.9)	0 (0.0)	1 (3.1)		2 (4.4)	0 (0.0)	2 (5.1)	
Sometimes (3-4days)	0 (0.0)	0 (0.0)	0 (0.0)		1 (2.2)	0 (0.0)	1 (2.6)	
Often (5-7days)	0 (0.0)	0 (0.0)	0 (0.0)		1 (2.2)	0 (0.0)	1 (2.6)	

significant finding *p*= <0.05, ** *p*= <0.01, *p*= <0.001**

[1] Mann- Whitney U,[2] Independent t –Test ,[4] Chi-Square –Fishers Exact Test reported.

4.2.4 Nutrient Intakes from 24 hour MPR

Respective mean and median intakes of energy, protein and micronutrients; calcium, vitamin D, phosphorous, magnesium and potassium for Māori, by gender and fracture occurrence are displayed in Table 4.2-6, with reference to respective EAR or AI values.

Māori men had a significantly higher median energy intake than women, consuming 23.9% more energy per day (U= 501, P=0.0001, r=0.38). Adequate protein intake was achieved by both men and women, and there was a significant difference in mean protein (g/day) intake by gender (t=3.124, 64.5 df, P=0.003, r =0.36). The average protein intake for men was 17.7g (32%) greater than the mean intake for women. Men also consumed 17.5 % higher protein g/kg compared to women, with both achieving similar percentage energy contribution from protein (2.6% difference). Breakdown of protein as a percentage of energy between fracture groups did not differ significantly. However, a high proportion of men (27.5%) and women (35.6%) were consuming protein below ADMR recommended ranges (<15% energy).

Median calcium intake by both Māori men (559mg/day) and women (539 mg/day) fell below EAR values, with 90.0% and 88.9% failing to achieve the daily EAR, respectively. Men and women consuming similar intakes of calcium (mg/day) and women achieving 46.0mg/1000kcal (11.9%) greater nutrient density calcium (mg/1000kcal) then men, with no significant difference observed. Median vitamin D (µg/day) intake by Māori men and women fell below EAR values with both consuming the same median intake of vitamin D per day (3µg/day), and a total 97.5% and 93.3% not meeting the daily EAR. Median vitamin D differed significantly between genders which can be justified by the relatively small effect size (U= 669, P=0.042, r=0.22) and subsequently no difference was observed for nutrient density. Intakes of phosphorous in Māori men (1163mg/day) and women (911 mg/day) were adequate, with only 5% and 11.1% failing to meet daily EAR values, respectively. Men were found to consume significantly more phosphorous than women (t=2.862, 63.2 df, P=0.006, r =0.72) consuming 252mg/1000kcal (27.6%) more per day. This difference disappeared when nutrient density was considered with women consuming 17mg/1000kcal,2.3% more phosphorous per day than men. Median magnesium (mg/day) intake by Māori men (259mg/day) and women (204mg/day) fell below EAR values, with a total 82.5% and 77.8% of participants failing to achieve daily EAR intakes, respectively. Median intake of magnesium (mg/day) didn't differ between genders however nutrient density was significantly greater for women (t=-2.022, 83 df, P=0.046, r =0.23) with women consuming an average 14.6mg/1000kcal greater intake of magnesium than in men. Mean potassium (mg/day) intake by both Māori men (2712mg/day) and women (2306mg/day) fell below EAR values with a total

90.0% and 73.3% of participants failing to achieve daily EAR intakes, respectively. Men consumed significantly greater potassium consuming 406mg/day (17.6%) more compared to women (t=2.120, 72.6 df, P=<0.037, r =0.24), conversely for nutrient density women consumed 147mg/1000kcal (9.6%) more potassium compared to men.

For fractured and non-fractured Māori men energy and protein markers were within nutrient reference ranges, with no significant differences between individuals. Māori men who sustained fractures exhibited 42.5% higher intakes of energy (kJ and kcal), 30.1% more protein (g), 64.0% more g/kg and 5.0% more percent energy from protein. Protein intake in fractured Māori men was maintained above the lower cut-off ADMR range (>15% energy from protein), yet close to a third (28.9%) of non-fractured participants exhibited small protein (% kJ) intake (<15% energy from protein). Intakes of calcium, vitamin D, potassium and magnesium fell below EAR recommendations however none of these differed significantly between fracture groups.

Energy intakes in women in fractured and non-fractured women were below-estimated requirements, with median energy intake for fractured women being 12.1% (616kJ) lower than those non-fractured and 11.1% (558kJ) lower than overall median intakes these figures did not differ significantly. Protein intake (g) and (g/kg) was less in women who sustained fractures by 18.3% and 13.8% respectively, without differing significantly. Protein as a %age of energy and protein distribution ranges were comparable in fractured and non-fractured Māori women, 15.4%kJ and 15.7%kJ respectively and both having over a third of participants consuming <15% energy from protein (40% and 34.3% respectively).

The following nutrient intakes by fractured and non-fractured Māori women fell below estimated average requirements calcium (mg/day), vitamin D (µg/day), potassium (mg/day) and magnesium (mg/day), yet these micronutrient intakes did not differ for calcium (mg/day), phosphorus (mg/day) and potassium (mg/day), there was a significant difference observed for vitamin D (µg/day) and magnesium (mg/day). Intake of vitamin D (µg) was significantly lower in fractured Māori women (U= 82.0, P=0.01, r=0.32), while intake differed by 1µg (50%), the range of each parameter overlapped where the other started). Intake of magnesium (mg/day) was significantly lower in fractured Māori women (U= 97.0, P=0.033, r=0.32), with fractured women consuming 68mg (47.5%) less magnesium than non-fractured.

Table 4.2-6

Nutrient intake and micro-nutrient density, of Māori, by gender and fracture occurrence.

	Men				Women			
Nutrients	Total Men, *n=40*	Fracture, *n=2*	Non-fracture, *n=38*	P-value	Total Women, n=45	Fracture, n=10	Non-fracture, n=35	P-value
Energy (kJ) [a]	6,943 (5,935-8,949)	9,899 (6,301-13,496)	6,943 (5,673-8,863)	0.56[1]	5,603 (4,776-6,681)	5,045 (4,521-6,031)	5,661 (5,1017,084)	0.15[1]
Energy (kcal)	1,659 (1,419-2,139)	2,356 (1,500-3,213)	1,653 (1,351-2,110)	-	1,339 (1,142-1,597)	1,206 (1,081-1,442)	1,353 (1,219-1,693)	-
Protein (g) [b]	74 ± 31	95 ± 42)	73 ± 30	0.33[2]	56 ± 19	49 ± 18	58 ± 20	0.19[2]
Protein (g/kg) [a]	0.94 (0.74-1.36)	1.5 (0.9-2.1)	0.91 (0.7-1.3)	0.78[1]	0.80 (0.66-0.93)	0.71 (0.4-0.9)	0.82 (0.7-1.1)	0.13[1]
Protein (% kJ) [a]	15.9 (14.2-18.1)	16 .7 (15.7-17.7)	15.9 (14.1-18.1)	0.61[1]	15.5 (13.8-18.1)	15.4 (13.0-17.7)	15.7 (13.8-20.6)	0.51[1]
<14.9, n (%)	**11 (27.5)**	0 (0.0)	**11 (28.9)**	0.30[4]	**16 (35.6)**	**4 (40.0)**	**12 (34.3)**	0.71[4]
15-24.99, n (%)	28 (70.0)	2 (100)	26 (68.4)		28 (62.2)	6 (60.0)	22 (62.9)	
>25, n (%)	1 (2.5)	0 (0.0)	1 (2.7)		1 (2.2)	0 (0.0)	1 (2.8)	
Calcium (mg/day) [a]	**559 (384-891)**	**985 (780-1,189)**	**548 (384-876)**	0.20[1]	**539 (400-763)**	**433 (356-763)**	**578 (454-770)**	0.44[1]
< EAR, n (%)[t]	**36 (90.0)**	**1 (50.0)**	**35 (92.1)**		**40 (88.9)**	**9 (90.0)**	**31 (88.6)**	
Calcium (mg/1000 kcal)[b]	385 ± 180	443 ± 105	381 ± 184	0.64[2]	431 ± 169	444 ±178	427 ± 169	0.70[2]
Vitamin D (µg/day) [a]	**3 (3-7)**	**8 (8-9)**	**3 (3-7)**	0.77[1]	**3 (2-4)**	**2 (1-2)**	**3 (2-4)**	0.01*[1]
< EAR, n (%)[t]	**39 (97.5)**	**2 (100)**	**37 (97.3)**		**42 (93.3)**	**9 (90.0)**	**33 (94.3)**	
Vitamin D (µg/1000 kcal)[b]	3 ± 2	4 ± 2	3 ± 2	0.37[2]	3 ± 3	2 ± 3	3 ± 3	0.45[2]
Phosphorous (mg/day)[b]	1,163 ± 481	1445 ± 731	1148 ± 474	0.40[2]	911 ± 295	797 ± 331	944 ± 281	0.17[2]
<EAR, n (%)[t]	**2 (5.0)**	0 (0.0)	**2 (5.3)**		**5 (11.1)**	**2 (20.0)**	**3 (8.6)**	
Phosphorous (mg/1000 kcal)[b]	647 ± 141	612 ± 6	649 ± 145	0.73[2]	662 ± 161	630 ± 169	671 ± 160	0.48[2]
Magnesium (mg/day) [a]	**259 (182-281)**	**300 (182-417)**	**259 (183-279)**	0.78[1]	**204 (155-252)**	**143 (129- 231)**	**211 (170-273)**	0.03*[1]
<EAR, n (%)[t]	**33 (82.5)**	**1 (50.0)**	**32 (84.2)**		**35 (77.8)**	**9 (90.0)**	**26 (74.2)**	
Magnesium (mg/1000 kcal)[b]	139 ± 32	125 ± 6	140 ± 33	0.54[2]	154 ± 34	139 ± 32	158 ± 34	0.14[2]
Potassium (mg/day) [b]	**2712 ± 985**	**3243 ± 2339**	**2684 ± 927**	0.44[2]	**2306 ± 752**	**1951 ± 582**	**2407 ± 771**	0.09[2]
<EAR, n (%)[t]	**36 (90.0)**	**1 (50.0)**	**35 (92.1)**		**33 (73.3)**	**9 (90.0)**	**24 (68.6)**	
Potassium (mg/1000 kcal)[b]	1523 ± 395	1287 ± 327	1536 ± 397	0.39[2]	1670 ± 390	1582 ± 349	1706 ± 401	0.38[2]

[a] Median (25th- 75th), [b] Mean ± SD, *significant finding *p*= <0.05, ** *p*= <0.01,*** *p*= <0.001. [1] Mann- Whitney U,[2] Independent t –Test ,[4] Chi-Square –Fishers Exact Test reported.**Mean or Median, nutrient reference values below respected (EAR or AI),**

[t] Respective nutrient estimated average requirements (EAR); Calcium: 1100mg/day, Vitamin D 15 µg/day, Phosphorous: 580mg/day, Magnesium: 350mg/day (men) 265mg/day (women) and Potassium: 3800mg/day (men) and 2800mg/day (women).

4.2.4.1 Logistic Regression Analysis

Nutrients identified by univariate analysis to be correlated with fractures in Māori included vitamin D (µg/day) and magnesium (mg/day). Multiple logistic regression models were constructed to examine the independent association between the bone related nutrients and fracture occurrence, controlling for age, gender, NZ deprivation index, BMI and previous facture. Adjusted and unadjusted model findings are found below in table 4.2-7.

There was no association between fractures and intakes of energy (kJ and kcal), protein (g/day, g/kg and %kJ), calcium (mg/day and mg/1000kcal), vitamin D (µg/day and µg/1000kcal), phosphorous (mg/day and mg/1000kcal), magnesium (mg/day and mg/1000kcal) and potassium (mg/day and mg/1000kcal) in Māori.

Table 4.2-7

Logistic regression comparing nutrient intakes against fracture occurrence in non-Māori.

Independent Variables	Unadjusted OR (95% CI), *p*- Value	Adjusted OR (95% CI), *p*- Value
Energy (kJ) and(kcal) [2]	1.000 (1.000-1.000) *p*=0.287	1.001 (1.000-1.002) *p*=0.304
Protein (g) [1]	0.985 (0.958-1.012) *p*=0.276	0.933 (0.817-1.065) *p*=0.303
Protein (g/kg) [1]	0.398 (0.070-2.263) *p*=0.299	0.004 (0.000-134.8) *p*=0.303
Protein (% kJ) [1]	0.410 (0.025-6.798) *p*=0.534	0.010 (0.00-64.3) *p*=0.303
Calcium (mg/day)[1]	1.000 (0.998-1.002) *p*=0.962	0.998 (0.993-1.004) *p*=0.582
Calcium (mg/1000 kcal)[2]	1.001 (0.998-1.005) *p*=0.456	0.998 (0.989-1.006) *p*=0.614
Vitamin D (µg/day)[1]	0.999 (0.997-1.001) *p*=0.257	0..000 (0.000-0.000) *p*=0.582
Vitamin D (µg/1000 kcal)[2]	0.941 (0.713-1.243) *p*=0.670	0..000 (0.000-0.000) *p*=0.988
Phosphorous (mg/day) [1]	1.000 (0.998-1.001) *p*=0.487	0.997 (0.991-1.003) *p*=0.271
Phosphorous (mg/1000 kcal)[2]	0.998 (0.994-1.003) *p*=0.488	0..095 (0.986-1.004) *p*=0.247
Magnesium (mg/day) [1]	0.993 (0.894-1.002) *p*=0.142	0.983 (0.955-1.011) *p*=0.220
Magnesium (mg/1000 kcal)[2]	0.989 (0.969-1.009) *p*=0.290	0..970 (0.928-1.013) *p*=0.171
Potassium (mg/day) [1]	0.999 (0.999-1.000) 0.167	0.999 (0.997-1.001) *p*=0.420
Potassium (mg/1000 kcal)[2]	0.999 (0.998-1.001) *p*=0.493	0..998 (0.995-1.002) *p*=0.296

[1] Adjusted for age, gender, NZ Deprivation Index, BMI, energy and previous fracture

[2] Adjusted only for age, gender, NZ Deprivation Index, BMI and previous fracture

4.2.5 Food Sources

4.2.5.1 Macronutrients

4.2.5.1.1 Energy

Percentage contribution of foods to total energy intake for Māori, men and women is depicted in Table 4.2.5a. Full tables of the thirty two food groups contributing to energy are located in Appendix D, Table 4 -1.

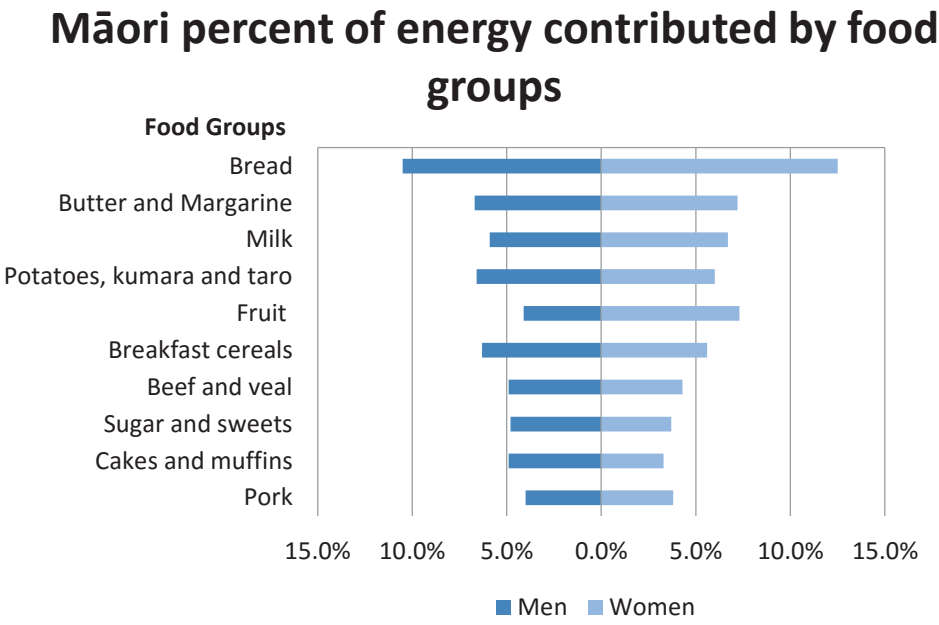

Figure 4-1 **Percent of energy from top ten food groups, by gender.**

The *bread* group was the principle source of energy for Māori men, contributing 10.5%, followed by *butter & margarine* (6.7%), *potato, kumara & taro (*6.6%), b*reakfast cereals* (6.3%), m*ilk* (5.9%), c*ake & muffins* (4.9%), s*ugar & sweets* (4.8%) and b*eef & veal* (4.5%). The b*read* group was the principle source of energy for Māori women, contributing 12.5%, followed by b*utter & margarine* (7.2%), fruit *(*7.3%), m*ilk* (6.7%), p*otato, kumara & taro* (6.0%), b*reakfast cereals* (5.6%), b*eef & veal* (4.3%) and v*egetables* (4.1%).

Of the top contributors to energy, both men and women consumed similar energy from b*eef and veal* (<0.5%difference). Men consumed comparatively more energy from p*otato, kumara & taro and breakfast cereals (+*0.6% each), with women consuming proportionately more energy from *bread* (+2.0%), *milk* (0.8%) and *butter & margarine* (+0.5%). While *cakes & muffins and sugar & sweets* made the leading contributors to energy in men, this was displaced by *fruit and vegetables* in women.

4.2.5.1.2 Protein

Percentage contribution of foods to total protein intake for Māori, men and women is depicted in Table 4-2. Full tables of the thirty two food groups contributing to protein are located in Appendix D, Table 4b.

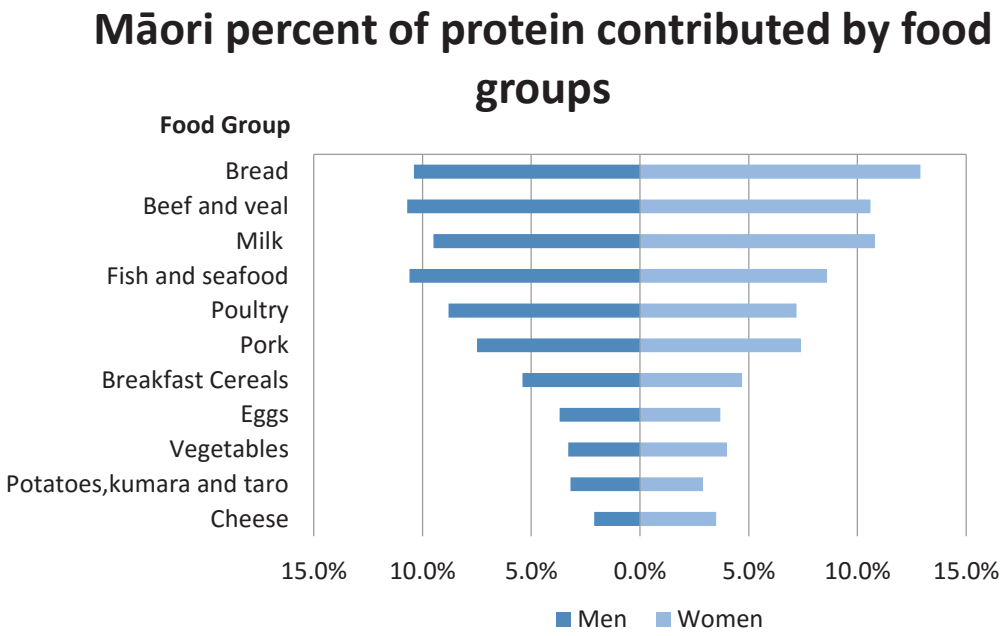

Figure 4-2 **Percent of protein from top ten food groups, by gender.**

The *beef & veal* group was the principle source of protein for Māori men, contributing 10.7%, followed by *fish & seafood* (10.6%), *bread (*10.4%), *milk* (9.5%), *poultry* (8.8%), *pork* (7.5%), *breakfast cereals* (5.4%) and *eggs & egg dishes* (3.7%).The *bread* group was the principle source of protein for Māori women, contributing 12.9%, followed by *milk* (10.8%), *beef & veal (*10.6%), *fish & seafood* (8.6%), *pork* (7.4%), *poultry* (7.2%), *breakfast cereals* (4.7%) and *vegetables* (4.0%).

Of the top contributors to protein, both men and women consumed similar energy from *beef & veal, and pork* (<0.5% difference). Men consumed comparatively more protein from *fish & seafood (+*2.0%), *poultry (+*1.6%) and breakfast *cereals* (0.7%), with women consuming proportionately more protein from *bread* (+2.5%) and *milk* (1.3%). While *eggs & egg dishes* made the leading contributors to protein in men, this was displaced by *vegetables* in women.

4.2.5.2 Micronutrients

4.2.5.2.1 Calcium

Percentage contribution of foods to total calcium for Māori, men and women is depicted in Table 4-3. Full tables of the thirty two food groups contributing to calcium are located in Appendix D, Table 4c.

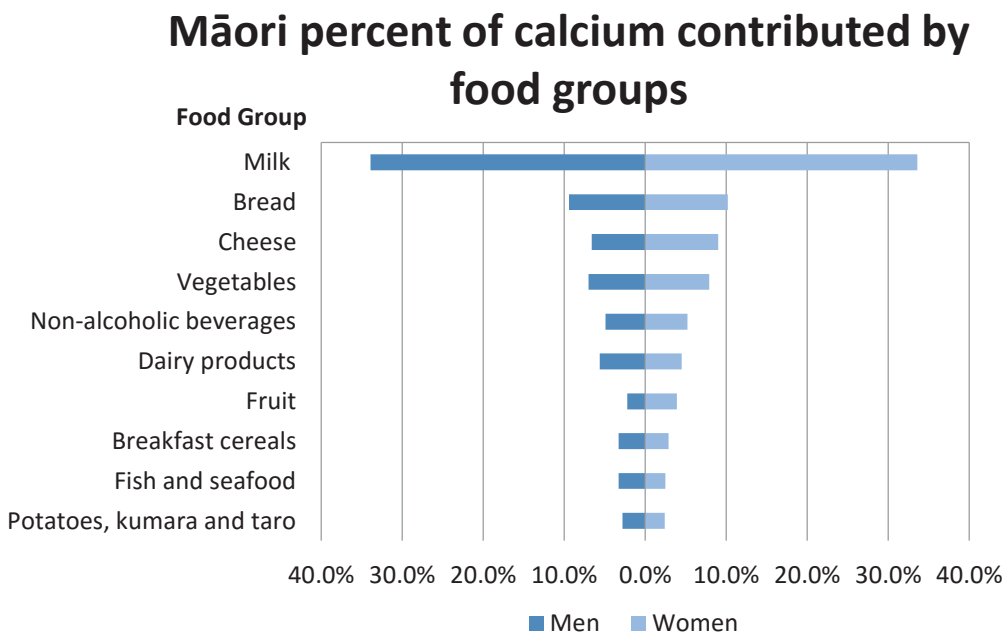

Figure 4-3 **Percent of calcium from top ten food groups, by gender.**

The *Milk* group was the principle source of calcium for Māori men, contributing 33.9%, followed by *bread* (9.4%), *vegetables* (7.0%), *cheese* (6.6%), *dairy products (*5.6%), *non-alcoholic beverages* (4.9%), *fish & seafood* (3.3%) and *breakfast cereals* (3.3%). The *milk* group was the principle source of calcium for Māori women, contributing 33.6%, followed by *bread (*10.2%), *cheese* (9.0%), *vegetables (*7.9%), *non-alcoholic beverages* (5.2%), *dairy products* (4.5%), *fruit* (3.9%) and *breakfast cereals* (2.9%).

Of the top contributors to calcium, both men and women consumed similar calcium from *milk, non-alcoholic beverages and breakfast cereals* (<0.5% difference). Men consumed comparatively more calcium from *dairy (+*1.1%), with women consuming proportionately more calcium from *cheese* (+2.4%), *vegetables* (+0.9%) and *bread* (+0.8%). While *fish & seafood* made the leading contributors to calcium in men, this was displaced by *fruit* in women.

4.2.5.2.2 Vitamin D

Percentage contribution of foods to total vitamin D intake for Māori, men and women is depicted in Table 4-4. Full tables of the thirty two food groups contributing to vitamin D are located in Appendix D, Table 4d.

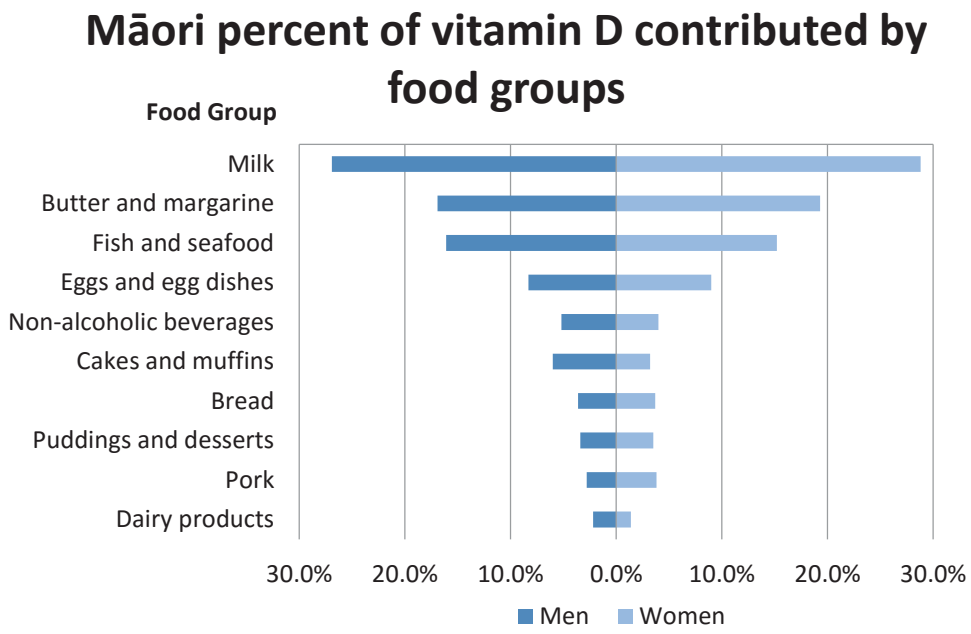

Figure 4-4 **Percent of vitamin D from top ten food groups, by gender.**

The *milk* group was the principle source of vitamin D for Māori men, contributing 26.9%, followed by *butter & margarine* (16.9%), *fish & seafood* (16.1%), *eggs & egg dishes* (8.3%), *cakes & muffins (*6.0%), *non-alcoholic beverages* (5.2%), *bread* (3.6%) and *pudding & desserts* (3.4%). The *milk* group was the principle source of vitamin D for Māori women, contributing 28.8%, followed by *butter & margarine (*19.3%), *fish & seafood* (15.2%), *eggs & egg dishes (*9.0%), *non-alcoholic beverages* (4.0%), *pork* (3.8%), *bread* (3.7%) and *puddings & desserts* (3.5%).

Of the top contributors to vitamin D, both men and women consumed similar vitamin D from *bread & Pudding* (<0.5% difference). Men consumed comparatively more vitamin D from *non-alcoholic beverages (+*1.2%) and *fish & seafood* (+0.9%), with women consuming proportionately more vitamin D from *butter & margarine* (+2.4%), *milk* (+1.9%) and *egg & egg dishes* (+0.7%). While *cakes and muffins* made the leading contributors to vitamin D in men, this was displaced by *pork* in women.

4.2.5.2.3 Phosphorous

Percentage contribution of foods to total phosphorous intake for Māori, men and women is depicted in Table 4-5. Full tables of the thirty two food groups contributing to phosphorous are located in Appendix D, Table 4e

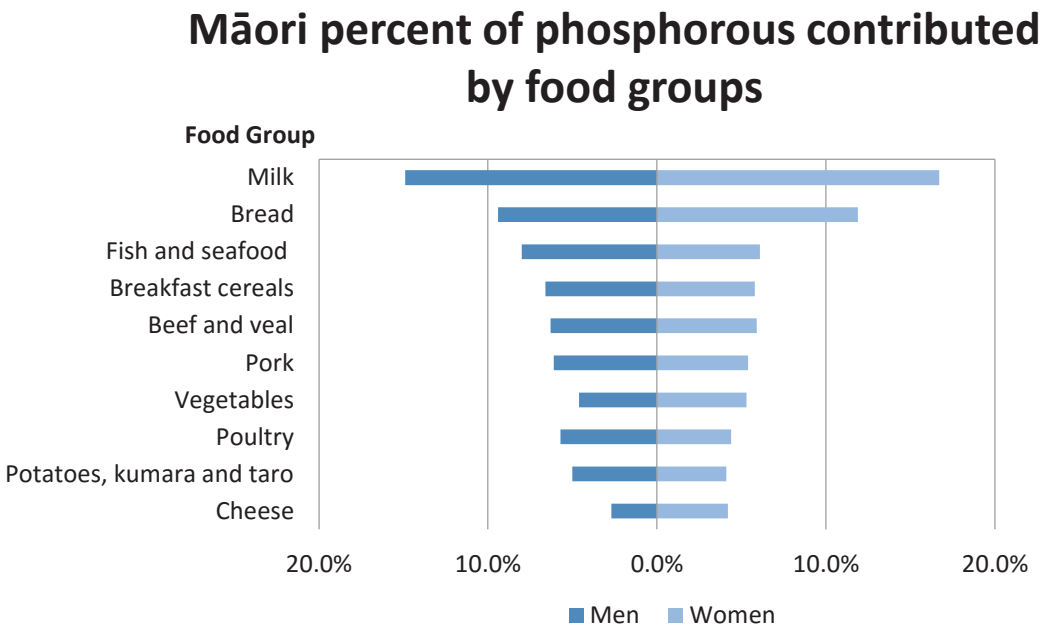

Figure 4-5 **Percent of phosphorous from top ten food groups, by gender.**

The *Milk* group was the principle source of phosphorous for Māori men, contributing 14.9%, followed by *Bread* (9.4%), *Fish & seafood* (8.0%), *Breakfast cereals* (6.6%), *Beef & veal (*6.3%), *Pork* (6.1%), *Poultry* (5.7%) and *Potatoes, kumara and taro* (5.0%). The *Milk* group was the principle source of phosphorous for Māori women, contributing 16.7%, followed by *Bread (*11.9%), *Fish & seafood* (6.1%), *Beef & veal (*5.9%), *Breakfast cereals* (5.8%), *Pork* (5.4%), *Vegetables* (5.3%) and *Poultry* (4.4%).

Men consumed comparatively more phosphorous from *Fish & seafood (+*1.9%), *Poultry* (+1.3%), *Breakfast cereals* (+0.8%) and *Pork* (+0.7%), with women consuming proportionately more phosphorous from *Bread* (+2.5%) and *Milk* (+1.8%). While *Potato, kumara & taro* made the leading contributors to phosphorous in men, this was displaced by *Vegetables* in women.

4.2.5.2.4 Magnesium

Percentage contribution of foods to total magnesium for Māori, men and women is depicted in Table 4-6. Full tables of the thirty two food groups contributing to magnesium are located in Appendix D, Table 4f

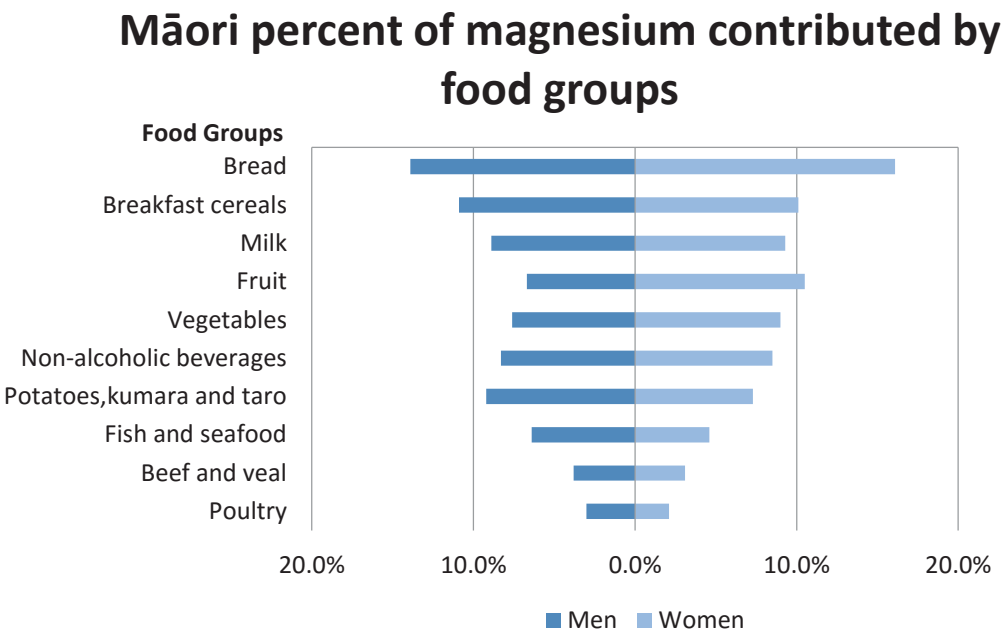

Figure 4-6 **Percent of magnesium from top ten food groups, by gender.**

The *Bread* group was the principle source of magnesium for Māori men, contributing 13.9%, followed by *Breakfast cereals* (10.9%), *Potato, kumara & taro* (9.2%), *Milk* (8.9%), *Non-alcoholic beverages (*8.3%), *Vegetables* (7.6%), *Fruit* (6.7%) and *Fish & seafood* (6.4%). The *Bread* group was the principle source of magnesium for Māori women, contributing 16.1%, followed by *Fruit (*10.9%), *Breakfast cereals* (10.1%), *Milk (*9.3%), *Vegetables* (9.0%), *Non-alcoholic beverages* (8.5%), *Potatoes, kumara & taro* (7.3%) and *Fish & seafood* (4.6%).

Of the top contributors to magnesium, both men and women consumed similar magnesium from *Milk and Non-alcoholic beverages* (<0.5% difference). Men consumed comparatively more magnesium from *Potato, kumara & taro (+*1.9%), *Fish & seafood* (+1.8%) and *Breakfast cereal* (+0.8%), with women consuming proportionately more magnesium from *Bread* (+4.2%), *Fruit* (+3.8%) and *Vegetables* (+1.4%).

4.2.5.2.5 Potassium

Percentage contribution of foods to total potassium for Māori, men and women is depicted in Table 4-7. Full tables of the thirty two food groups contributing to potassium are located in Appendix D, Table 4f.

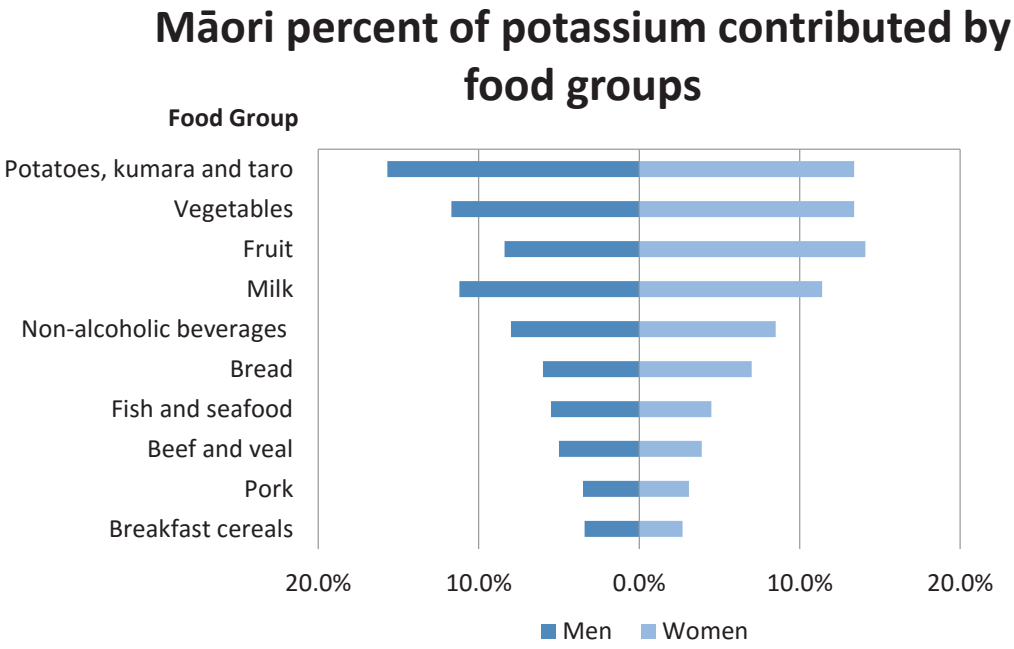

Figure 4-7 **Percent of potassium from top ten food groups, by gender.**

The *Potatoes, kumara & taro* group was the principle source of potassium for Māori men, contributing 15.7%, followed by *Vegetables* (11.7%), *Milk* (11.2%), *Fruit* (8.4%), *Non-alcoholic beverages (*8.0%), *Bread* (6.0%), *Fish & seafood* (5.5%) and *Beef & veal* (5.0%). The *Fruit* group was the principle source of potassium for Māori women, contributing 14.1%, followed by *Potato, kumara & taro (13.4%*), *Vegetables* (13.4%), *Milk (*11.4%), *Non-alcoholic beverages* (8.5%), *Bread* (7.0%), *Fish & seafood* (4.5%) and *Beef & veal* (3.9%).

Of the top contributors to potassium, both men and women consumed similar potassium from *Milk* (<0.5% difference). Men consumed comparatively more potassium from *Potato, kumara & taro (+*2.3%), *Beef & veal* (+1.1) and *Fish & seafood* (+1.0%), with women consuming proportionately more potassium from *Fruit* (+5.7%), *Vegetables* (+1.7%), *Bread* (+1.0%) and *Non-alcoholic beverages* (+0.5%).

4.3 Non-Māori Participants

4.3.1 Demographic and lifestyle characteristics

The overall demographic breakdown of non-Māori participants, by gender and fracture occurrence is depicted in Table 4.3-1 and 4.3-2. Fractionally more women than men were represented in this cohort (52% and 48% respectively). All non-Māori participants were aged over 80 years with a median age of 86 years, spanning a two-year range from 85-86. Of these participants over 97% had been married at some point, one-quarter of these were still married (26.9%), and two-thirds (62.9%) now widowed. Marital status differed significantly between men and women ($x2=63.2$, $p=<0.001$), women were 1.5 times more likely than men to have never been married and men were 2.9 times more likely to be still married rather than widowed compared to women.

Just over half, (50.7%) of non-Māori participants were living alone with NZ superannuation being the predominant source of income for most (83.4%). Living status differed significantly between genders, with men being 1.3 times more likely than women to live alone ($x2=36.9$, $p=0.001$). More women relied primarily on the NZ superannuation, with men more frequently living off invested money than women (12.9% and 4.2% respectively). Secondary level education with no qualification was the most frequent highest level of education (38.1%), after that similar numbers of individuals attaining secondary qualified (18.3%), primary (16.8%) and tertiary (16.3%). Education differed significantly between men and women ($x2=10.2$, $p=0.037$), men being 1.1 times more likely than women to have attained a trade or occupational qualifications and women being just as more likely than men to have completed full secondary education. Main lifetime occupation in non-Māori individuals was most commonly Clerks, Factory workers and other (52.0%). Occupation differed significantly between men and women ($x2=10.2$, $p=0.037$); men were 7.7 times more likely than women to have worked in a Trade and 3.1 times more likely to have been a Professional than as a Clerk, Factory worker or other.

Non-Māori men and women predominantly lived in the most deprived areas (Quintile 5, most deprived) (43.8% and 30.2%, respectively), proportionate numbers men and women living in the quintiles decrease as deprivation level decrease, leaving less than five percent (3.8%) living in quintile 1 (least deprived). Deprivation status varied based on gender, over 40.0 % of men resided within quintile five comparatively only 30.2 % of women did, leaving quintile four as the predominant area of residence for women (32.1%). Financial security was similar in both men and women, over 90% of participants stated they didn't have enough money to make ends meet (98.8% men and 94.7% women, respectively). This finding didn't directly affect financial accessibility to food, as over 95% stated that they can always afford to eat properly (98.8% men and 97.9% women).

Age of non-Māori men and financial security in women differed significantly between fractured and non-fractured individuals. Fractured men were significantly older than non-fractured men while the median age of individuals was the same at 86 the range of age for non-fractured men was between 85-86 whereas those fractured were all within the 86 years (U= 629, P=0.046, r=0.21). Non - fractured women were 1.1 times more likely to always have enough money to makes ends meet compared to those with women fractures (x2=5.904, p=0.033). No significant findings were observed for marital status, living situation, occupation, education, income deprivation status or ability to afford food, between fractured vs. non-fractured individuals, by gender.

Table 4.3-1

Demographic and Lifestyle measures of non-Māori in advanced age, by gender and fracture occurrence.

	Men				Women			
	Total Men	Fracture	Non-fracture	P-value	Total Women	Fracture	Non-fracture	P-value
Total, n (%)								
Age (years)	86 (85-86)	86 (86-86)	86 (85-86)	0.05*[1]	86 (85-86)	86 (85-86)	86 (85-86)	0.90[1]
Median (25th- 75th)								
Marital Status, n (%)	*n=96*	*n=16*	*n=80*	0.87[4]	n=105	n=14	n=46	0.14[4]
Never Married/Partnered	3 (3.2)	0 (0.0)	3 (3.7)		3 (2.9)	0 (0.0)	3 (6.5)	
Married/Partnered	27 (28.1)	4 (25.0)	23 (28.8)		27 (25.7)	7 (50.0)	24 (52.2)	
Widow/Widower	56 (58.3)	10 (62.5)	46 (57.5)		70 (66.6)	7 (50.0)	18 (39.1)	
Separated	0 (0.0)	0 (0.0)	0 (0.0)		0 (0.0)	0 (0.0)	0 (0.0)	
Divorced	10 (10.4)	2 (12.5)	8 (10.0)		5 (4.8)	0 (0.0)	1 (2.2)	
Living Situation, n (%)	*n=67*	*n=11*	*n=56*	0.73[4]	*n=81*	*n=10*	*n=32*	0.06[4]
Living alone	36 (53.7)	6 (54.5)	30 (53.6)		39 (48.1)	6 (60.0)	14 (43.7)	
Living with partner /spouse /child	25 (37.3)	3 (27.3)	22 (39.3)		36 (44.4)	4 (40.0)	18 (56.3)	
Living with others	6 (8.9)	2 (18.2)	4 (7.1)		6 (7.5)	0 (0.0)	0 (0.0)	
Occupation, n (%)	n=98	n=17	n=81	0.52[4]	n=106	n=15	n=81	0.11[4]
Professional	42 (42.9)	7 (41.2)	35 (43.2)		20 (18.9)	2 (13.3)	18 (22.2)	
Trades and Techs	30 (30.6)	7 (41.2)	23 (28.4)		6 (5.6)	0 (0.0)	6 (7.5)	
Clerks, Factory, other	26 (26.5)	3 (17.6)	23 (28.4)		80 (75.5)	13 (86.7)	57 (70.3)	
Education, n (%)	*n=98*	*n=17*	*n=81*	0.57[4]	*n=91*	*n=25*	*n=79*	0.99[4]
Primary/None	23 (23.5)	3 (17.6)	20 (24.7)		11 (10.6)	2 (8)	9 (11.3)	
Secondary/ No qualification	37 (37.8)	7 (41.2)	30 (37.0)		40 (38.5)	11(44.0)	29 (36.7)	
Secondary/ Qualification	12 (12.2)	2 (11.8)	10 (12.3)		25 (24.0)	6 (24.0)	19 (24.1)	
Trade/ Occupational	8 (8.1)	3 (17.6)	5 (6.2)		13 (12.5)	3 (12.0)	10 (12.7)	
Tertiary	18 (18.4)	2 (11.8)	16 (19.8)		15 (14.4)	3 (12.0)	12 (15.2)	

*significant finding *p*= <0.05, ** *p*= <0.01,*** *p*= <0.001

[1] Mann- Whitney U,[2] Independent t –Test ,[4] Chi-Square –Fishers Exact Test reported.

Table 4.3-2

Deprivation and Income measures of non-Māori participants in advanced age, by gender and fracture occurrence.

	Men				Women			
	Total Men	*Fracture*	*Non-fracture*	*P*-value	*Total Women*	*Fracture*	*Non-fracture*	*P*-value
Income, n (%)	*n=85*	*n=15*	*n=70*	0.93[4]	*n=96*	*n=22*	*n=74*	0.08[4]
NZ Superannuation	66 (77.6)	13 (86.7)	53 (75.7)		85 (88.4)	20 (91.0)	65 (87.8)	
Other Superannuation	5 (5.9)	0 (0.0)	5 (7.1)		5 (6.2)	0 (0.0)	5 (6.8)	
Other Pension	1 (1.2)	0 (0.0)	1 (1.4)		0 (0.0)	0 (0.0)	0 (0.0)	
Tribal trust / land	0 (0.0)	0 (0.0)	0 (0.0)		0 (0.0)	0 (0.0)	0 (0.0)	
Inheritance	0 (0.0)	0 (0.0)	0 (0.0)		0 (0.0)	0 (0.0)	0 (0.0)	
Investment	11 (12.9)	2 (13.3)	9 (12.9)		4 (4.2)	0 (0.0)	4 (5.4)	
Salary/ Wages	2 (2.4)	0 (0.0)	2 (2.9)		1 (0.6)	1 (4.5)	0 (0..0)	
Support from family	0 (0.0)	0 (0.0)	0 (0.0)		0 (0.0)	0 (0.0)	0 (0.0)	
Other financial support	0 (0.0)	0 (0.0)	0 (0.0)		1 (0.6)	1 (4.5)	0 (0.0)	
Deprivation (2006 quintile)	*n=98*	*n=17*	*n=81*	0.05[4]	*n=106*	*n=25*	*n=78*	0.98[4]
1	3 (3.1)	0 (0.0)	3 (3.6)		5 (4.7)	2 (8.0)	3 (3.9)	
2	14 (14.3)	3 (17.7)	11 (13.6)		8 (7.5)	2 (8.0)	6 (7.7)	
3	9 (9.2)	1 (5.9)	8 (9.9)		24 (22.6)	5 (20.0)	19 (24.4)	
4	29 (29.6)	4 (23.5)	25 (30.9)		34 (32.1)	8 (32.0)	26 (33.3)	
5	43 (43.8)	9 (52.9)	34 (42.0)		32 (30.2)	8 (32.0)	24 (30.7)	
Financial Security	*n=86*	*n=15*	*n=71*	1.0[4]	*n=95*	*n=21*	*n=74*	0.03*[4]
Unable to make ends meet	85 (98.8)	15 (100)	70 (98.6)		90 (94.7)	18 (85.7)	72 (97.2)	
I have just enough	1 (1.2)	0 (0)	1 (1.4)		4 (4.2)	3 (14.3)	1 (1.4)	
I am comfortable	0 (0.0)	0 (0)	0 (0.0)		1 (1.1)	0 (0.0)	1 (1.4)	
Can you afford to eat properly	*n=87*	*n=16*	*n=71*		*n=95*	*n=21*	*n=74*	
Always	85 (97.7)	15 (93.6)	70 (98.6)	1.0[4]	93 (97.9)	21 (100)	72 (97.3)	1.0[4]
Sometimes	2 (2.3)	1 (6.4)	1 (1.4)		2 (2.1)	0 (0.0)	2 (2.7)	
Never	0 (0.0)	0 (0.0)	0 (0.0)		0 (0.0)	0 (0.0)	0 (0.0)	
I don't know	0 (0.0)	0 (0.0)	0 (0.0)		0 (0.0)	0 (0.0)	0 (0.0)	

*significant finding p= <0.05, ** p= <0.01,*** p= <0.001

[1] Mann- Whitney U,[2] Independent t –Test ,[4] Chi-Square –Fishers Exact Test reported.

4.3.2 Anthropometric measures

The overall anthropometric breakdown of non-Māori participants, by gender and fracture occurrence is depicted in Table 4.3-3. Non-Māori men were significantly heavier than women (U= 1399, P=0.0001, r=0.55), with the median weight of non-Māori men being 12kg (16.0%) heavier than women. Non-Māori men and women both had a median BMI, which fell within an overweight BMI range (25.0 to 29.9kg/$m^{2,}$ with no significant difference between the genders. Greater number of non-Māori men fell within the overweight BMI category (50.6%) than women who had the main number of individuals within a healthy weight range (43.3%). There was a median weight loss in both men and women over the 24 months (-1kg and -2kg respectively), of those who's weight changed 35.3% of men and 40.4% of women experience weight loss greater than five percent over the 24 month period.

There was no significant difference between those who fractured vs. non-fractured in any or the tabulated anthropometric measures below. Fractured and non-fractured men both had BMI's within the overweight BMI range. Greater weight loss over the 24 months was, however, greater in fractured men (-2.5kg fractured and -1kg non-fractured). Likewise, those who experience greater than five percent weight loss over 24 months was 23.6% more in fractured men vs. non-fractured. The median BMI of fractured women was within a healthy weight range while non-fractured women were within the overweight BMI range. Weight loss experienced by both fractured and non-fractured women (-3kg and -1kg respectively), this was again seen as seven percent more fractured women experienced > 5% weight loss over the 24 months.

Table 4.3-3.

Anthropometric measures of non-Māori participants in advanced age.

	Men				Women			
	Total Men	Fracture	Non-fracture	P-value	Total Women	Fracture	Non-fracture	P-value
Weight (kg) Median (25^{th}-75^{th})[a]	75 (70-84)	76 (72-82)	75 (70-84)	0.62[1]	63 (56-71)	61 (53-67)	64 (56-72)	0.08[1]
Height (cm) Mean ± SD [b]	169 ± 6	1.72 ± 8	169 ± 5	0.82[2]	156 ± 7	155 ±6	156 ± 6	0.53[2]
	n=81	*n=9*	*n=72*		*n=90*	*n=19*	*n=71*	
BMI (kg/m^2) Median (25^{th}-75^{th})[a]	26 (25-29)	26 (23-28)	26 (25-29)	0.70[1]	26 (23-29)	25 (22-29)	26 (23-30)	0.11[1]
BMI ≤ 18.5 kg/m^2	1 (1.2)	0 (0.0)	1(1.4)	0.44[4]	2 (2.3)	1 (5.3)	1 (1.4)	0.67[4]
BMI >18.6-24.9 kg/m^2	22 (27.2)	4 (44.5)	18 (25.0)		39 (43.3)	8 (42.1)	31 (43.7)	
BMI >25-29.9 kg/m^2	41 (50.6)	3 (33.3)	38 (52.8)		30 (33.3)	7 (36.8)	23 (32.4)	
BMI ≥30 kg/m^2	17 (21.0)	2 (22.2)	15 (20.8)		19 (21.1)	3 (15.8)	16 (22.5)	
Weight Change in the last 24 months (kg) Median (25^{th}-75^{th})[a]	-1 (-4- 1)	-2.5 (-4- 1)	-1 (-4 – 1)	0.44[1]	-2 (-5 – 1)	-3 (-7-0)	-2 (-5- 0)	0.17[1]
Increase **n, (%)**				0.53[4]				0.67[4]
0.1-5%	19 (29.2)	2 (22.2)	17 (30.4)		15 (17.8)	4 (23.5)	11 (16.9)	
>5%	2 (3.1)	0 (0.0)	2 (3.6)		9 (10.7)	0 (0.0)	9 (13.8)	
>10%	4 (6.2)	1 (11.1)	3 (5.3)		1 (1.3)	0 (0.0)	1 (1.5)	
Decrease **n, (%)**								
0.1-5%	17 (26.1)	1 (11.1)	16 (28.6)		25 (29.8)	5 (29.5)	18 (27.8)	
>5%	16 (24.6)	3 (33.4)	13 (23.2)		18 (21.4)	4 (23.5)	14 (21.5)	
>10%	7 (10.7)	2 (22.2)	5 (8.9)		16 (19.0)	4 (23.5)	12 (18.5)	

[a] Median (25^{th}- 75^{th}), [b] Mean ± SD

*significant finding p= <0.05, ** p= <0.01,*** p= <0.001

[1] Mann- Whitney U,[2] Independent t –Test ,[4] Chi-Square –Fishers Exact Test reported.

4.3.3 Physical and Health characteristics

The physical and health characteristics of non-Māori participants, by gender and fracture occurrence, are depicted in Table 4.3-4 and 4.3-5. Over 90% of men and women consumed prescription medications and where prescription medication use was slightly higher in men (+4.7%); more women used herbal/traditional medications the men (+4.1%). A significant difference was observed with the use of nutritional supplements between men and women (x2=6.528, p=0.011); women were 1.7 times more likely than men to take dietary supplements.

While proportionally more women than men had been previously diagnosed with osteoporosis (23.4% and 9.3%, respectively), similarly more women reported a family history of hip fractures in both parents. The occurrence of the previous fracture was high in both men and women, with over half sustaining an earlier fracture at some point in their life (58.5% and 51.0%, respectively). Very few participants currently smoked, over 95 % of men and 100 % of women being smoke-free now and in the past. There was a significant difference in alcohol consumption by men and women (x2=26.329, p=<0.001). While 47.5 % of men consumed alcohol frequently (4+ times weekly), this was comparatively less in women (14.7% drinking alcohol regularly). Women were 2.1 times more likely than men to never drink alcohol than drink frequently (+4 per week). Of those who consumed alcohol men were 2.2 times more likely than women to drink regularly (4+ per week) than at any other rate (<monthly, 2-4x monthly and 2-3 weekly).

Walking was the most popular form of activity with over 80% of participants walking off their property at least 1-2 times per week. Close to half of the participants walked at least 5-7 times weekly (57.0% men and 49.2% women), most commonly for less than an hour. A fifth of men (18.8%) and one in seven women (15.1%) participated in a weekly exercise to help increase muscle strength and endurance. A significant difference was observed for moderate physical activity, between men and women (x2=6.372, p=0.001). The frequency of moderate physical activity was greater in women as men were found to be 3.0 times more likely than women to exercise moderately, sometimes (1-2days weekly) rather than often (3-4 times weekly).

Smoking by non-Māori men was the only factor between fractured and non-fractured individuals to differ significantly, non-fractured Māori men were 1.2 times more likely to have never smoked compared to those men with fractures (x2=7.862, p=0.044). For non-Māori women, no Physical and health characteristics differed significantly. Previous fractures were the only other parameter of note to differ, with 22.3 % more fractured participants than non-fractured having experienced a previous fracture.

Table 4.3-4

Physical and health characteristics of non-Māori, by gender and fracture occurrence.

	Men				Women			
	Total Men	Fracture	Non-fracture	P-value	Total Women	Fracture	Non-fracture	P-value
Do you currently take:								
Prescribed Medication	85 (92.4)	12 (100)	73 (91.3)	0.29[4]	99 (97.1)	21 (95.4)	78 (97.5)	0.62[4]
Non Prescribed Medication	30 (32.6)	3 (25.0)	27 (33.8)	0.75[4]	32 (31.7)	4 (19.0)	28 (35.4)	0.19[4]
Nutritional Supplements	22 (24.2)	1 (8.3)	21 (26.6)	0.28[4]	42 (41.6)	8 (36.4)	34 (43.0)	0.63[4]
Herbal/ Traditional Medicines	8 (8.8)	0 (0.0)	8 (10.3)	0.59[4]	13 (12.9)	3 (13.6)	10 (12.7)	1.0[4]
Have you ever been told by a Doctor that you have osteoporosis	*n=86*	*n=15*	*n=71*	1.0[4]	*n=94*	*n=22*	*n=72*	0.39[4]
Yes	8 (9.3)	1 (6.7)	7 (9.9)		22 (23.4)	7 (31.8)	15 (20.8)	
No	78 (90.7)	14 (93.3)	64 (90.1)		72 (76.6)	15 (68.2)	57 (79.2)	
Have you had a previous fracture?	*n=82*	*n=15*	*n=67*	0.19[3]	*n=96*	*n=22*	*n=74*	0.06[3]
Yes	48 (58.5)	11 (73.3)	37 (55.2)		49 (51.0)	15 (68.2)	34 (45.9)	
No	34 (41.5)	4 (26.7)	30 (44.8)		47 (49.0)	7 (31.8)	40 (54.1)	
Family history of hip fracture:	*n=75*	*n=14*	*n=61*		*n=87*	*n=20*	*n=67*	
Mother, n (%)				0.76[4]				0.95[4]
Yes	6 (8.0)	0 (0.0)	6 (9.8)		13 (17.3)	3 (15.0)	10 (14.9)	
No	69 (92.0)	14 (100)	55(90.2)		74 (82.7)	17(85.0)	57 (85.1)	
Age (years) Median, (25^{th}-75^{th})	70 (70-83)	-	70 (70-83)	-	81 (67-85)	83 (81-90)	75 (65-85)	0.23[1]
Father, n (%)	*n=72*	*n=13*	*n=59*	0.34[4]	*n=88*	*n=22*	*n=64*	0.25[4]
Yes	1 (1.4)	1 (7.7)	0 (0.0)		4 (4.6)	2 (9.0)	2 (3.1)	
No	71 (98.6)	12 (92.3)	59 (100)		84 (95.4)	20 (91.0)	62 (96.9)	
Age (years) Median, (25^{th}-75^{th})	55 (55-55)	55 (55-55)	-	-	87 (70-99)	79 (70-87)	99 (99-99)	0.67[1]
Do you currently or have you ever smoked cigarettes?	*n=92*	*n=12*	*n=80*	0.04*[4]	*n=102*	*n=22*	*n=80*	0.32[4]
Never	89 (96.7)	10 (83.3)	79 (98.8)		102 (100)	22 (100)	80 (100)	
Current	3 (3.3)	2 (16.7)	1 (1.2)		0 (0.0)	0 (0.0)	0 (0.0)	
Past	0 (0.0)	0 (0.0)	0 (0.0)		0 (0.0)	0 (0.0)	0 (0.0)	
Alcohol intake	n=92	n=12	n=80	0.95[4]	n=102	n=22	n=80	0.28[4]
Never	19(20.6)	2 (16.7)	17 (21.3)		44 (43.1)	9 (40.9)	35 (43.8)	

Monthly or less	13 (14.1)	1 (8.3)	12 (15.0)	21 (20.6)	3 (13.6)	18 (22.5)
2-4x per month	6 (6.5)	1 (8.3)	5 (6.2)	12 (11.8)	1 (4.6)	11 (13.8)
2-3x per week	12 (13.0)	2 (16.7)	10 (12.5)	10 (9.8)	3 (13.6)	7 (8.8)
4 + per week	42 (45.7)	6 (50.0)	36 (45.0)	15 (14.7)	6 (27.3)	9 (11.1)

[a] Median (25^{th}- 75^{th}), [b] Mean ± SD (range)

*significant finding p= <0.05, ** p= <0.01,*** p= <0.001

[1] Mann- Whitney U,[2] Independent t –Test ,[4] Chi-Square –Fishers Exact Test reported.

Table 4.3-5

Exercise participation over the last 7 days in non-Māori, by gender and fracture occurrence.

Q: How often have you?	Men				Women			
	Total Men	Fracture	Non-fracture	P-value	Total Women	Fracture	Non-fracture	P-value
Walked outside your home or yard for any reason.	*n=86*	*n=15*	*n=71*	0.81[4]	n=95	*n=21*	*n=74*	0.14[4]
Never (0days)	15 (17.4)	2 (13.3)	13 (18.3)		17 (17.9)	3 (14.3)	14 (18.9)	
Seldom (1-2day)	9 (10.5)	2 (13.3)	7 (9.9)		17 (17.9)	3 (14.3)	14 (18.9)	
Sometimes (3-4days)	18 (20.9)	4 (26.7)	14 (19.7)		15 (15.8)	7 (33.3)	8 (10.8)	
Often (5-7days)	44 (51.2)	7 (46.7)	37 (52.1)		46 (48.4)	8 (38.1)	38 (51.4)	
Hours spent walking	*n=86*	*n=15*	*n=71*	0.15[4]	*n=95*	*n=21*	*n=74*	0.96[4]
No exercise	15 (17.4)	2 (13.3)	13 (18.3)		17 (17.9)	3 (14.3)	14 (18.9)	
<1 hour	49 (57.0)	11 (73.3)	38 (53.5)		47 (49.5)	11 (52.4)	36 (48.6)	
1-2 hours	14 (16.3)	0 (0.0)	14 (19.7)		25 (26.3)	6 (28.6)	19 (25.7)	
2- 4 hours	5 (5.8)	2 (13.3)	3 (4.2)		6 (6.3)	1 (4.8)	5 (6.8)	
>4 hours	3 (3.5)	0 (0.0)	3 (4.2)		0 (0.0)	0 (0.0)	0 (0.0)	
Engaged in light sport or recreational activities.	*n=85*	*n=14*	*n=71*	0.11[4]	*n=94*	*n=20*	*n=74*	0.38[4]
Never (0days)	38 (44.7)	10 (71.4)	28 (39.4)		48 (51.1)	11 (55.0)	37 (50.0)	
Seldom (1-2day)	19 (22.4)	3 (21.4)	16 (22.5)		18 (19.1)	6 (30.0)	12 (13.2)	
Sometimes (3-4days)	13 (15.3)	0 (0.0)	13 (18.3)		9 (9.6)	1 (5.0)	8 (10.8)	
Often (5-7days)	15 (17.6)	1 (7.1)	14 (19.7)		19 (20.2)	2 (10.0)	17 (23.0)	
Engaged in moderate sport or recreational activities.	*n=85*	*n=14*	*n=71*	0.67[4]	n=94	n=20	n=74	0.87[4]
Never (0days)	64 (75.3)	13 (92.9)	51 (71.8)		86 (91.5)	19 (95.0)	67 (90.5)	
Seldom (1-2day)	14 (16.5)	1 (7.1)	13 (18.3)		3 (3.2)	1 (5.0)	2 (2.7)	
Sometimes (3-4days)	3 (3.5)	0 (0.0)	3 (4.2)		2 (2.1)	0 (0.0)	2 (2.7)	
Often (5-7days)	4 (4.7)	0 (0.0)	4 (5.6)		3 (3.2)	0 (0.0)	3 (4.1)	
Engaged in strenuous sport or recreational activities.	*n=85*	*n=14*	*n=71*	1.0[4]	*n=94*	*n=20*	*n=74*	1.0[4]
Never (0days)	79 (92.9)	14 (100)	65 (91.5)		91 (96.8)	20 (100)	71 (95.9)	
Seldom (1-2day)	4 (4.7)	0 (0.0)	4 (5.6)		2 (2.1)	0 (0.0)	2 (2.7)	
Sometimes (3-4days)	2 (2.4)	0 (0.0)	2 (2.8)		1 (1.1)	0 (0.0)	1 (1.4)	
Often (5-7days)	0 (0.0)	0 (0.0)	0 (0.0)		0 (0.0)	0 (0.0)	0 (0.0)	

Exercise specifically to increase muscle strength and endurance.	n=85	n=14	n=71	1.0[4]	n=93	n=19	n=74	0.74[4]
Never (0days)	*69 (81.2)*	*12 (85.8)*	*57 (80.3)*		*79 (84.9)*	*17 (89.5)*	*62 (83.8)*	
Seldom (1-2day)	5 (5.9)	1 (7.1)	4 (5.6)		6 (6.5)	1 (5.3)	5 (6.8)	
Sometimes (3-4days)	2 (2.3)	0 (0.0)	2 (2.8)		3 (3.2)	1 (5.3)	2 (2.7)	
Often (5-7days)	9 (10.6)	1 (7.1)	8 (11.3)		5 (5.4)	0 (0.0)	5 (6.8)	

*significant finding p= <0.05, ** p= <0.01,*** p= <0.001

[1] Mann- Whitney U,[2] Independent t –Test ,[4] Chi-Square –Fishers Exact Test reported.

4.3.4 Nutrient Intakes from 24 hour MPR

Respective mean and median intakes of energy, protein and micronutrients calcium, vitamin D, phosphorous, magnesium and potassium by Māori and non-Māori, men and women are displayed in Table 4.3-6, with a comparison to the particular nutrient reference Estimated Average Requirement (EAR) or Adequate Intake (AI) values.

Men achieved significantly higher energy intake, consuming 31.8% more energy per day than women (U=1949, P=0.0001, r=0.45). Adequate protein intake was obtained by both genders with a significant difference in mean protein (g/day) intake with men consuming an average 31.0% (17.9g) more protein g/day than women (t=6.175, 180 df, P=<0.001, r =0.42). Both genders achieved similar protein intakes when corrected for weight (g/kg) and energy intake (% of energy) with 3.0% and 1.3% greater consumption by men respectively. The distribution of protein (% energy) into the three AMDR categories differed significantly between genders (x2=19.252, p=<0.001), both men (43.5%) and women (41.7%) had a high proportion of individuals with protein intake below the AMDR range (<15% energy), yet men were 1.1 times more likely than women to consume less than <15% energy from protein.

Median calcium intake by both Māori men (748mg/d) and women (672mg/d) fell below EAR values, with 86.0% of men and 90.6% women not meeting daily calcium requirements. The average nutrient density of calcium for women was 26.5mg/1000kcal (6.4%) greater than that for men (t=2.891, 180 df, P=<0.004, r =0.22). Median vitamin D intake by both non-Māori men and women fell below EAR with 96.5% of men and 98.9% of women not meeting daily dietary vitamin D requirements. Median intake of vitamin D (µg/d) in men and women was similar (4µg/d and 3µg/d, respectively) yet differed significantly overall (U= 2896, P=0.001, r=0.25) with no significant difference in nutrient density between genders. Median magnesium intake in men (271mg/day) and women (238mg/day) fell below EAR values with 84.9% of men and 65.3% of women failing to meet daily magnesium requirements, median intake was significantly greater for men who consumed 33.0 mg/d (12.2%) more than women (U= 3084, P=0.003, r=0.22) and nutrient density was significantly greater in women, who achieved 25.9mg/1000kcal (17.8%) more magnesium than men (t=-3.133, 180 df, P=0.002, r =0.24). Mean potassium intake by both genders fell below EAR values, with 84.9% of men and 65.6% of women not meeting daily requirements. Potassium intake was significantly greater for men who consumed 552.0mg/d (20.4%) more potassium than women (t=4.668, 180 df, P=<0.001, r =0.33) and women achieved greater nutrient density consuming 52.7mg/1000kcal more potassium daily than men (t=-2.778, 180 df, P=0.006, r =0.21).

Mean phosphorus intake was adequate for both non-Māori man and women, 6% of women failed to meet daily phosphorous intake however 100% of men were reaching the EAR. Phosphorous intake was significantly greater in men who consumed 228.7mg/day (21.9%) more than women (t=4.659, 180 df, P=<0.001, r =0.32) and nutrient density in women who achieved 46mg/1000kcal (7.0%) more phosphorous per day then men.

Energy (kJ/Kcal) and protein (g, g/kg and %kJ) did not differ significantly between fractured and non-fractured individuals in either gender. No significant difference was observed in the distribution of protein as % of energy for fractured vs. non-fractured individuals yet higher relative numbers of people from the non-fractured groups in both men (8.5%) and women (2.1%) were consuming below 15% energy from protein.

The following nutrient intakes by fractured and non-fractured men fell below estimated average requirements by -34.9% and -30.4 % respectively for median calcium (mg/day), -73.3% for vitamin D (µg/day) and -23.7% and -21.4% respectively for magnesium (mg/day). Similarly these nutrients with the addition of potassium were below EAR's in fractured and non-fractured non-Māori women by -43.5% and -37.3 % respectively for calcium (mg/day), -80% for vitamin D (µg/d), -11.3% and -10.1% respectively for magnesium (mg/d) and -12.5% and -7.5% respectively for potassium (mg/d)

There was no significant difference between those who had fractured and those who hadn't in any nutrient marker for men and women. However, both nutrient intakes and nutrient densities except protein (g, g/kg and %kJ) in men were consistently less in those who had fractures compare to those non-fractured. The same was observed in non-Māori women with the exception of protein (g/kg), vitamin D (µg/1000kcal), phosphorous (mg/1000kcal) and magnesium (mg/day).

Table 4.3-6

Nutrient intake and micro-nutrient density, of non-Māori, by gender and fracture occurrence.

	Men				Women			
	Total Men, *n=86*	Fracture, *n=12*	Non-fracture, *n=74*	*P*-value	Total Women, *n=96*	Fracture, *n=20*	Non-fracture, *n=76*	*P*-value
Energy (kJ) [a]	8,203 (5,056-7,457)	8,179 (7,205-10,034)	8,203 (6,746-9,457)	0.49[1]	6,225(5,056-7,457)	6,023 (5,041-7,457)	6,398 (5,673-7,469)	0.47[1]
Energy (kcal)[a]	1,960 (1,620-2,280)	1,955 (1,722-2,398)	1,960 (1,612-2,260)	-	1,488(1,208-1,782)	1,439(1,205-1,782)	1,529 (1,208-1,785)	-
Protein (g) [b]	76 ± 20	80 ± 14	75 ± 21	0.43[2]	58 ± 19	56 ± 18	59 ±19	0.59[2]
Protein (g/kg) [a]	0.95 (0.86-1.14)	0.98 (0.88-1.18)	0.95 (0.85-1.13)	0.81[1]	0.92 (0.68-1.1)	0.93 (0.8-1.09)	0.90 (0.67-1.12)	0.32[1]
Protein (% kJ) [a]	15.7 (14.2-18.1)	15.7 (14.6-16.8)	15.6 (12.7-18.1)	0.59[1]	15.5 (13.4-12.8)	15.5 (14.1-17.6)	15.5 (13.4-17.8)	0.70[1]
<14.9, n (%)	**37 (43.5)**	**4 (36.4)**	**33 (44.6)**	0.52[4]	**40 (41.7)**	**8 (40.0)**	**32 (42.1)**	0.63[4]
15-24.99, n (%)	46 (54.1)	7 (63.6)	39 (52.7)		55 (57.3)	12 (60.0)	43 (56.6)	
>25, n (%)	2 (2.4)	0 (0..0)	2 (2.7)		1 (1.0)	0 (0.0)	1 (1.3)	
Calcium (mg/day) [a]	**748 (596-924)**	**716 (548-889)**	**766 (602-938)**	0.37[1]	**672 (526-824)**	**621 (490-741)**	**689 (553-882)**	0.16[1]
<EAR, n (%)[t]	**74 (86.0)**	**12 (100)**	**62 (83.8)**		**87 (90.6)**	**19 (95.0)**	**68 (89.5)**	
Calcium (mg/1000 kcal)[b]	417 ± 176	361± 131	426 ± 182	0.24[2]	494 ± 182	473 ± 142	499 ± 191	0.57[2]
Vitamin D (µg/day) [a]	**4 (3-6)**	**4 (3-7)**	**4 (3-6)**	0.71[1]	**3 (2-5)**	**3 (2-4)**	**3 (2-6)**	0.13[1]
<EAR, n (%)[t]	**83 (96.5)**	**11 (91.7)**	**72 (97.3)**		**94 (98.9)**	**19 (95.0)**	**76 (100)**	
Vitamin D (µg/1000 kcal)[b]	3 ± 2	3 ± 2	3 ± 2	0.91[2]	3 ± 2	4 ± 4	3 ± 2	0.51[2]
Phosphorous (mg/day) [b]	1,273 ± 332	1,252 ± 153	1,276 ± 353	0.70[2]	1,044 ± 329	1,030 ± 289	1,048 ±341	0.83[2]
<EAR, n (%)[t]	0 (0.0)	0 (0.0)	0 (0.0)		**6 (6.3)**	**1 (5.0)**	**5 (6.6)**	
Phosphorous (mg/1000kcal)[b]	657 ± 164	636 ± 156	660 ± 166	0.63[2]	703 ± 153	724 ± 142	698 ± 156	0.50[2]
Magnesium (mg/day) [a]	**271 (230-328)**	**267 (255-309)**	**275 (228-332)**	1.00[1]	**238 (182-309)**	**234 (187-304)**	**238 (182-311)**	0.70[1]
<EAR, n (%)[t]	**73 (84.9)**	**12 (100)**	**61 (82.4)**		**62 (65.3)**	**13 (65.0)**	**49 (65.3)**	
Magnesium (mg/1000 kcal)[b]	146 ± 34	137 ± 28	147 ± 35	0.34[2]	172 ± 69	169 ± 40	172 ± 75	0.85[2]
Potassium (mg/day) [b]	**3,075 ± 748**	**3,056 ± 639**	**3,078 ± 768**	0.93[2]	**2,552 ± 760**	**2,450 ± 640**	**2,590±788**	0.34[2]
<EAR, n (%)[t]	**73 (84.9)**	**10 (83.3)**	**63 (85.1)**		**63 (65.6)**	**16 (80.0)**	**47 (61.8)**	
Potassium (mg/1000 kcal)[b]	1580 ± 340	1514 ± 261	1591 ± 35	0.47[2]	1727 ± 371	1672 ± 211	1742 ± 402	0.30[2]

[a] Median (25th- 75th), [b] Mean ± SD, *significant finding *p*= <0.05, ** *p*= <0.01,*** *p*= <0.001, [1] Mann- Whitney U,[2] Independent t –Test ,[4] Chi-Square –Fishers Exact Test reported. **Mean or Median, nutrient reference values below respected (EAR or AI),**

[t] Respective nutrient estimated average requirements (EAR); Calcium: 1100mg/day, Vitamin D 15 µg/day, Phosphorous: 580mg/day, Magnesium: 350mg/day (men) 265mg/day (women) and Potassium: 3800mg/day (men) and 2800mg/day (women).

4.3.4.1 Logistic Regression Analysis

Univariate analysis identified none of the bone related nutrients to be correlated with fracture in non-Māori. Multiple logistic regression models were constructed to examine the independent association between the bone related nutrients and fracture occurrence, controlling for age, gender, NZ deprivation index, BMI, light physical activity and previous facture. Adjusted and unadjusted model findings are found below in table 4.3-7. There was no association between fractures and intakes of energy (kJ and kcal), protein (g/day, g/kg and %kJ), calcium (mg/day and mg/1000kcal), vitamin D (µg/day and µg/1000kcal), phosphorous (mg/day and mg/1000kcal), magnesium (mg/day and mg/1000kcal) and potassium (mg/day and mg/1000kcal) in non- Māori.

Table 4.3-7

Logistic regression analysis comparing nutrient intakes against fracture occurrence in non-Māori.

Independent Variables	Unadjusted OR (95% CI), *p*- Value	Adjusted OR (95% CI), *p*- Value
Energy (kJ) and (kcal)[2]	1.000 (1.000-1.000) *p*=0.497	1.000 (1.000-1.000) *p*=0.940
Protein (g) [1]	0.996 (0.978-1.014) *p*=0.683	1.009 (0.997-1.0.42) *p*=0.571
Protein (g/kg) [1]	1.096 (0.288-4.169) *p*=0.893	1.860 (0.236-14.680) *p*=0.556
Protein (% kJ) [1]	1.103 (0.177-6.877) *p*=0.916	1.134 (0.121-10.672) *p*=0.912
Calcium (mg/day)[1]	0.999 (0.997-1.000) *p*=0.112	0.999 (0.997-1.001) *p*=0.398
Calcium (mg/1000 kcal)[2]	0.999 (0.997-1.001) *p*=0.366	0.999 (0.996-1.002) *p*=0.499
Vitamin D (µg/day)[1]	1.000 (0.998-1.001) *p*=0.487	1.006 (0.883-1.145) *p*=0.934
Vitamin D (µg/1000 kcal)[2]	1.042 (0.877-1.240) *p*=0.638	1.032 (0.857-1.241) *p*=0.742
Phosphorous (mg/day) [1]	1.000 (0.998-1.001) *p*=0.487	1.000 (0.998-1.002) *p*=0.882
Phosphorous (mg/1000 kcal)[2]	1.000 (0.998-1.003) *p*=0.713	1.001 (0.998-1.003) *p*=0.694
Magnesium (mg/day) [1]	0.998 (0.993-1.003) *p*=0.385	0.998 (0.993-1.004) *p*=0.564
Magnesium (mg/1000 kcal)[2]	0.999 (0.992-1.006) *p*=0.794	0.998 (0.998-1.005) *p*=0.615
Potassium (mg/day) [1]	1.000 (0.999-1.000) *p*=0.242	1.000 (0.999-1.001) *p*=0.713
Potassium (mg/1000 kcal)[2]	1.000 (0.998-1.001) *p*=0.437	1.000 (0.998-1.001) *p*=0.737

[1] Adjusted for age, gender, NZ Deprivation Index, BMI, energy, previous fracture and light physical activity.

[2] Adjusted only for age, gender, NZ Deprivation Index, BMI, previous fracture and light physical activity.

4.3.4.2 Macronutrients

4.3.4.2.1 Energy

Percentage contribution of foods to total energy for non-Māori, men and women is depicted in Table 4-8. Full tables of the thirty two food groups contributing to energy are located in Appendix D, Table 4 a.

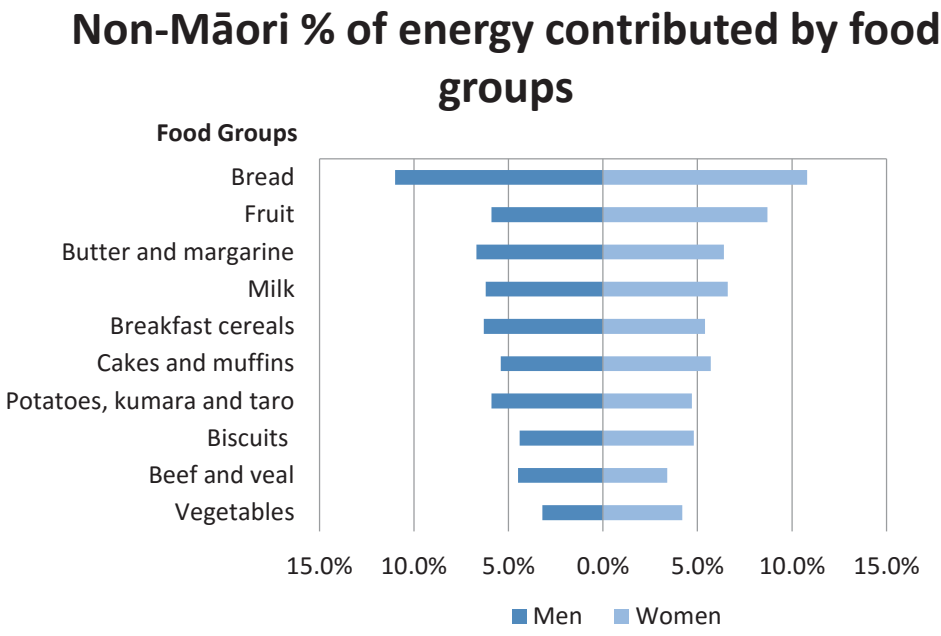

Figure 4-8 **Percent of energy from top ten food groups, by gender.**

The *Bread* group was the principle source of energy for non-Māori men, contributing 11.0%, followed by *Butter & margarine* (6.7%), *Breakfast cereals* (6.3%), *Milk* (6.2%), *Potato, kumara & taro and Fruit (*5.9%), *Cake & muffins* (5.4%), and *Alcoholic beverages* (5.1%). The *Bread* group was the principle source of energy for non-Māori women, contributing 10.8%, followed by *Fruit (*8.7%), *Milk*(6.6%), *Butter & margarine* (6.4%), *Cakes & muffins* (5.7%), *Breakfast cereals* (5.4%), *Biscuits* (4.8%) and *Potato, kumara & taro* (4.7%).

Of the top contributors to energy, both men and women consumed similar energy from *Bread, Butter & margarine, Cakes & muffins and Milk* (<0.5% difference). Men consumed comparatively more energy from *Breakfast cereals (+*0.9%), with women consuming proportionately more energy from *Fruit* (+2.8%). While *Alcoholic beverages* made the leading contributors to energy in men, this was displaced by *Biscuits* in women.

Protein

Percentage contribution of foods to total protein for non-Māori, men and women is depicted in Table 4-9. Full tables of the thirty two food groups contributing to protein are located in Appendix D, Table 4 b.

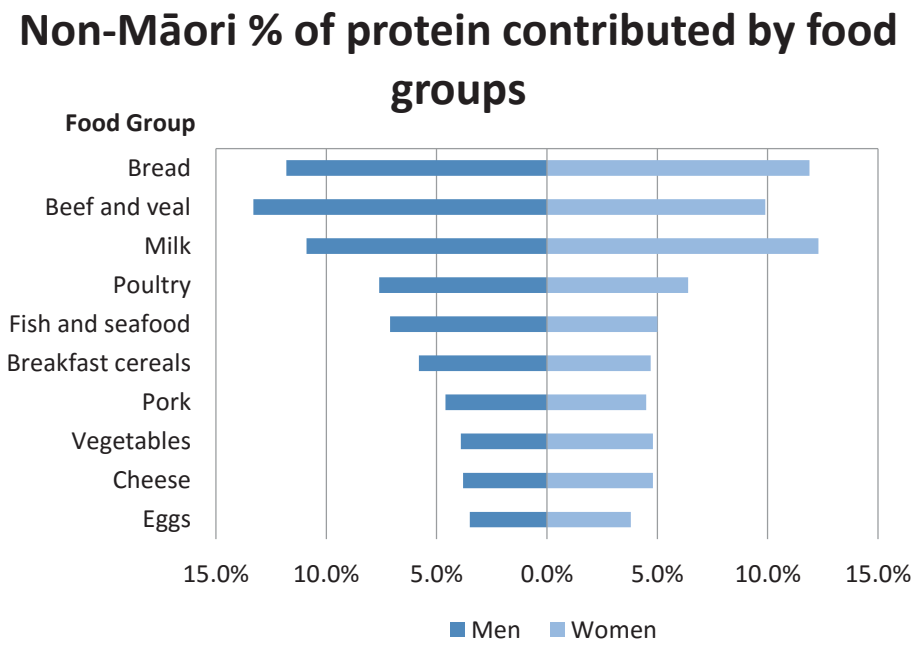

Figure 4-9 **Percent of protein from top ten food groups, by gender.**

The *Beef & veal* group was the principle source of protein for non-Māori men, contributing 13.3%, followed by *Bread* (11.8%), *Milk* (10.9%), *Poultry* (7.6%), *Fish & seafood (*7.1%), *Breakfast cereals* (5.8%), *Pork* (4.7%), *Vegetables* (3.9%), and *Cheese* (3.8%). The *Milk* group was the principle source of protein for non-Māori women, contributing 12.3%, followed by *Bread (*11.9%), *Beef & veal* (9.9%), *Poultry* (6.4%), *Fish & seafood* (5.0%), *Vegetables* (4.8%), *Cheese* (4.8%), *Breakfast cereals* (4.7%) and *Pork* (4.5%).

Of the top contributors to protein, both men and women consumed similar protein from *Bread, Breakfast cereals and Pork* (<0.5% difference). Men consumed comparatively more protein from *Meat (+*3.4%), *Fish & seafood* (+2.1%) and *Poultry* (+1.2%), with women consuming proportionately more protein from *Milk (+*1.4%), *Cheese* (+1.0%) and *Vegetables* (+0.9%).

4.3.4.3 Micronutrients

4.3.4.3.1 Calcium

Percentage contribution of foods to total calcium for non-Māori, men and women is depicted in Table 4-10. Full tables of the thirty two food groups contributing to calcium are located in Appendix D, Table 4 c

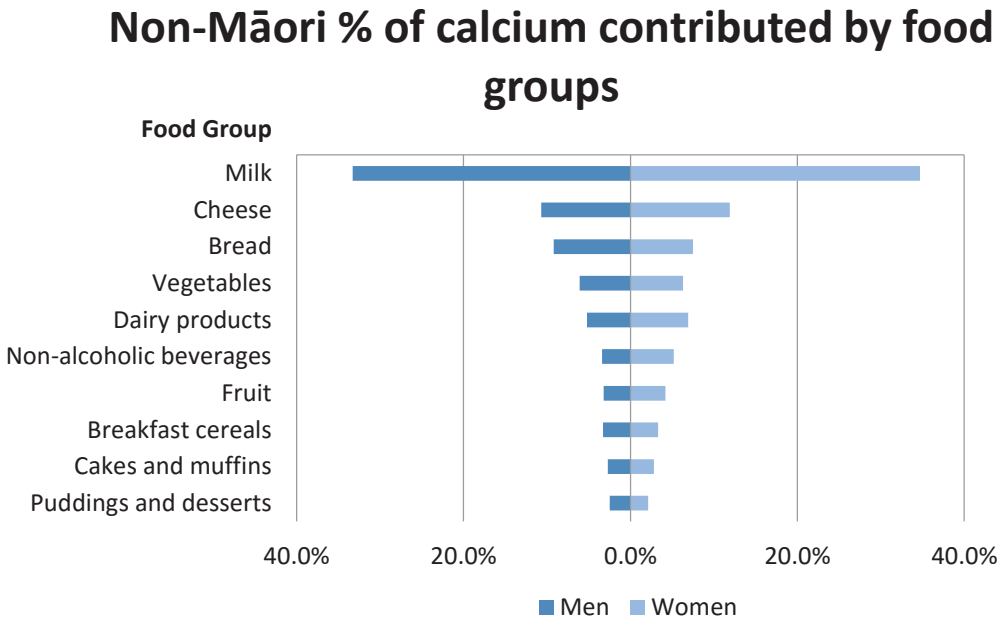

Figure 4-10 **Percent of calcium from top ten food groups, by gender.**

The *Milk* group was the principle source of calcium for non-Māori men, contributing 34.7%, followed by *Cheese* (10.7%), *Bread* (9.2%), *Vegetables* (6.1%), *Dairy products (*5.2%), *Non-alcoholic beverages* (3.4%), *Breakfast cereals* (3.3%) and *Fruit* (3.2%). The *Milk* group was the principle source of calcium for non-Māori women, contributing 33.3%, followed by *Cheese (*11.9%), *Bread* (7.5%), *Dairy products (*6.9%), *Vegetables* (6.3%), *Non-alcoholic beverages* (5.2%), *Fruit* (4.2%) and *Breakfast cereals* (3.3%).

Of the top contributors to calcium, both men and women consumed similar calcium from *Vegetables Breakfast cereals* (<0.5% difference). Men consumed comparatively more calcium from *Bread (+*1.7%) and *Milk* (+1.4%), with women consuming proportionately more calcium from *Non-alcoholic beverages* (+1.8%), *Dairy* (+1.7%), *Cheese* (+1.2%) and *Fruit* (+1.0%).

Vitamin D

Percentage contribution of foods to total vitamin D for non-Māori, men and women is depicted in Table 4-11. Full tables of the thirty two food groups contributing to vitamin D are located in Appendix D, Table 4 d.

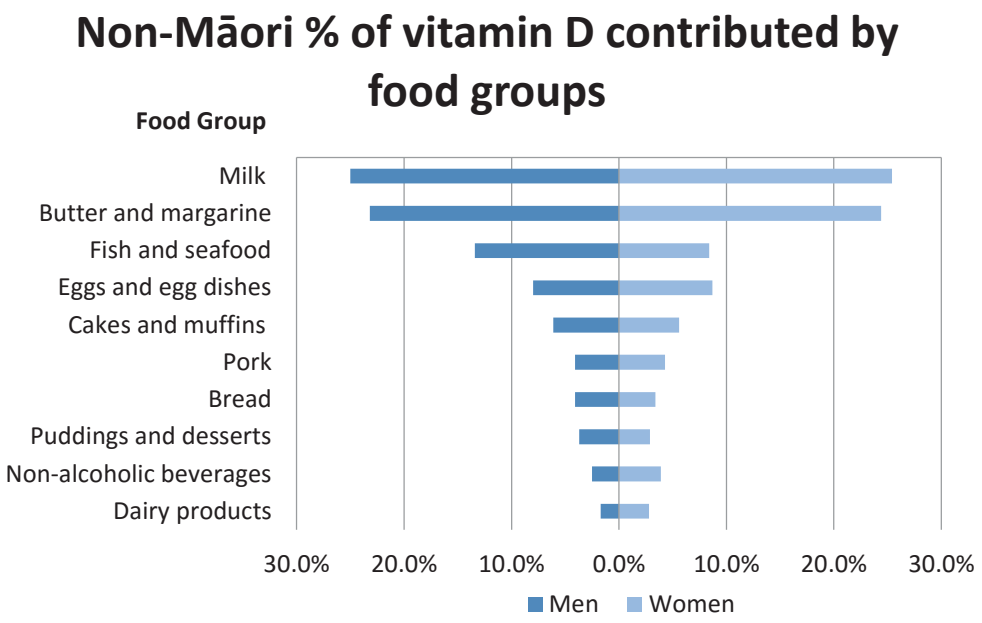

Figure 4-11 **Percent of vitamin D from top ten food groups, by gender**.

The *Milk* group was the principle source of vitamin D for non-Māori men, contributing 25.0%, followed by *Butter and margarine* (23.2%), *Fish and seafood* (13.4%), *Eggs and egg dishes* (8.0%), *Cakes and muffins (*6.1%), *Bread* (4.1%), *Pork* (4.1%) and *Pudding and desserts* (3.7%). The *Milk* group was the principle source of vitamin D for non-Māori women, contributing 25.4%, followed by *Butter and margarine (*24.4%), *Egg & egg dishes* (8.7%), *Fish & seafood (*8.4%), *Cakes & muffins* (5.6%), *Pork* (4.3%), *Non-alcoholic beverages* (3.9%) and *Bread* (3.4%).

Of the top contributors to vitamin D, both men and women consumed similar vitamin D from *Pork and Milk* (<0.5% difference). Men consumed comparatively more vitamin D from *Fish & seafood (+*5.0%), *Bread* (+0.7%), and *Cakes & muffins* (+0.5%), with women consuming proportionately more vitamin D from *Butter* (+1.2%) and *Eggs & egg dishes* (+0.7%). While *Puddings & desserts* made the leading contributors to vitamin D in men, this was displaced by *Non-alcoholic beverages* in women.

4.3.4.3.2 Phosphorous

Percentage contribution of foods to total phosphorous for non-Māori, men and women is depicted in Table 4-12. Full tables of the thirty two food groups contributing to phosphorous are located in Appendix D, Table 4 e

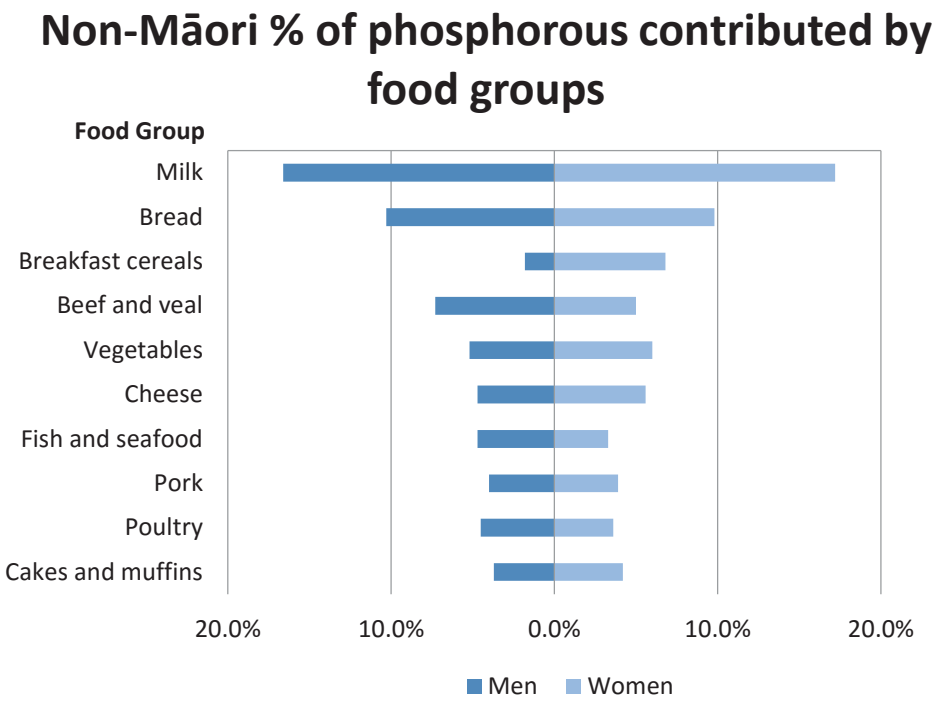

Figure 4-12 **Percent of phosphorous from top ten food groups, by gender.**

The *Milk* group was the principle source of phosphorous for non-Māori men, contributing 16.6%, followed by *Bread* (10.3%), *Breakfast cereals* (7.8%), *Beef & veal* (7.3%), *Vegetables (*5.2%), *Fish & seafood* (4.7%), *Cheese* (4.7%) and *Poultry* (4.5%). The *Milk* group was the principle source of phosphorous for non-Māori women, contributing 17.7%, followed by *Bread (*9.8%), *Breakfast cereals* (6.8%), *Vegetables (*6.0%), *Cheese* (5.6%), *Beef & veal* (5.0%), *Cakes &muffins* (4.2%), and *Fruit* (4.0%).

Men consumed comparatively more phosphorous from *Beef & veal (+*2.3%), *Breakfast cereals* (+1.0%), and *Bread* (+0.5%), with women consuming proportionately more phosphorous from *Milk* (+1.1%), *Cheese* (+0.9%) and *Vegetables* (+0.8%). While *Fish and poultry* made the leading contributors to phosphorous in men, this was displaced by *Fruit and Cake & puddings* in women.

4.3.4.3.3 Magnesium

Percentage contribution of foods to total magnesium for non-Māori, men and women is depicted in Table 4-13. Full tables of the thirty two food groups contributing to magnesium are located in Appendix D, Table 4f.

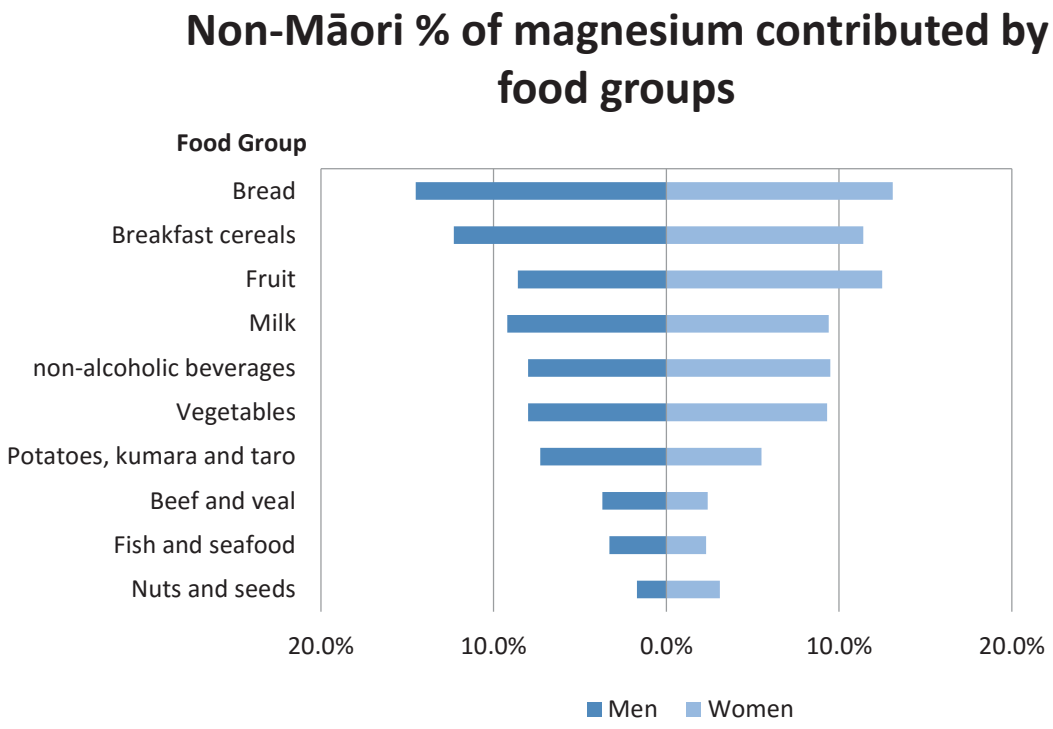

Figure 4-13 **Percent of magnesium from top ten food groups, by gender.**

The *Bread* group was the principle source of magnesium for non-Māori men, contributing 14.5%, followed by *Breakfast cereals* (12.3%), *Milk* (9.2%), *Fruit* (8.6%), *Non-alcoholic beverages (*8.3%), *Vegetables* (7.6%), *Fruit* (6.7%) and *Fish & seafood* (6.4%). The *Bread* group was the principle source of magnesium for non-Māori women, contributing 16.1%, followed by *Fruit (*10.5%), *Breakfast cereals* (10.1%), *Milk (*9.3%), *Vegetables* (9.0%), *Non-alcoholic beverages* (8.5%), *Potato, kumara & taro* (7.3%) and *Fish & seafood* (4.6%).

Of the top contributors to magnesium, both men and women consumed similar magnesium from *Milk* (<0.5% difference). Men consumed comparatively more magnesium from *Potato, kumara & taro (+*1.8%), *Bread* (+1.5%), *Beef & veal* (+1.3%) and *Breakfast cereal* (+1.1%), with women consuming proportionately more magnesium from *Fruit* (+3.9%), *Non-alcoholic beverages* (+1.5%) and *Vegetables* (+1.3%).

4.3.4.3.4 Potassium

Percentage contribution of foods to total potassium for non-Māori, men and women is depicted in Table 4-14. Full tables of the thirty two food groups contributing to potassium are located in Appendix D, Table 4 g

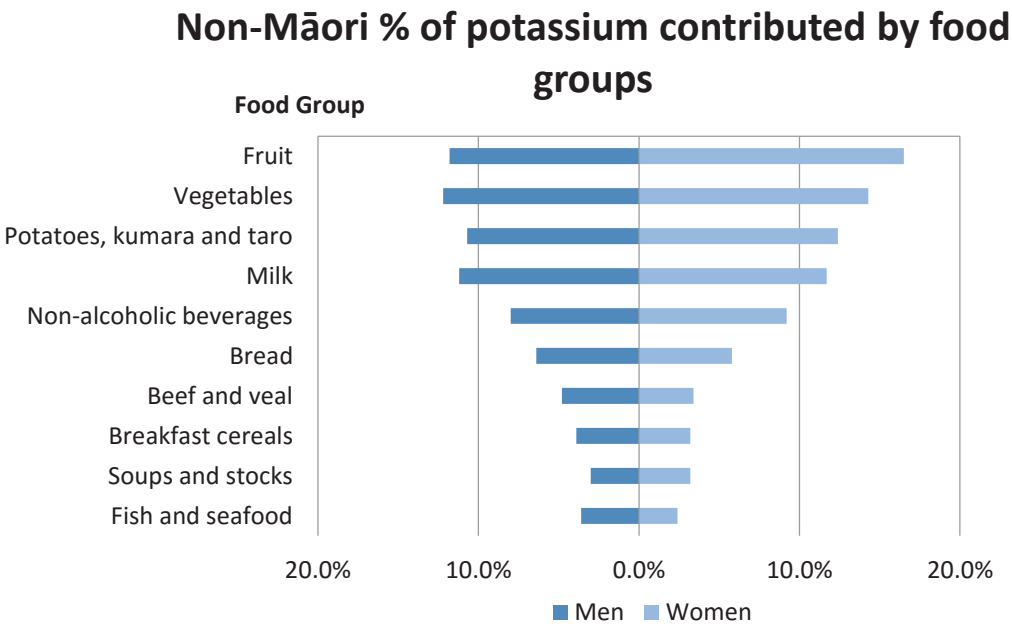

Figure 4-14 **Percent of potassium from top ten food groups, by gender**.

The *Potato, kumara & taro group* was the principle source of potassium for non-Māori men, contributing 14.2%, followed by *Vegetables* (12.2%), *Fruit* (11.8%), *Milk* (11.2%), *Non-alcoholic beverages (*8.0%), *Bread* (6.4%), *Beef & veal* (4.8%), *Breakfast cereals* (3.9%) and *Fish & seafood* (3.6%). The *Fruit* group was the principle source of potassium for non-Māori women, contributing 16.5%, followed by *Vegetables (*14.3%), *Milk* (11.7%), *Potato, kumara & taro (*10.7%), *Non-alcoholic beverages* (9.2%), *Bread* (5.8%), *Beef & veal* (3.4%), *Breakfast cereals* (3.2%) and *Soups & Stocks* (3.2%).

Men consumed comparatively more potassium from *Potato, kumara and taro (*+3.5%), *Beef & veal* (+1.4%), and *Breakfast cereals* (+0.7%), with women consuming proportionately more potassium from *Fruit* (+4.7%), *Vegetables* (+2.1%), *Non-alcoholic beverages* (+1.2%) and *Milk* (+0.5%). While *Fish & seafood* made the leading contributors to potassium in men, this was displaced by *Soup & stocks in* women.

5 Discussion

The purpose of this study was to investigate the nutrient and food group intakes of Māori and non-Māori individuals of advanced age (80-90years) and to assess the relative risk of fracture in relation to consumption of energy, protein, calcium, vitamin D, phosphorous, magnesium and potassium.

Among the participants in this study Māori men most commonly lived alone (63.6% of men and 47.6% women) compared to non-Māori (53.7% men and 48.1% women). The reason for this is unknown as living alone is more common in women of advanced age (Ministry of Health, 2002a). This may relate to decreased family closeness, greater geographical displacement or availability of more services in the community to support independent living (Ministry of Health, 2002a). This finding in Māori is an anomaly, as living with whānau or having close contact with family and social networks is an integral part of Māori culture and the maintenance of good health (Dulin et al., 2011; Gergen & Gergen, 2006; Kalafatelis et al., 2006).

Overall most (80%) of Māori and non-Māori, men and women in this study walked for less than an hour a day, 5 -7 times a week. Māori women were more likely than men to participate in strenuous activity (P=0.023), and non-Māori women were more consistent with exercise than non-Māori men (P=0.001). Participation in specific exercises to increase muscle strength and endurance was low (with participation rates for non-Māori men 18.8%; women 15.5%; and Māori 10.9% men; women 10.8%). Physical activity in older age is recommended to improve muscle strength (Deutz et al., 2014) and reduce the risk to falls and fractures (Karlsson et al., 2008). The findings suggest octogenarians in this study may benefit from more frequent participation in these activities to increase muscle strength and to protect them from fracture risk.

5.1 Food and Nutrient intake

The median energy intakes of participants in this study were lower than those previously observed in adults aged over 70 years in the 2008/09 NZANS. Māori had median energy intakes of 6,943kJ and, 5,603kJ in men and women respectively; non-Māori, 8,203kJ and 6,225kJ respectively, versus participants over 70 years in the NZANS (8,067kJ in men and 6,116kJ in women) (Ministry of Health, 2012b). Energy intake has previously been observed to decline with advancing age and so this finding was not unexpected (Chapman et al., 2002; Malafarina et al., 2013; Visvanathan, 2015).

A lower energy intake was observed in Māori women compared to the other subgroups and the reasons for this are unknown. Income and food security can impact food and energy intake and NZ Māori

experience comparatively greater hardship in these areas compared to non-Māori which may be a contributing factor (Cunningham et al., 2002; Stephens, Alpass, Towers, Noone, & Stevenson, 2011).

While the primary food source of energy was bread for all the participants, other main contributors differed by subgroup. The top three food sources contributing to energy were for Māori men: bread (10.5%), butter & margarine (6.7%) and potato, kumara and taro (6.6%); for Māori women: bread (12.5%), butter & margarine (7.2%) and fruit (7.3%). Conversely, for non-Māori men top energy contributors were: bread (11.0%), butter & margarine (6.7%) and breakfast cereals (6.3%); for non-Māori women: bread (10.8%), fruit (8.3%) and milk (6.6%). These findings are comparable to those in the 2008/09 NZANS for adults over 70 years where bread was the main contributor of energy i.e. for men >70 years: bread (13.0%), fruit (7.0%) and potato, kumara and taro (6.3%); and for women >70 years: bread (14.1%), fruit (8.8%) and milk (6.2%) (Ministry of Health & Otago University, 2012). Where butter and margarine didn't factor at all in the top 22 food groups provided in the 2008/09 NZANS it contributed the second greatest amount of energy for Māori and non-Māori men and Māori women. The main food contributors of energy for non-Māori women resembled women in the 2008/09 NZANS.

Mean protein intake of the participants was slightly lower than those observed in the 2008/09 NZANS. In this study, Māori men and women had mean protein intakes of 74g and 56g per day respectively; non-Māori men and women, were 76g and 58g per day respectively, versus participants over 70 years in the NZANS (79g for men and 62g for women) (Ministry of Health, 2012a). When adjusted for energy, median protein intake was below the acceptable macronutrient distribution range (AMDR) for participants in each subgroup; for Māori, 27.5% men and 40.0% women; and non-Māori 37.0% men and 40.0% women, achieving less than 15% of energy from protein. When energy intake is low, and protein contributes less than 15% of energy, individual ability to stimulate muscle synthesis and maintain lean muscle mass may be hindered (Bauer et al., 2013; Bonjour, 2011; B. T. Wall & L. J. van Loon, 2013).

Per kg body weight median protein intake was for Māori (0.95g/kg and 0.92g/kg for men and women respectively) and for non-Māori (0.94g/kg and 0.80g/kg for men and women respectively). These intakes are lower than the new protein recommendations of 1- 1.2g/kg (Deutz et al., 2014; Gaffney-Stomberg et al., 2009) which may be necessary for optimal health of older adults.

Predominant food sources of protein differed for the participants in each subgroup. The top three food source contributors of protein were for Māori men: beef & veal (10.7%), fish and seafood (10.6%) and bread (10.4%); for Māori women: bread (12.9%), milk (10.8%) and beef & veal (9.0%). Conversely, top

protein food sources for non-Māori men were: milk (34.7%), cheese (10.7%) and bread (9.2%); similar for non-Māori women: milk (33.3%), cheese (11.9%) and bread (7.5%).

Octogenarians may benefit from a diet rich in protein foods particularly leucine containing (i.e. meat, poultry or fish, milk, yoghurt, eggs and cheese) for promotion of muscle protein synthesis and reduction of sarcopenia (Deutz et al., 2014; Deutz & Wolfe, 2013; Paddon-Jones et al., 2015; Paddon-Jones & Rasmussen, 2009).

Findings showed calcium intakes in this study were suboptimal with intakes below the EAR of 1100mg per day (NHMRC, 2006), in all subgroups. The median calcium intake for Māori men was 559mg/day (90.0% of participant below EAR) and 539mg/day by women (88.9% of participants below EAR); for non-Māori; 748mg/day for men (86.0% of participants below EAR) and 672mg/day by women (98.9% of participants below EAR). Intakes for older adults in the 2008/09 NZANS and other studies have similarly found suboptimal calcium intakes, commonly between 400-800mg per day (Nguyen, Center, & Eisman, 2010a; Nowson, Sherwin, McPhee, Wark, & Flicker, 2003a). Calcium is an essential mineral for cardiac and nerve function along with bone integrity (Bolland et al., 2008; Gaffney-Stomberg et al., 2009; Khan et al., 2015; Miggiano & Gagliardi, 2005a; Slinin, Blackwell, Ishani, Cummings, & Ensrud, 2011; Tai, Bolland, Reid, Leung, et al., 2015; Tang et al., 2007), thus prolonged suboptimal intake of calcium in adults in advanced age may compromise bone health..

The top three food source contributors to calcium were for Māori men: milk (33.9%), bread (9.4%) and vegetables (7.0%); for Māori women: milk (33.6%), bread (10.2%) and cheese (9.0%). Similarly, top calcium food sources for non-Māori men were: milk (34.7%), cheese (10.7%) and bread (9.2%); and for non-Māori women: milk (33.3%), cheese (11.9%) and bread (7.5%). Hence calcium food sources were similar for all subgroups apart from Māori men, where vegetables displaced cheese. This may explain the lower intake of calcium in Māori compared to non-Māori men. However while it may be beneficial for octogenarians to increase intake of calcium rich food to match current EAR values, recent evidence suggests this is not likely to result in sustained BMD increases (Tai, Bolland, Reid, Grey, et al., 2015). A recent meta-analysis and systematic review of calcium intake and BMD of adults >50 years from 59 studies found that while an increased calcium intake may slightly increase BMD, this effect is often not converted into decreased fracture risk (Tai, Bolland, Reid, Leung, et al., 2015).

In this study, suboptimal dietary vitamin D intakes below the EAR of 15 µg per day (NHMRC, 2006) were seen in all subgroups. Median vitamin D intake for Māori men and women were three µg /day (97.5% and

93.3% of men and women falling below EAR); for non-Māori intakes were four µg /day in men (96.5% of men below EAR) and were three µg/day in women (98.9% of women below EAR). This is not unexpected as sources of vitamin D in common foods is low and sunlight or supplementation commonly provides the predominant source of vitamin D (Bertone-Johnson et al., 2011; Grant et al., 2005; Heaney, 2005; Heaney & Holick, 2011; Palacios, 2006b).

Studies which investigate bone mineral density in older people usually measure sun exposure, serum vitamin D levels and vitamin D supplementation (Binkley, 2013; Bolland et al., 2010; Dawson-Hughes et al., 1997; Grant et al., 2005; Hansen et al., 2015; Ministry of Health, 2012c; Salovaara et al., 2010; Tang et al., 2007; Uusi-Rasi et al., 2015). While sunlight is the predominant source of vitamin D for most people, skin synthesis of vitamin D in older adults is compromised thus leaving a greater reliance on both diet and supplementation for octogenarians (Bischoff-Ferrari et al., 2004). As low dietary vitamin D intakes have been associated with poorer quality of life (QOL), poorer mental health and depressive symptoms in postmenopausal women (Motsinger, Lazovich, MacLehose, Torkelson, & Robien, 2012), strategies to increase dietary vitamin D are required in both Māori and non-Maori, men and women.

The predominant food groups contributing to vitamin D were similar for all subgroups of this study with milk and butter & margarine being the major two contributors. Fish and seafood provided the third most common food source for the participants except non-Māori women, where fish and seafood was displaced by egg & egg dishes. Octogenarians may benefit from a diet higher in vitamin D rich foods (including oily fish, meat, egg and dairy foods), alongside adequate UVB light exposure to maintain adequate serum vitamin D levels (NHMRC, 2006).

Mean intakes of phosphorus among the participants was within EAR values (NHMRC, 2006), with both Māori and non-Māori, men and women on average consuming more than 580mg of phosphorous per day. Fewer the 10% of all subgroups failed to meet daily phosphorous requirements with only 5.0% of Maori men and 11.1% women, 6.3 % of non-Māori women and no non-Maori men falling below EAR requirements. The top two contributors to phosphorus were milk and bread. For Māori men and women, fish & seafood was the third most common contributing food source, whilst for non-Māori men and women it was breakfast cereals. Fish and seafood contribution in Māori may reflect cultural preferences for this food group (Pfeiffer & Voeks, 2014).

In general a suboptimal median magnesium intake was observed, with intakes below the EAR (350mg/day men, 265mg/day women) (NHMRC, 2006), for all subgroups. Māori men achieved 259mg/day and women

204mg/day; non-Māori men 271mg/day and women 238mg/day. Similar suboptimal intakes have previously been observed in adults over 70 years; New Zealanders in the Mosgiel Study (300mg/day) (Horwath et al., 1992) and American men and women in NHANES III (314mg/day and 230mg/day, respectively) (Ford & Mokdad, 2003). Between 65 and 85% of all Maori and non-Maori participants failed to meet their daily magnesium requirements, therefore, the need for a diet higher in magnesium rich foods that include a variety of predominately green leafy vegetables, whole grains, fruit and nuts can be indicated here. Sustained inadequate intakes of magnesium may be detrimental to the health of older adults; secondary to magnesium playing an integral role in muscle and nerve function (Y. Huang et al., 2015; Topf & Murray, 2003; Vaquero, 2002) and inflammatory processes (Barbagallo et al., 2009; Y. Huang et al., 2015).

Bread was the top contributor to magnesium for all the participants. Main food sources were for Māori men: bread (13.9%), breakfast cereals (10.9%) and potatoes, kumara & taro (9.2%); for Māori women: bread (16.1%), fruit (10.9%) and breakfast cereals (10.1%);for non-Māori men : bread (14.5%), breakfast cereals (12.3%) and milk (9.2%); for non-Māori women: bread (16.1%), fruit (10.5%) and breakfast cereals (10.1%). To enrich the diet magnesium foods including green leafy vegetables, fish (salmon), yoghurt, mushrooms, avocado, banana and beans (each providing >360/100g) may be beneficial for older adults.

Suboptimal potassium intakes below the EAR (3800mg/d men and 2800mg/d women) (NHMRC, 2006), were seen in all subgroups. Median potassium intakes for Māori men 2,712mg/day in men and 2,306mg/day in women; for non-Māori intake were 3,075mg/day in men and 2,552mg/day in women. Between 65 -90 % of all Maori and non-Maori participant failed to meet daily potassium requirements. Maintaining adequate potassium intake and status is important in older adults due to its role in cardiovascular (Lai et al., 2015) and bone health (Heaney, 2015; Orchard et al., 2014).

For Māori men, potatoes, kumara & taro (15.7%), vegetables (11.7%) and milk (11.2%); for Māori women, fruit (14.1%), potatoes, kumara & taro and vegetables (13.4%). Conversely, top potassium food sources for non-Māori men were: potatoes, kumara & taro (14.2%), vegetables (12.2%) and fruit (11.8%); for non-Māori women: fruit (16.5%), vegetables (14.3%) and milk (11.7%). The main food sources of potassium were potatoes, kumara, taro and vegetables which have an average of 25 mg/100g of potassium. Octogenarians may benefit from consuming more potassium-rich foods including green leafy vegetables, beans, avocado, banana, nuts and pumpkin seeds which provide between 27 to 543 mg/100g.

5.2 Fractures

In this study, 20% (n=63) of participants experienced fractures within 24 months of the dietary assessment. In total, 18.6% of Māori and 20.6% of non-Māori either: self-reported fractures or were hospitalised secondary to fracture in this period; therefore close to one in every five Māori and non-Māori participants sustained a fracture. Fractures occurred more commonly in women, as a third of the fractures were in men and two-thirds in women, overall. While a greater frequency of fractures in women is expected (L. A. Ahmed et al., 2013; Barber et al., 1995; Brown et al., 2011). It appears that fracture occurrence in Māori and non-Māori, men and women, in advanced age is similar which differs to previous findings for fractures in adult New Zealanders (Brown, 2007; Brown et al., 2011). With the gap in life expectancy between Māori and non-Māori decreasing, Māori, particularly women may experience longer exposure to age-related risk factors for fracture (malnutrition, previous fractures and weight loss) (Nguyen et al., 2010a) hence may explain the comparative fracture rates observed in this study.

5.3 Fracture risk factors

Fractured non-Māori men were significantly older at 86 years than those not fractured (85 to 86 years) (p=0.046). This is to be expected as the risk of fracture increases with age (Ahmed et al., 2013; Prior et al., 2015).

Those who sustained fractures had higher rates of previous fractures for all subgroups compared to non-fractured individuals. Fractured Māori women especially were 3.3 times more likely than those non-fractured to have sustained a previous fracture (p=0.012). This is to be expected as previous fractures are related to subsequent fractures in men (Drake et al., 2012) and women (Kanis, Odén, McCloskey, Johansson, Wahl, Cooper, et al., 2012), however why the disparity between fractured and non-fractured Māori women is so significant is unknown. It is possible that lower access to health services and greater unmet needs experienced by Māori may play a role (L. Ellison-Loschmann & N. Pearce, 2006; Harris et al.). Conversely, the risk of fractures has in the past been greater for non-Māori women (Barber et al., 1995). Māori women may have both limited access to hospital-based care and limited awareness of their potential fracture risk (Brown, 2007; L. Ellison-Loschmann & N. Pearce, 2006). Economic disparities between Māori and non-Māori may have a role to play in both previous fracture rates and current fracture occurrence in this study. Financial security in fractured non-Māori women and food security in fractured Māori women differed significantly from those who were non-fractured. Firstly, non-fractured non-Māori women were 1.1 times more likely to have enough money to make ends meet (p=0.033); secondly, non-fractured Māori women were 1.5 times more likely to a have enough money to eat properly (p=0.015). This secondary finding may also be related to the lower comparative energy intakes observed for Māori women.

5.4 Nutrients related to fractures

Median calcium intakes in this study were consistent with findings in previous research; there is debate over the appropriate level of calcium required in advanced age to promote bone health (Andon et al., 1996; National Academy Press, 2010) and the need for supplementation without compromising cardiovascular and gastrointestinal health (Andon et al., 1996; M. J. Bolland et al., 2010; M. J. Bolland, Grey, Avenell, Gamble, & Reid, 2011; Lau, Lynn, Chan, & Woo, 2002; Michaelsson, Melhus, Warensjo Lemming, Wolk, & Byberg, 2013). A recent systematic review and meta- analysis of research concerning calcium intake (diet and supplemented) and bone suggest increased calcium intakes in older adults, are

of no consequence to decreased fracture risk with only slight increases in BMD observed (Tai, Bolland, Reid, Grey, et al., 2015).

Interestingly median vitamin D intake in fractured Māori women (2.0 µg/day (1-2 µg/day)) were significantly less than those non-fractured (*P*=0.01). While it is unlikely that nutrient intake of vitamin D has a role to play as serum vitamin D levels are associated with risk (Ebeling et al., 1992; Miggiano & Gagliardi, 2005b; Ministry of Health, 2012c). Māori women are at a relatively higher likelihood of vitamin D deficiency, optimal dietary intake of vitamin D and sufficient sun exposure may be recommended (Binkley, 2013; Ministry of Health, 2012c).

In this study fractured Māori women consumed significantly less median magnesium 143.0 mg/d versus 211.0 mg/d then non-fractured women (P=0.033), this relationship disappeared with multivariate analysis and may be secondary to underreporting in Māori participants however this statistic was not further investigated. Magnesium has multiple roles in the body. However, it is particularly integral to adequate nerve and muscle function with magnesium resulting in poor physical performance in elderly adults (Veronese et al., 2014). Decreased muscle function, therefore, may aid decreased BMD secondary to decrease muscle tension exerted on bone and accelerated sarcopenia secondary to decreased physical function (Ferrucci, 2002). Low magnesium intakes have previously been associated with reduced BMD in women, with no subsequent increase in fracture (Orchard et al., 2014). Long term magnesium deficiency is also implicated in attenuated oxidative stress and secondary inflammation (Y. Huang et al., 2015) which may have a role in facilitating the ageing process, frailty, subsequent falls and fracture risk (Barbagallo et al., 2009).

In this study, we observed relationships for fractures between smoking history in non-Māori men; financial security in non-Māori women; and food security, previous fractures, vitamin D and magnesium intake in Māori women. While several relationships were identified between physical characteristics and nutrient intakes with fracture rates for both Māori and non-Māori, no direct causation of fractures was determined through regression analysis.

5.5 Strengths

The current study is a sub-study of a larger longitudinal cohort study, designed with a robust methodology and strict protocols for data collection. The study is longitudinal in nature, with data extrapolated at 12 and 24 month follow up in this current study, hence future investigations into nutrient intakes and fracture occurrence are possible.

5.6 Limitations

Data collection was not uniform for all sections of the LiLACS NZ collection process and thus hampered the strength of statistical analysis particularly in Māori men. Considering the age of participants interviewed and the robust nature of the questionnaire; some participants completed a shorter, less burdensome questionnaire. Fracture occurrence was ascertained within a separate section of the main questionnaire. However 24hour MPR's were not available for each participant who responded with fracture data and thus affected results in this study.

Furthermore, with this research being a subset of a larger longitudinal cohort study, limitations occurred concerning available biochemical markers; urinary sodium and serum vitamin D were unavailable and are integral to understanding nutrient exposure and bone turnover (Curhan, Willett, Speizer, Spiegelman, & Stampfer, 1997; Ebeling et al., 1992; Gallagher et al., 1979; Heaney, 2005, 2015; Miggiano & Gagliardi, 2005b; Muldowney, Freaney, & Moloney, 1982). While extensive nutritional data was collected and dietary sodium intakes were available, urinary sodium is the best measure of sodium intake (Muldowney et al., 1982; Stanhewicz & Larry, 2015) and would have been a valuable inclusion to the nutrient investigation. Similarly, serum vitamin D is a valuable marker for nutrient investigation concerning bone and while not a dietary measure it would have provided valuable clarification to the effect of inadequate vitamin D intake.

A key oversight in this study was not identifying fracture and osteoporosis-related medications (bisphosphates) or specific protein, vitamin or mineral supplementation. These could potentially contribute to overall nutrient intakes and prevention of subsequent fractures in older adults (Bischoff-Ferrari et al., 2005; Dawson-Hughes et al., 1997; Jackson et al., 2006; Reid, 2015). Additionally, in interpretation of data Goldberg cut-offs were not utilised to identify those who under or over reported.

6 Conclusion and Recommendations

6.1 Conclusion

This study provides novel descriptions of food and nutrient intakes for Māori and non-Māori > 80 years. We can conclude the median energy intakes in Māori and non-Māori, men and women were low, with comparatively lower energy intakes observed for Māori men and women. Higher nutrient density consistently achieved by Māori and non-Māori women compared to men. Furthermore, we can conclude that the low energy intakes observed may have manifested the suboptimal intakes of calcium, vitamin D, magnesium and potassium. In addition with bread, butter and margarine contributing most to energy in all subgroups, nutrient density may have been compromised. This study suggests there may be an opportunity for advanced age adults to consume intakes of higher quality protein sources as well as calcium, vitamin D, magnesium and potassium rich foods.

We can conclude that both Māori and non-Māori experienced a similar occurrence of fracture in advanced age. Close to one in every five Māori and non-Māori men and women suffered a fracture over the 24 month period. Therefore both Māori and non-Māori, men and women in advanced age appear to be at a similar risk of fracture than previously noted in the literature.

Finally we can conclude that fractured Māori women consumed significantly less vitamin D and magnesium through the diet than other subgroups. However, fractured Māori women experience significantly lower food security than non-fractured Māori women. Further research into magnesium intake in older women, particularly Māori, is warranted as magnesium may have an important role in bone health.

6.2 Recommendations

- With an increased number of New Zealand Māori living into advanced age, future investigations into nutrient intakes and subsequent health outcomes is needed as Māori over 50 years in the NZANS 2008/09 were aggregated.
- Further investigation into the food source intake of magnesium and the role of inadequate magnesium intake on bone health and fracture risk is required especially for Māori women.
- Nutrient intakes of calcium, phosphorous and potassium were low in this study and further investigation is necessary as the current Nutrient reference Values for these nutrients may not be appropriate for those in advanced age with respect to bone health. Māori women in advanced age were found to be at-risk for fractures in this study. Interventions which decrease barriers to fracture prevention and care as well as increase awareness of bone health should be given greater priority.

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7 Appendices

1. Ethical Approval.
2. Participants consent form Wave 1,2 and 3.
3. Dietary assessment -24hour multiple pass recall form.
4. Food Group tables.

Health and Disability Ethics Committees

Northern X Regional Ethics Committee
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Please note postal address is : Northern X Regional Ethics Committee, C/o Ministry of Health, PB 92 522 Wellesley St Auckland

17 December 2009

Dr N Kerse
Dept of General Practice
University of Auckland
Private Bag 92019
Auckland 1142

Dear Ngaire

NTX/09/09/088	**Study title: Life and living in advanced age: the cohort study. Te Puawaitanga O Nga Tapuwae kia ora tonu: PIS/Cons V#4, 5/10/09**
Principal Investigator:	Dr Ngaire Kerse
Co-Investigators	Ms Karen Hayman, Dr Mere Kepa, Dr Lorna Dyall, Prof. Martin Connolly, A/Prof Tim Wilkinson, A/Prof Robert Scragg, Dr Carol Wham, Dr Valerie Wright St-Claire, Prof. Peter Davis, Ruth Teh, Dr Santosh Jatrana, Dr Sally Keeling, Dr Kathy Peri, Dr Janine Wiles
Localities:	University of Auckland, Bay of Plenty DHB, Lakes District Health Board

Thank you for your letter and Committee requirements, received 16 December 2009. The above study has been given ethical approval by the **Northern X Regional** Ethics Committee.

Approved Documents

- Participant Information Sheet/Consent Form: V. ISPA V#4 dated 5/10/09
- Participant Information Sheet/Consent Form: V. ISKM V#4 dated 5/10/09
- Participant Information Sheet/Consent Form: V. ISFW V#4 dated 5/10/09
- Participant Information Sheet/Consent Form: V. ISMR V#4 dated 5/10/09
- Questionnaires 4/11/09

Certification
The Committee is satisfied that this study is not being conducted principally for the benefit of the manufacturer or distributor of the medicine or item in respect of which the trial is being carried out.

Accreditation
The Committee involved in the approval of this study is accredited by the Health Research Council and is constituted and operates in accordance with the Operational Standard for Ethics Committees, April 2006.

Progress Reports
The study is approved until 31 October 2019. However, the Committee will review the approved application annually and notify the Principal Investigator if it withdraws approval. It is the Principal Investigator's responsibility to forward a progress report covering all sites prior to ethical review of the project on **17 December 2010**. The report form should be forwarded to you but if not received, it is available on http://www.ethicscommittees.health.govt.nz (forms – progress reports). Please note that failure to provide a progress report may result in the withdrawal of ethical approval.

Final Report
A final report is required at the end of the study. The report form is available on http://www.ethicscommittees.health.govt.nz (progress reports) and should be forwarded along with a

Administered by the Ministry of Health   Approved by the Health Research Council   http://www.ethicscommittees.health.govt.nz

summary of the results. If the study will not be completed as advised, please forward a progress report and an application for extension of ethical approval one month before the above date.

Requirements for SAE Reporting
The Principal Investigator will inform the Committee as soon as possible of the following:

- Any related study in another country that has stopped due to serious or unexpected adverse events
- all serious adverse events occurring during the study NZ/worldwide which are considered related to the study

All SAE reports must be signed by the Principal Investigator and include a comment on whether he/she considers there are any ethical issues relating to this study continuing due to this adverse event. It is assumed by signing the report, the Principal Investigator has undertaken to ensure that all New Zealand investigators are made aware of the event.

Amendments
All amendments to the study must be advised to the Committee prior to their implementation, except in the case where immediate implementation is required for reasons of safety. In such cases the Committee must be notified as soon as possible of the change.

Please quote the above ethics committee reference number in all correspondence.

The Principal Investigator is responsible for advising any other study sites of approvals and all other correspondence with the Ethics Committee.

It should be noted that Ethics Committee approval does not imply any resource commitment or administrative facilitation by any healthcare provider within whose facility the research is to be carried out. Where applicable, authority for this must be obtained separately from the appropriate manager within the organisation.

We wish you well with your study.

Yours sincerely

Pat Chainey
Administrator
Northern X Regional Ethics Committee

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CONSENT FORM (Wave II)

for Participants in the LILAC S NZ study

Project title:

Life and Living in Advanced Age: A Cohort Study

Te Puāwaitanga o Ngā Tapuwae Kia ora Tonu

The LILAC study

Researcher Name:

Professor Ngaire Kerse, Dr Lorna Dyall

	WHAKAWHITI KAI KORERO/ **REQUEST FOR INTERPRETER**		
Turi/**Deaf**	Kai te hiahia mo tetahi Tutohu Reo o Aotearoa, mehemea kai konai tetahi/ **I wish to have a New Zealand Sign Language Interpreter, if one available**	Ae/**Yes**	Kao/**No**
English	I wish to have an Interpreter.	Yes	No
Maori	E hiahia ana ahau ki tetahi kaiwhakamaori/kaiwhaka pakeha korero.	Ae	Kao
Samoan	Oute mana'o ia iai se fa'amatala upu.	Ioe	Leai
Tongan	Oku ou fiema'u ha fakatonulea.	Io	Ikai
Cook Island	Ka inangaro au i tetai tangata uri reo.	Ae	Kare
Niuean	Fia manako au ke fakaaoga e taha tagata fakahokohoko kupu.	E	Nakai

Kua riti ahau, a kau te marama nga korero i runga i tenei pepa 19th January 2011 **mo nga Koroheke kua tonu atu kia uru mai ki roto i enei uiuitanga Akoranga mo te noho ki te koroheketanga.** / I have read and I understand the Information Sheet 19th January 2011 for older people invited to participate in the interview study about living to advanced age.

I waitea au ki te korerorero mo tenei Akoranga maua me taku Kairangahau. I te whakahoki mai ana ki ahau./ I have had the opportunity to discuss this study with the Researcher. I am satisfied with the answers I have been given.

Kai te marama ki ahau i ahau e uru atu ana ki enei Akoranga naku tena, ana ka watea ahau kit e puta mai i enei Akoranga i te wa e hiahia ana ahua, ano kahore tenei e kati ana te huarahi mo etahi hauora awhina, i ko atu. / I understand that my taking part in this Study is voluntary (my choice) and that I may withdraw from the study at any time and this will in no way affect my continuing or future Health care.

Kai te marama ki ahau mehemea kai te hiahia au ki te kume mai i etahi wahi o aku korero mai i te Akoranga tae ki te wa./ I understand that I may withdraw any part of my information from the study up until (6 months from the interview).

Main consent v4: 19 Jan 11 | Page 2 of 4

Kai te marama ki ahua ko taku uru atu ki enei Akoranga ka nohotapu, kahore e kore re he aha atu ka mohio ko hau tera ka uru atu ki tahi tuhituhi i roto i tenei mahi Akoranga. / I understand that my participation in this Study is confidential and that no material that could identify me will be used in any reports on this Study. **Kai te marama ki ahau ko te whakawateatanga ki tenei whakataputanga, ka watea mehemea mo taku oranga me etahi atu.** / I am aware that the exception to confidentiality will be if the Interviewer has significant concerns about the safety of myself or others.
Kai te marama ki ahua ko te kai whakapatsitai me etahi atu whakatau, ka mutu mehemea ka kitea ka pa mai ki ahua e mea raruraru. / I understand that the Interview or Assessment will be stopped if it should appear harmful to me.
Kai te marama ahau e whakaritenga ano mo enei Akoranga./ I understand the compensation provisions for this Study.
Kua whakaarotia ahau mo te tahi wa, mehemea ka uru atu ahau ki enei mahi./ I have had time to consider whether to take part.
Kai te mohio ahau ko wai taku e tata atu, mehemea e patai aku mo tenei Akoranga./ I know whom to contact if I have any questions about the Study.

Kai te tohu atu ahau ki taku whakaetanga mo enei e whai ake enei./ I indicate my approval (or otherwise) for the following:

Ki te uru atu ki enei patai whakarite. To participate in the full interview	Ae/**Yes** Kao/**No**
~~**OR**~~	
Kit e uru atu ki enei patai whakarite iti. To participate in a partial interview	Ae/**Yes** Kao/**No**
Kit e uru atu ki etahi atu e korerotia ana tinana To participate in a physical assessment including talking about food	Ae/**Yes** Kao/**No**
Ko te Rōpū Rangahau, ka korero atu ki toku Takuta mo etahi atu mate ka kitea./ That the Research Team will inform my GP of any unusual findings	Ae/**Yes** Kao/**No**
Kai te hiahia ahau kia homai ki ahau era kiteatanga./ I wish to receive a copy of the results.	Ae/**Yes** Kao/**No**
I understand that there may be a significant delay between data collection and the publication of the study results.	

Toto me te tataritanga**/ Blood for analyses**

~~**Ka whakaeatu au ki te heata oku Toto me te mahi Tataritanga./** I give~~ permission to take a sample of blood and to conduct analyses. Ae/**Yes**

Kai te marama au akuni pea ka roa te wa, mai i wai tuku Toto ki te wa ka otu na whakatataritanga./ I understand that there may be a delay between the blood being taken and analyses being completed. Kao/**No**

Ka te hiahia ahau kia whakahokia mai oku Toto kahore e tataritia./ I wish to receive back any blood not used in analyses. Ae/**Yes** Kao/**No**

Kai te marama ahau akuni pea ka rere ke te ahua, i muri o te tataritangatia./ I understand the Blood may look different as it has been processed. Ae/**Yes** Kao/**No**

~~Etahi atu Matauranga/**Further studies**~~

Ka whakaea ahau mo aku kitenga, ka whakaritea atu ki te Newcastle University Study. Ki te Koroheketanga me etahi atu akoranga kite whakapai atu whakamatautau ka tukua ma te tahi ano tono ki te Rōpū Mahi Whakatikatika ana e kore e taea kite kite ko wai ena, etahi atu mahi akoranga./ I give permission for my Results to be combined with the Newcastle Study on ageing and any other studies to improve the health of older people. Further studies would be guided by a separate application to an ethics committee and I would not be able to be identified individually in any further studies Ae/**Yes** Kao/**No**

Ko au I konei ka whakae au kia uru atu ki roto I te LILACS Mahi Akoranga Taumatatuarua.

/ I ____________________________________ hereby consent to participate in the LILAC study Wave II.

Tohu/**Signature** .... Tohu o Kai Awhina/ **Signature of**
....

witness........................ Te ra/**Date**:

.... Ingoa/**Name of**

witness.............................

Kai Whakamarama/**Project explained by**

.... Tu nga/**Project role**

....

Tohu/**Signature** .... Te ra/**Date**
....

Main consent v4: 19 Jan 11 Page 4 of 4

DIETARY ASSESSMENT: 24 HOUR MULTIPLE PASS RECALL

LILACS NZ

PARTICIPANT'S NAME	
PARTICIPANT'S ID NUMBER	
GENDER	
DATE OF BIRTH	
DAY OF WEEK RECALLED	
TODAY'S DATE	
STUDY NURSE NAME	
START TIME	

Quick List	Time (24 hr)	Description of food or drink (as much detail as possible)	Homemade / retail Homemade: H Retail: R Not Appl: NA If H: Prompt for recipes	Cooking method Oven : O Fried : F Grilled : G Boiled: B Steamed: S Not Appl: NA	Brand	Amount served Preface with W: Weight P: Photo code H: Household	Leftover Preface with W: Weight P: Photo code H: Household AA: Ate All	To be completed by nutritionist	
								Food code	Weight

RECIPE 1:
Name of home-made dish:_____

Ingredients	Amount
Cooking method	

RECIPE 2:
Name of home-made dish:_____

Ingredients	Amount
Cooking method	

Appendix 4: *Food Source Tables*

Table 7-1

Energy sources, percent (95% CI), by gender and ethnicity.

	Māori			Non- Māori		
	Men	*Women*	*Total Māori*	*Men*	*Women*	*Total non-Māori*
Bread	10.5 (4.2,16.8)	12.5 (6.7, 18.3)	11.6 (7.3, 15.9)	11.0(6.3,15.7)	10.8 (6.4,15.2)	10.9(7.7,14.1)
Butter and margarine	6.7 (1.6, 11.8)	7.2 (2.6, 11.8)	7.0 (3.6, 10.4)	6.7 (3.0, 10.4)	6.4 (2.9, 9.9)	6.6 (4.0, 9.2)
Fruit	4.1 (0.0, 8.2)	7.3 (2.7, 11.9)	5.9 (2.7, 9.1)	5.9 (2.4, 9.4)	8.7 (4.7, 12.7)	7.4 (4.7, 10.1)
Beef and veal	4.5 (0.2, 8.8)	4.3 (0.7, 7.9)	4.4 (1.7, 7.1)	4.5 (1.4,7.6)	3.4 (0.8, 6.0)	3.9 (1.9, 5.9)
Biscuits*	3.1 (0.0, 6.6)	3.4 (0.2, 6.6)	3.3 (0.9, 5.7)	4.4 (1.3, 7.5)	4.8 (1.7, 7.9)	4.6 (2.4, 6.8)
Milk	5.9 (1.1, 10.7)	6.7 (2.3, 11.1)	6.4 (3.1, 9.7)	6.2 (2.6, 9.8)	6.6 (3.1, 10.1)	6.4 (3.9, 8.9)
Breakfast cereals	6.3 (1.3, 11.3)	5.6 (1.5, 9.7)	5.9 (2.8, 9.0)	6.3 (2.7, 9.9)	5.4 (2.2, 8.6)	5.9 (3.5, 8.3)
Potatoes, kumara and taro	6.6 (1.5, 11.7)	6.0 (1.8, 10.2)	6.3 (3.1, 9.5)	5.9 (2.4, 9.4)	4.7 (1.7, 7.7)	5.3 (3.0, 7.6)
Cakes and muffins*	4.9 (0.5, 9.3)	3.3 (0.2, 6.4)	4.0 (1.4, 6.6)	5.4 (2.0, 8.8)	5.7 (2.4, 9.0)	5.5 (3.1, 7.9)
Vegetables	2.8 (0.0, 6.2)	4.1 (0.6, 7.6)	3.5 (1.0, 6.0)	3.2 (0.6, 5.8)	4.2 (1.3, 7.1)	3.8 (1.8, 5.8)
Dairy products	4.4 (0.2, 8.6)	3.2 (0.1, 6.3)	3.7 (1.2, 6.2)	3.2 (0.6, 5.8)	3.8 (1.1, 6.5)	3.5 (1.6, 5.4)
Sugar and sweets	4.8 (0.5, 9.1)	3.7 (0.4, 7.0)	4.2 (1.5, 6.9)	3.8 (0.9, 6.7)	3.1 (0.6, 5.6)	3.4 (1.5, 5.3)
Alcoholic beverages	2.3 (0.0, 5.4)	1.7 (0.0,3.9)	2.0 (0.2,3.8)	5.1(1.8,8.4)	2.1 (0.1,4.1)	3.5 (1.6,5.4)
Pork	4.0 (0.0, 8.0)	3.8 (0.4, 7.2)	3.9 (1.3, 6.5)	2.1 (0.0, 4.2)	2.2 (0.1, 4.3)	2.2 (0.7, 3.7)
Fish and seafood	4.2 (0.1, 8.3)	3.2 (0.1, 6.3)	3.6 (1.1, 6.1)	2.8 (0.3, 5.3)	1.9 (0.0, 3.8)	2.3 (0.7, 3.9)
Poultry	3.0 (0.0, 6.5)	2.5 (0.0, 5.2)	2.7 (0.5, 4.9)	2.7 (0.3, 5.1)	2.1 (0.0, 4.2)	2.4 (0.8, 4.0)
Non-alcoholic beverages	2.8 (0.0, 6.1)	2.5 (0.0, 5.2)	2.6 (0.5, 4.7)	2.1 (0.0, 4.2)	2.9 (0.5, 5.3)	2.5 (0.9, 4.1)
Cheese	1.4 (0.0, 3.8)	2.2 (0.0, 4.8)	1.8 (0.0, 3.6)	2.3 (0.1, 4.5)	3.0 (0.6, 5.4)	2.7 (1.0, 4.4)
Puddings and desserts	2.2 (0.0, 5.2)	1.7 (0.0, 4.0)	1.9 (0.1, 3.7)	2.4 (0.1, 4.7)	2.3 (0.2, 4.4)	2.4 (0.8, 4.0)
Grains and pasta	1.4 (0.0, 3.8)	2.4 (0.0, 5.1)	2.0 (0.1, 3.9)	1.6 (0.0, 3.5)	2.4 (0.2, 4.6)	2.0 (0.6, 3.4)
Pies and pasties	2.2 (0.0, 5.2)	1.7 (0.0, 4.0)	1.9 (0.1, 3.7)	2.4 (0.1, 4.7)	1.4 (0.0, 3.1)	1.9 (0.5, 3.3)
Soups and stocks	1.6 (0.0, 4.1)	1.7 (0.0, 4.0)	1.6 (0.0, 3.3)	1.7 (0.0, 3.6)	2.2 (0.1, 4.3)	1.9 (0.5, 3.3)
Eggs and egg dishes	1.8 (0.0, 4.5)	1.8 (0.0, 4.2)	1.8 (0.0, 3.6)	1.5 (0.0, 3.3)	1.8 (0.0, 3.7)	1.7 (0.4, 3.0)
Savoury sauces and condiments.	1.5 (0.0, 4.0)	1.3 (0.0, 3.3)	1.4 (0.0, 3.0)	1.7 (0.0, 3.6)	1.7 (0.0, 3.5)	1.7 (0.4, 3.0)
Sausages and processed meats.	2.4 (0.0, 5.5)	1.4 (0.0, 3.5)	1.8 (0.0, 3.6)	1.4 (0.0, 3.2)	1.6 (0.0, 3.4)	1.5 (0.2, 2.8)
Lamb and mutton	2.2 (0.0, 5.2)	1.7 (0.0, 3.9)	1.9 (0.1, 3.7)	1.1 (0.0, 2.7)	1.1 (0.0, 2.6)	1.1 (0.0, 2.2)
Fats and oils	1.2 (0.0, 3.4)	1.6 (0.0, 3.8)	1.4 (0.0, 3.0)	1.2 (0.0, 2.8)	1.3 (0.0, 2.9)	1.2 (0.1, 2.3)
Nuts and seeds	0.2 (0.0, 1.2)	0.9 (0.0, 2.5)	0.6 (0.0, 1.6)	0.9 (0.0, 2.3)	1.8 (0.0, 3.7)	1.3 (0.1, 2.5)
Bread-based dishes	0.6 (0.0, 2.2)	0.2 (0.0, 1.0)	0.4 (0.0, 1.2)	0.1 (0.0, 0.5)	0.2 (0.0, 0.8)	0.1 (0.0, 0.5)
Other meat	0.3 (0.0, 1.4)	0.4 (0.0, 1.5)	0.3 (0.0, 1.1)	0.1 (0.0, 0.4)	0.0 (0.0, 0.2)	0.0 (0.0, 0.2)
Snack bars	0.0 (0.0, 0.0)	0.1 (0.0, 0.6)	0.0 (0.0, 0.3)	0.3 (0.0, 1.1)	0.1 (0.0, 0.5)	0.2 (0.0, 0.6)

Table 7-2

Protein sources, percent (95% CI), by gender and ethnicity.

	Māori			Non- Māori		
	Men	*Women*	*Total Māori*	*Men*	*Women*	*Total non-Māori*
Bread	10.4 (4.2, 16.6)	12.9 (7.0,18.8)	11.8 (7.5, 16.1)	11.8(7.0,16.6)	11.9(7.3,16.5)	11.9 (8.6, 15.2)
Beef and veal	10.7 (4.4, 17.0)	10.6 (5.2,16.0)	10.6 (6.5, 14.7)	13.3(8.2,18.4)	9.9(5.6,14.2)	11.5 (8.2, 14.8)
Milk	9.5 (3.5, 15.5)	10.8 (5.3,16.3)	10.2 (6.2, 14.2)	10.9(6.2,15.6)	12.3 (7.6, 17)	11.7 (8.4, 15)
Poultry	8.8 (3.0, 14.6)	7.2 (2.6, 11.8)	7.9 (4.3, 11.5)	7.6 (3.6, 11.6)	6.4 (2.9, 9.9)	7.0 (4.4, 9.6)
Fish and seafood	10.6 (4.3, 16.9)	8.6 (3.7, 13.5)	9.4 (5.5, 13.3)	7.1 (3.3, 10.9)	5.0 (1.9, 8.1)	6.0 (3.6, 8.4)
Breakfast cereals	5.4 (0.8, 10.0)	4.7 (1.0, 8.4)	5.0 (2.1, 7.9)	5.8 (2.3, 9.3)	4.7 (1.7, 7.7)	5.2 (2.9, 7.5)
Pork	7.5 (2.1, 12.9)	7.4 (2.8, 12.0)	7.4 (3.9, 10.9)	4.6 (1.5, 7.7)	4.5 (1.6, 7.4)	4.5 (2.4, 6.6)
Vegetables	3.3 (0.0, 6.9)	4.0 (0.5, 7.5)	3.7 (1.2, 6.2)	3.9 (1.0, 6.8)	4.8 (1.8, 7.8)	4.4 (2.3, 6.5)
Cheese	2.1 (0.0, 5.0)	3.5 (0.3, 6.7)	2.9 (0.7, 5.1)	3.8 (1.0, 6.6)	4.8 (1.7, 7.9)	4.3 (2.2, 6.4)
Eggs and egg dishes	3.7 (0.0, 7.6)	3.7 (0.4, 7.0)	3.7 (1.2, 6.2)	3.5 (0.8, 6.2)	3.8 (1.1, 6.5)	3.7 (1.8, 5.6)
Potatoes, kumara and taro	3.2 (0.0, 6.8)	2.9 (0.0, 5.8)	3.0 (0.7, 5.3)	3.2 (0.6, 5.8)	2.6 (0.3, 4.9)	2.9 (1.2, 4.6)
Lamb and mutton	3.6 (0.0, 7.4)	2.3 (0.0, 4.9)	2.9 (0.7, 5.1)	2.3 (0.1, 4.5)	2.6 (0.3, 4.9)	2.4 (0.8, 4.0)
Sausages and processed meats	3.3 (0.0, 6.9)	2.0 (0.0, 4.5)	2.5 (0.4, 4.6)	2.2 (0.0, 4.4)	2.3 (0.2, 4.4)	2.2 (0.7, 3.7)
Cakes and muffins*	2.2 (0.0, 5.2)	1.6 (0.0, 3.8)	1.9 (0.1, 3.7)	2.3 (0.0, 4.6)	2.6 (0.3, 4.9)	2.5 (0.9, 4.1)
Non-alcoholic beverages	1.8 (0.0, 4.5)	2.0 (0.0, 4.4)	1.9 (0.1, 3.7)	1.8 (0.0, 3.8)	2.4 (0.2, 4.6)	2.1 (0.6, 3.6)
Pies and pasties	2.2 (0.0, 5.2)	1.7 (0.0, 4.0)	1.9 (0.1, 3.7)	2.5 (0.2, 4.8)	1.6 (0.0, 3.4)	2.0 (0.6, 3.4)
Fruit	1.2 (0.0, 3.4)	2.3 (0.0, 4.9)	1.8 (0.0, 3.6)	1.9 (0.0, 3.9)	2.9 (0.5, 5.3)	2.4 (0.8, 4.0)
Grains and pasta	1.3 (0.0, 3.6)	2.2 (0.0, 4.8)	1.8 (0.0, 3.6)	1.6 (0.0, 3.5)	2.5 (0.3, 4.7)	2.1 (0.6, 3.6)
Soups and stocks	1.8 (0.0, 4.5)	1.7 (0.0, 4.0)	1.8 (0.0, 3.6)	1.8 (0.0, 3.8)	2.4 (0.2, 4.6)	2.1 (0.6, 3.6)
Dairy products	1.7 (0.0, 4.4)	1.4 (0.0, 3.5)	1.6 (0.0, 3.2)	1.7 (0.0, 3.7)	2.6 (0.4, 4.8)	2.2 (0.7, 3.7)
Biscuits*	1.1 (0.0, 3.2)	1.4 (0.0, 3.5)	1.2 (0.0, 2.7)	1.6 (0.0, 3.5)	1.9 (0.0, 3.8)	1.8 (0.4, 3.2)
Savoury sauces and condiments	1.0 (0.0, 3.0)	1.1 (0.0, 2.9)	1.1 (0.0, 2.5)	1.6 (0.0, 3.4)	1.6 (0.0, 3.4)	1.6 (0.3, 2.9)
Puddings and desserts	1.2 (0.0, 3.4)	1.2 (0.0, 3.1)	1.2 (0.0, 2.6)	1.4 (0.0, 3.2)	1.3 (0.0, 2.9)	1.3 (0.1, 2.5)
Nuts and seeds	0.2 (0.0, 1.1)	1.0 (0.0, 2.7)	0.6 (0.0, 1.7)	0.9 (0.0, 2.3)	1.7 (0.0, 3.5)	1.3 (0.1, 2.5)
Bread-based dishes	0.6 (0.0, 2.2)	0.2 (0.0, 0.9)	0.4 (0.0, 1.2)	0.1 (0.0, 0.5)	0.3 (0.0, 1.0)	0.2 (0.0, 0.6)
Sugar and sweets	0.2 (0.0, 1.1)	0.4 (0.0, 1.5)	0.3 (0.0, 1.0)	0.3 (0.0, 1.2)	0.3 (0.0, 1.1)	0.3 (0.0, 0.9)
Alcoholic beverages	0.3 (0.0, 1.4)	0.1 (0.0, 0.7)	0.2 (0.0, 0.8)	0.4 (0.0, 1.3)	0.1 (0.0, 0.6)	0.2 (0.0, 0.7)
Butter and margarine	0.1 (0.0, 0.7)	0.1 (0.0, 0.7)	0.1 (0.0, 0.5)	0.1 (0.0, 0.6)	0.1 (0.0, 0.6)	0.1 (0.0, 0.4)
Snack bars*	0.0 (0.0, 0.0)	0.0 (0.0, 0.3)	0.0 (0.0, 0.2)	0.2 (0.0, 0.8)	0.0 (0.0, 0.3)	0.1 (0.0, 0.4)
Other meat	1.2 (0.0, 3.4)	1.0 (0.0, 2.7)	1.0 (0.0, 2.4)	0.1 (0.0, 0.5)	0.0 (0.0, 0.2)	0.0 (0.0, 0.2)
Fats and oils	0.0 (0.0, 0.0)	0.0 (0.0, 0.1)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)
Snack foods	0.0 (0.0, 0.1)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.0 (0.0, 0.2)	0.0 (0.0, 0.1)	0.0 (0.0, 0.1)

Table 7-3

Calcium sources, percent (95% CI), by gender and ethnicity.

	Māori			Non- Māori		
	Men	*Women*	*Total Māori*	*Men*	*Women*	*Total non-Māori*
Milk	33.9(24.2,43.6)	33.6(25.3,41.9)	33.7(27.4,40.0)	34.7(27.6,41.8)	33.3 (26.6,40.0)	34.0(29.1,38.9)
Cheese	6.6 (1.5, 11.7)	9.0 (4.0, 14.0)	8.0 (4.4, 11.6)	10.7 (6.1,15.3)	11.9 (7.3, 16.5)	11.3 (8.0, 14.6)
Bread	9.4 (3.4, 15.4)	10.2 (4.9,15.5)	9.9 (5.9, 13.9)	9.2 (4.9, 13.5)	7.5 (3.7, 11.3)	8.3 (5.5, 11.1)
Vegetables	7.0 (1.8, 12.2)	7.9 (3.2, 12.6)	7.5 (4.0, 11.0)	6.1 (2.5, 9.7)	6.3 (2.8, 9.8)	6.2 (3.7, 8.7)
Dairy products	5.6 (0.9, 10.3)	4.5 (0.9, 8.1)	5.0 (2.1, 7.9)	5.2 (1.9, 8.5)	6.9 (3.3, 10.5)	6.1 (3.6, 8.6)
Non-alcoholic beverages	4.9 (0.5, 9.3)	5.2 (1.3, 9.1)	5.1 (2.2, 8.0)	3.4 (0.7, 6.1)	5.2 (2.1, 8.3)	4.3 (2.2, 6.4)
Fruit	2.2 (0.0, 5.2)	3.9 (0.5, 7.3)	3.2 (0.9, 5.5)	3.2 (0.6, 5.8)	4.2 (1.3, 7.1)	3.7 (1.7, 5.7)
Breakfast cereals	3.3 (0.0, 7.0)	2.9 (0.0, 5.8)	3.0 (0.7, 5.3)	3.3 (0.6, 6.0)	3.3 (0.7, 5.9)	3.3 (1.4, 5.2)
Cakes and muffins*	3.0 (0.0, 6.5)	2.0 (0.0, 4.4)	2.4 (0.4, 4.4)	2.7 (0.3, 5.1)	2.8 (0.4, 5.2)	2.8 (1.1, 4.5)
Puddings and desserts	2.7 (0.0, 6.0)	2.1 (0.0, 4.6)	2.4 (0.4, 4.4)	2.5 (0.2, 4.8)	2.1 (0.1, 4.1)	2.3 (0.8, 3.8)
Fish and seafood	3.3 (0.0, 6.9)	2.5 (0.0, 5.3)	2.9 (0.7, 5.1)	2.4 (0.1, 4.7)	1.5 (0.0, 3.2)	1.9 (0.5, 3.3)
Potatoes, kumara and taro	2.8 (0.0, 6.2)	2.4 (0.0, 5.1)	2.5 (0.4, 4.6)	2.2 (0.0, 4.4)	1.6 (0.0, 3.4)	1.8 (0.4, 3.2)
Eggs and egg dishes	1.8 (0.0, 4.5)	1.9 (0.0, 4.3)	1.9 (0.1, 3.7)	1.7 (0.0, 3.6)	1.7 (0.0, 3.5)	1.7 (0.4, 3.0)
Soups and stocks	1.4 (0.0, 3.8)	2.1 (0.0, 4.7)	1.8 (0.0, 3.6)	1.8 (0.0, 3.8)	1.9 (0.0, 3.8)	1.9 (0.5, 3.3)
Savoury sauces and condiments	1.9 (0.0, 4.7)	1.6 (0.0, 3.8)	1.7 (0.0, 3.4)	1.8 (0.0, 3.8)	1.9 (0.0, 3.8)	1.8 (0.4, 3.2)
Grains and pasta	0.9 (0.0, 2.8)	1.0 (0.0, 2.8)	1.0 (0.0, 2.3)	1.1 (0.0, 2.7)	1.5 (0.0, 3.2)	1.3 (0.1, 2.5)
Sugar and sweets	1.1 (0.0, 3.2)	1.2 (0.0, 3.1)	1.2 (0.0, 2.6)	1.3 (0.0, 3.0)	0.9 (0.0, 2.2)	1.1 (0.0, 2.2)
Pies and pasties	1.0 (0.0, 3.0)	0.7 (0.0, 2.2)	0.8 (0.0, 2.0)	1.1 (0.0, 2.7)	0.7 (0.0, 1.9)	0.9 (0.0, 1.9)
Beef and veal	1.2 (0.0, 3.4)	0.9 (0.0, 2.5)	1.0 (0.0, 2.3)	1.0 (0.0, 2.5)	0.7 (0.0, 1.9)	0.8 (0.0, 1.7)
Biscuits	0.8 (0.0, 2.6)	0.7 (0.0, 2.2)	0.8 (0.0, 2.0)	1.0 (0.0, 2.5)	1.1 (0.0, 2.6)	1.0 (0.0, 2.0)
Poultry	0.8 (0.0, 2.7)	0.6 (0.0, 1.9)	0.7 (0.0, 1.8)	0.7 (0.0, 1.9)	0.6 (0.0, 1.7)	0.6 (0.0, 1.4)
Sausages and processed meats	1.0 (0.0, 3.0)	0.4 (0.0, 1.4)	0.6 (0.0, 1.7)	0.6 (0.0, 1.7)	0.5 (0.0, 1.5)	0.5 (0.0, 1.2)
Alcoholic beverages	0.5 (0.0, 2.0)	0.3 (0.0, 1.2)	0.4 (0.0, 1.2)	0.7 (0.0, 1.9)	0.3 (0.0, 1.1)	0.5 (0.0, 1.2)
Nuts and seeds	0.1 (0.0, 0.7)	0.2 (0.0, 1.0)	0.1 (0.0, 0.6)	0.3 (0.0, 1.1)	0.6 (0.0, 1.7)	0.5 (0.0, 1.2)
Pork	1.0 (0.0, 3.1)	1.0 (0.0, 2.7)	1.0 (0.0, 2.3)	0.3 (0.0, 1.2)	0.3 (0.0, 1.0)	0.3 (0.0, 0.9)
Lamb and mutton	1.1 (0.0, 3.2)	0.6 (0.0, 1.9)	0.8 (0.0, 2.0)	0.4 (0.0, 1.3)	0.2 (0.0, 0.9)	0.3 (0.0, 0.9)
Butter and margarine	0.3 (0.0, 1.5)	0.3 (0.0, 1.3)	0.3 (0.0, 1.1)	0.2 (0.0, 0.9)	0.2 (0.0, 0.9)	0.2 (0.0, 0.7)
Bread-based dishes	0.4 (0.0, 1.7)	0.1 (0.0, 0.7)	0.2 (0.0, 0.8)	0.1 (0.0, 0.5)	0.3 (0.0, 1.0)	0.2 (0.0, 0.6)
Other meat	0.1 (0.0, 0.6)	0.3 (0.0, 1.2)	0.2 (0.0, 0.8)	0.0 (0.0, 0.1)	0.0 (0.0, 0.0)	0.0 (0.0, 0.1)
Fats and oils	0.0 (0.0, 0.1)	0.0 (0.0, 0.1)	0.0 (0.0, 0.1)	0.0 (0.0, 0.1)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)
Snack bars*	0.0 (0.0, 0.0)	0.0 (0.0, 0.3)	0.0 (0.0, 0.2)	0.3 (0.0, 1.1)	0.0 (0.0, 0.3)	0.1 (0.0, 0.5)
Snack foods	0.0 (0.0, 0.1)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.0 (0.0, 0.1)	0.0 (0.0, 0.1)	0.0 (0.0, 0.1)

Table 7-4

Vitamin D sources, percent (95% CI), by gender and ethnicity.

	Māori			Non- Māori		
	Men	*Women*	*Total Māori*	*Men*	*Women*	*Total non-Māori*
Milk	26.9 (17.8, 36.0)	28.8(20.8,36.8)	28.0(22.0,34.0)	25.0(18.5,31.5)	25.4(19.2,31.6)	25.2 (20.729.7)
Butter and margarine	16.9 (9.3, 24.5)	19.3(12.4,26.2)	18.2(13.0,23.4)	23.2(16.9,29.5)	24.4(18.3,30.5)	23.9(19.5,28.3)
Fish and seafood	16.1 (8.6, 23.6)	15.2 (8.9, 21.5)	15.6(10.8,20.4)	13.4 (8.3, 18.5)	8.4 (4.5, 12.3)	10.8 (7.6, 14.0)
Eggs and egg dishes	8.3 (2.7, 13.9)	9.0 (4.0, 14.0)	8.7 (4.9, 12.5)	8.0 (3.9, 12.1)	8.7 (4.7, 12.7)	8.4 (5.5, 11.3)
Cakes and muffins	6.0 (1.1, 10.9)	3.2 (0.1, 6.3)	4.4 (1.7, 7.1)	6.1 (2.5, 9.7)	5.6 (2.3, 8.9)	5.8 (3.4, 8.2)
Bread	3.6 (0.0, 7.4)	3.7 (0.4, 7.0)	3.7 (1.2, 6.2)	4.1 (1.1, 7.1)	3.4 (0.8, 6.0)	3.7 (1.8, 5.6)
Non-alcoholic beverages	5.2 (0.6, 9.8)	4.0 (0.5, 7.5)	4.5 (1.7, 7.3)	2.5 (0.2, 4.8)	3.9 (1.2, 6.6)	3.2 (1.4, 5.0)
Puddings and desserts	3.4 (0.0, 7.1)	3.5 (0.3, 6.7)	3.4 (1.0, 5.8)	3.7 (0.9, 6.5)	2.9 (0.5, 5.3)	3.3 (1.5, 5.1)
Pork	2.8 (0.0, 6.2)	3.8 (0.4, 7.2)	3.4 (1.0, 5.8)	4.1 (1.1, 7.1)	4.3 (1.4, 7.2)	4.2 (2.1, 6.3)
Dairy products	2.2 (0.0, 5.2)	1.4 (0.0, 3.4)	1.7 (0.0, 3.4)	1.7 (0.0, 3.6)	2.8 (0.4, 5.2)	2.3 (0.8, 3.8)
Savoury sauces and condiments	2.3 (0.0, 5.3)	1.0 (0.0, 2.8)	1.6 (0.0, 3.3)	1.3 (0.0, 3.0)	1.6 (0.0, 3.4)	1.5 (0.3, 2.7)
Fats and oils	1.1 (0.0, 3.2)	1.4 (0.0, 3.5)	1.3 (0.0, 2.8)	0.9 (0.0, 2.3)	1.3 (0.0, 2.9)	1.1 (0.0, 2.2)
Cheese	1.0 (0.0, 3.1)	1.2 (0.0, 3.1)	1.1 (0.0, 2.5)	0.9 (0.0, 2.3)	1.2 (0.0, 2.7)	1.0 (0.0, 2.0)
Pies and pasties	0.5 (0.0, 2.0)	1.1 (0.0, 2.9)	0.8 (0.0, 2.0)	1.3 (0.0, 3.0)	1.2 (0.0, 2.8)	1.2 (0.1, 2.3)
Biscuits	0.4 (0.0, 1.6)	0.5 (0.0, 1.8)	0.5 (0.0, 1.4)	0.7 (0.0, 2.0)	1.3 (0.0, 2.9)	1.0 (0.0, 2.0)
Soups and stocks	0.4 (0.0, 1.6)	0.4 (0.0, 1.5)	0.4 (0.0, 1.2)	0.9 (0.0, 2.3)	1.2 (0.0, 2.7)	1.1 (0.0, 2.2)
Lamb and mutton	1.0 (0.0, 3.0)	0.9 (0.0, 2.6)	1.0 (0.0, 2.3)	0.4 (0.0, 1.3)	0.4 (0.0, 1.3)	0.4 (0.0, 1.1)
Beef and veal	1.1 (0.0, 3.2)	0.5 (0.0, 1.8)	0.8 (0.0, 2.0)	0.7 (0.0, 2.0)	0.2 (0.0, 0.9)	0.5 (0.0, 1.2)
Grains and pasta	0.5 (0.0, 1.9)	0.6 (0.0, 1.9)	0.5 (0.0, 1.5)	0.6 (0.0, 1.7)	0.6 (0.0, 1.7)	0.6 (0.0, 1.4)
Poultry	0.0 (0.0, 0.4)	0.0 (0.0, 0.0)	0.0 (0.0, 0.2)	0.2 (0.0, 0.9)	0.4 (0.0, 1.3)	0.3 (0.0, 0.9)
Vegetables	0.1 (0.0, 0.6)	0.1 (0.0, 0.7)	0.1 (0.0, 0.5)	0.1 (0.0, 0.5)	0.2 (0.0, 0.9)	0.2 (0.0, 0.6)
Potatoes, kumara and taro	0.1 (0.0, 0.8)	0.2 (0.0, 0.9)	0.1 (0.0, 0.6)	0.1 (0.0, 0.6)	0.1 (0.0, 0.6)	0.1 (0.0, 0.5)
Sausages and processed meats	0.1 (0.0, 0.7)	0.2 (0.0, 1.0)	0.1 (0.0, 0.6)	0.1 (0.0, 0.5)	0.1 (0.0, 0.5)	0.1 (0.0, 0.4)
Bread-based dishes	0.1 (0.0, 0.6)	0.1 (0.0, 0.6)	0.1 (0.0, 0.5)	0.0 (0.0, 0.1)	0.0 (0.0, 0.3)	0.0 (0.0, 0.2)
Sugar and sweets	0.0 (0.0, 0.0)	0.0 (0.0, 0.3)	0.0 (0.0, 0.2)	0.0 (0.0, 0.2)	0.1 (0.0, 0.5)	0.0 (0.0, 0.2)
Breakfast cereals	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.1 (0.0, 0.5)	0.0 (0.0, 0.2)
Other meat	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.0 (0.0, 0.2)	0.0 (0.0, 0.0)	0.0 (0.0, 0.1)
Alcoholic beverages	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)
Fruit	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)
Nuts and seeds	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)
Snack bars*	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)
Snack foods	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)

Table 7-5

Phosphorous sources, percent (95% CI), by gender and ethnicity.

	Māori			Non- Māori		
	Men	*Women*	*Total Māori*	*Men*	*Women*	*Total non-Māori*
Milk	14.9 (7.6,22.2)	16.7(10.1,23.3)	15.9(11.0,20.8)	16.6(11.0,22.2)	17.7(12.3,23.1)	17.2(13.3,21.1)
Bread	9.4 (3.4, 15.4)	11.9 (6.2,17.6)	10.9 (6.8,15.0)	10.3 (5.8,14.8)	9.8 (5.6,14.0)	10.1 (7.0, 13.2)
Breakfast cereals	6.6 (1.5, 11.7)	5.8 (1.7, 9.9)	6.1 (2.9, 9.3)	7.8 (3.8, 11.8)	6.8 (3.2,10.4)	7.3 (4.6, 10.0)
Beef and veal	6.3 (1.4, 11.2)	5.9 (1.7, 10.1)	6.1 (2.9, 9.3)	7.3 (3.4, 11.2)	5.0 (1.9, 8.1)	6.1 (3.6, 8.6)
Vegetables	4.6 (0.3, 8.9)	5.3 (1.4, 9.2)	5.0 (2.1, 7.9)	5.2 (1.9, 8.5)	6.0 (2.6, 9.4)	5.6 (3.2, 8.0)
Fish and seafood	8.0 (2.5, 13.5)	6.1 (1.9, 10.3)	6.9 (3.5, 10.3)	4.7 (1.5, 7.9)	3.3 (0.8, 5.8)	4.0 (2.0, 6.0)
Cheese	2.7 (0.0, 6.0)	4.2 (0.7, 7.7)	3.6 (1.1, 6.1)	4.7 (1.5, 7.9)	5.6 (2.3, 8.9)	5.2 (2.9, 7.5)
Pork	6.1 (1.2, 11.0)	5.4 (1.4, 9.4)	5.7 (2.6, 8.8)	4.0 (1.1, 6.9)	3.9 (1.1, 6.7)	4.0 (2.0, 6.0)
Poultry	5.7 (1.0, 10.4)	4.4 (0.8, 8.0)	4.9 (2.0, 7.8)	4.5 (1.4, 7.6)	3.6 (0.9, 6.3)	4.0 (2.0, 6.0)
Potatoes, kumara and taro	5.0 (0.5, 9.5)	4.1 (0.6, 7.6)	4.5 (1.7, 7.3)	4.1 (1.1, 7.1)	3.2 (0.7, 5.7)	3.6 (1.7, 5.5)
Cakes and muffins	3.9 (0.0, 7.9)	3.0 (0.0, 6.0)	3.4 (1.0, 5.8)	3.7 (0.9, 6.5)	4.2 (1.4, 7.0)	3.9 (1.9, 5.9)
Eggs and egg dishes	3.2 (0.0, 6.8)	3.4 (0.2, 6.6)	3.3 (0.9, 5.7)	3.0 (0.4, 5.6)	3.1 (0.6, 5.6)	3.0 (1.2, 4.8)
Fruit	1.8 (0.0, 4.5)	3.4 (0.2, 6.6)	2.7 (0.5, 4.9)	2.8 (0.3, 5.3)	4.0 (1.2, 6.8)	3.4 (1.5, 5.3)
Dairy products	2.9 (0.0, 6.4)	2.3 (0.0, 4.9)	2.6 (0.5, 4.7)	2.7 (0.3, 5.1)	3.9 (1.1, 6.7)	3.3 (1.4, 5.2)
Non-alcoholic beverages	2.3 (0.0, 5.3)	2.2 (0.0, 4.8)	2.2 (0.2, 4.2)	1.7 (0.0, 3.7)	2.5 (0.3, 4.7)	2.2 (0.7, 3.7)
Sausages and processed meats	2.9 (0.0, 6.3)	1.7 (0.0, 4.0)	2.2 (0.2, 4.2)	1.9 (0.0, 3.9)	1.8 (0.0, 3.7)	1.8 (0.4, 3.2)
Biscuits	1.4 (0.0, 3.8)	1.6 (0.0, 3.8)	1.5 (0.0, 3.1)	1.9 (0.0, 4.0)	2.0 (0.0, 4.0)	2.0 (0.6, 3.4)
Savoury sauces and condiments	1.4 (0.0, 3.8)	1.5 (0.0, 3.6)	1.4 (0.0, 3.0)	2.0 (0.0, 4.1)	1.9 (0.0, 3.8)	2.0 (0.6, 3.4)
Grains and pasta	1.3 (0.0, 3.6)	2.0 (0.0, 4.5)	1.7 (0.0, 3.4)	1.5 (0.0, 3.3)	2.2 (0.1, 4.3)	1.8 (0.4, 3.2)
Puddings and desserts	1.8 (0.0, 4.5)	1.5 (0.0, 3.7)	1.7 (0.0, 3.4)	1.8 (0.0, 3.8)	1.6 (0.0, 3.4)	1.7 (0.4, 3.0)
Soups and stocks	1.3 (0.0, 3.6)	1.6 (0.0, 3.8)	1.5 (0.0, 3.1)	1.6 (0.0, 3.5)	2.0 (0.0, 4.0)	1.8 (0.4, 3.2)
Pies and pasties	1.4 (0.0, 3.8)	1.3 (0.0, 3.3)	1.3 (0.0, 2.8)	1.7 (0.0, 3.6)	1.1 (0.0, 2.6)	1.3 (0.1, 2.5)
Lamb and mutton	2.4 (0.0, 5.5)	1.5 (0.0, 3.7)	1.9 (0.1, 3.7)	1.1 (0.0, 2.7)	1.4 (0.0, 3.1)	1.2 (0.1, 2.3)
Nuts and seeds	0.3 (0.0, 1.4)	0.8 (0.0, 2.4)	0.6 (0.0, 1.6)	1.0 (0.0, 2.5)	1.8 (0.0, 3.7)	1.4 (0.2, 2.6)
Alcoholic beverages	0.7 (0.0, 2.3)	0.5 (0.0, 1.7)	0.5 (0.0, 1.5)	1.0 (0.0, 2.5)	0.5 (0.0, 1.5)	0.8 (0.0, 1.7)
Sugar and sweets	0.3 (0.0, 1.5)	0.6 (0.0, 2.0)	0.5 (0.0, 1.4)	0.6 (0.0, 1.7)	0.5 (0.0, 1.5)	0.5 (0.0, 1.3)
Other meat	0.8 (0.0, 2.6)	0.6 (0.0, 2.0)	0.7 (0.0, 1.8)	0.1 (0.0, 0.4)	0.0 (0.0, 0.2)	0.0 (0.0, 0.2)
Bread-based dishes	0.4 (0.0, 1.8)	0.2 (0.0, 0.9)	0.3 (0.0, 1.0)	0.1 (0.0, 0.6)	0.2 (0.0, 0.9)	0.2 (0.0, 0.6)
Butter and margarine	0.2 (0.0, 1.0)	0.2 (0.0, 0.9)	0.2 (0.0, 0.7)	0.1 (0.0, 0.7)	0.1 (0.0, 0.6)	0.1 (0.0, 0.5)
Snack bars	0.0 (0.0, 0.0)	0.1 (0.0, 0.6)	0.0 (0.0, 0.3)	0.3 (0.0, 1.1)	0.1 (0.0, 0.4)	0.2 (0.0, 0.6)
Snack foods	0.0 (0.0, 0.1)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.0 (0.0, 0.2)	0.0 (0.0, 0.1)	0.0 (0.0, 0.1)

Table 7-6

Magnesium sources, percent (95% CI), by gender and ethnicity.

	Māori			Non- Māori		
	Men	*Women*	*Total Māori*	*Men*	*Women*	*Total non-Māori*
Bread	13.9 (6.8,21.0)	16.1 (9.6, 22.6)	15.2(10.4,20.0)	14.5 (9.2,19.8)	13.0(8.6,18.2)	13.9 (10.3,17.5)
Breakfast cereals	10.9 (4.5,17.3)	10.1 (4.8, 15.4)	10.4 (6.3, 14.5)	12.3 (7.4,17.2)	11.4(6.9,15.9)	11.9 (8.6, 15.2)
Fruit	6.7 (1.6, 11.8)	10.5 (5.1, 15.9)	8.9 (5.1, 12.7)	8.6 (4.4, 12.8)	12.5(7.8,17.2)	10.7 (7.5, 13.9)
Milk	8.9 (3.1, 14.7)	9.3 (4.2, 14.4)	9.1 (5.3, 12.9)	9.2 (4.9, 13.5)	9.4 (5.3, 13.5)	9.3 (6.3, 12.3)
Vegetables	7.6 (2.2, 13.0)	9.0 (4.0, 14.0)	8.4 (4.7, 12.1)	8.0 (4.0, 12.0)	9.3 (5.2, 13.4)	8.7 (5.8, 11.6)
Non-alcoholic beverages	8.3 (2.7, 13.9)	8.5 (3.6, 13.4)	8.4 (4.7, 12.1)	8.0 (3.9, 12.1)	9.5 (5.3, 13.7)	8.8 (5.9, 11.7)
Potatoes, kumara and taro	9.2 (3.3, 15.1)	7.3 (2.7, 11.9)	8.1 (4.5, 11.7)	7.3 (3.4, 11.2)	5.5 (2.3, 8.7)	6.4 (3.9, 8.9)
Fish and seafood	6.4 (1.4, 11.4)	4.6 (0.9, 8.3)	5.4 (2.4, 8.4)	3.3 (0.6, 6.0)	2.3 (0.2, 4.4)	2.8 (1.1, 4.5)
Beef and veal	3.8 (0.0, 7.7)	3.1 (0.1, 6.1)	3.4 (1.0, 5.8)	3.7 (0.9, 6.5)	2.4 (0.2, 4.6)	3.1 (1.3, 4.9)
Poultry	3.0 (0.0, 6.5)	2.1 (0.0, 4.6)	2.5 (0.4, 4.6)	2.4 (0.1, 4.7)	1.8 (0.0, 3.7)	2.0 (0.5, 3.5)
Pork	2.7 (0.0, 6.0)	2.1 (0.0, 4.6)	2.3 (0.3, 4.3)	1.4 (0.0, 3.2)	1.3 (0.0, 2.9)	1.3 (0.1, 2.5)
Cakes and muffins	2.3 (0.0, 5.3)	1.5 (0.0, 3.6)	1.8 (0.0, 3.6)	2.1 (0.0, 4.3)	2.2 (0.1, 4.3)	2.2 (0.7, 3.7)
Nuts and seeds	0.6 (0.0, 2.1)	1.2 (0.0, 3.1)	0.9 (0.0, 2.2)	1.7 (0.0, 3.7)	3.1 (0.6, 5.6)	2.5 (0.9, 4.1)
Alcoholic beverages	1.5 (0.0, 3.9)	1.0 (0.0, 2.7)	1.2 (0.0, 2.6)	2.3 (0.1, 4.5)	1.1 (0.0, 2.6)	1.7 (0.4, 3.0)
Biscuits	1.3 (0.0, 3.6)	1.4 (0.0, 3.5)	1.3 (0.0, 2.8)	1.7 (0.0, 3.6)	1.7 (0.0, 3.5)	1.7 (0.4, 3.0)
Dairy products	1.6 (0.0, 4.2)	1.1 (0.0, 3.0)	1.3 (0.0, 2.8)	1.3 (0.0, 3.0)	1.8 (0.0, 3.7)	1.6 (0.3, 2.9)
Savoury sauces and condiments	1.3 (0.0, 3.6)	1.4 (0.0, 3.4)	1.3 (0.0, 2.8)	1.8 (0.0, 3.8)	1.5 (0.0, 3.2)	1.6 (0.3, 2.9)
Grains and pasta	1.0 (0.0, 3.0)	1.6 (0.0, 3.8)	1.4 (0.0, 2.9)	1.3 (0.0, 3.0)	1.6 (0.0, 3.4)	1.4 (0.2, 2.6)
Soups and stocks	1.4 (0.0, 3.8)	1.5 (0.0, 3.6)	1.4 (0.0, 3.0)	1.9 (0.0, 3.9)	2.2 (0.1, 4.3)	2.1 (0.6, 3.6)
Pies and pasties	1.2 (0.0, 3.4)	0.9 (0.0, 2.6)	1.0 (0.0, 2.3)	1.2 (0.0, 2.8)	0.7 (0.0, 1.9)	0.9 (0.0, 1.9)
Cheese	0.7 (0.0, 2.4)	1.0 (0.0, 2.7)	0.9 (0.0, 2.1)	1.1 (0.0, 2.7)	1.3 (0.0, 2.9)	1.2 (0.1, 2.3)
Sausages and processed meats	1.2 (0.0, 3.5)	0.8 (0.0, 2.3)	1.0 (0.0, 2.3)	0.8 (0.0, 2.1)	0.7 (0.0, 1.9)	0.8 (0.0, 1.7)
Sugar and sweets	0.7 (0.0, 2.4)	0.9 (0.0, 2.6)	0.8 (0.0, 2.0)	1.2 (0.0, 2.8)	0.8 (0.0, 2.1)	1.0 (0.0, 2.0)
Puddings and desserts	1.0 (0.0, 3.0)	0.7 (0.0, 2.2)	0.8 (0.0, 2.0)	0.9 (0.0, 2.3)	0.9 (0.0, 2.2)	0.9 (0.0, 1.9)
Eggs and egg dishes	0.9 (0.0, 2.8)	0.9 (0.0, 2.6)	0.9 (0.0, 2.2)	0.8 (0.0, 2.1)	0.7 (0.0, 1.9)	0.8 (0.0, 1.7)
Lamb and mutton	1.4 (0.0, 3.8)	0.7 (0.0, 2.2)	1.0 (0.0, 2.3)	0.6 (0.0, 1.7)	0.6 (0.0, 1.7)	0.6 (0.0, 1.4)
Bread-based dishes	0.4 (0.0, 1.7)	0.1 (0.0, 0.8)	0.2 (0.0, 0.9)	0.1 (0.0, 0.5)	0.1 (0.0, 0.6)	0.1 (0.0, 0.4)
Snack bars	0.0 (0.0, 0.0)	0.2 (0.0, 0.9)	0.1 (0.0, 0.5)	0.4 (0.0, 1.3)	0.1 (0.0, 0.5)	0.2 (0.0, 0.7)
Other meat	0.5 (0.0, 1.9)	0.3 (0.0, 1.2)	0.3 (0.0, 1.1)	0.0 (0.0, 0.2)	0.0 (0.0, 0.1)	0.0 (0.0, 0.1)
Butter and margarine	0.1 (0.0, 0.7)	0.1 (0.0, 0.6)	0.1 (0.0, 0.5)	0.1 (0.0, 0.5)	0.1 (0.0, 0.5)	0.1 (0.0, 0.4)
Snack foods	0.0 (0.0, 0.1)	0.0 (0.0, 0.0)	0.0 (0.0, 0.1)	0.0 (0.0, 0.2)	0.0 (0.0, 0.1)	0.0 (0.0, 0.1)

Table 7-7

Potassium sources, percent (95% CI), by gender and ethnicity.

	Māori			Non- Māori		
	Men	*Women*	*Total Māori*	*Men*	*Women*	*Total non-Māori*
Potatoes, kumara and taro	15.7 (8.3,23.1)	13.4 (7.4,19.4)	14.4 (9.7,19.1)	14.2 (9.0, 19.4)	10.7 (6.3, 15.1)	12.4 (9.0, 15.8)
Fruit	8.4 (2.7, 14.1)	14.1 (8.0,20.2)	11.7 (7.4,16.0)	11.8 (7.0, 16.6)	16.5 (11.2,21.8)	14.3 (10.7, 17.9)
Vegetables	11.7 (5.1,18.3)	13.4 (7.4,19.4)	12.7 (8.3,17.1)	12.2 (7.3, 17.1)	14.3 (9.3, 19.3)	13.3 (9.8, 16.8)
Milk	11.2 (4.8,17.6)	11.4 (5.8,17.0)	11.3 (7.1,15.5)	11.2 (6.5, 15.9)	11.7 (7.1, 16.3)	11.4 (8.1, 14.7)
Non-alcoholic beverages	8.0 (2.5, 13.5)	8.5 (3.6, 13.4)	8.3 (4.6, 12.0)	8.0 (4.0, 12.0)	9.2 (5.1, 13.3)	8.6 (5.7, 11.5)
Bread	6.0 (1.1, 10.9)	7.0 (2.5, 11.5)	6.6 (3.3, 9.9)	6.4 (2.8, 10.0)	5.8 (2.5, 9.1)	6.0 (3.5, 8.5)
Fish and seafood	5.5 (0.8, 10.2)	4.5 (0.8, 8.2)	5.0 (2.1, 7.9)	3.6 (0.8, 6.4)	2.4 (0.2, 4.6)	3.0 (1.3, 4.7)
Beef and veal	5.0 (0.5, 9.5)	3.9 (0.5, 7.3)	4.3 (1.6, 7.0)	4.8 (1.6, 8.0)	3.4 (0.8, 6.0)	4.1 (2.1, 6.1)
Breakfast cereals	3.4 (0.0, 7.1)	2.7 (0.0, 5.6)	3.0 (0.7, 5.3)	3.9 (1.0, 6.8)	3.2 (0.7, 5.7)	3.5 (1.6, 5.4)
Soups and stocks	2.0 (0.0, 4.9)	2.4 (0.0, 5.1)	2.3 (0.3, 4.3)	3.0 (0.5, 5.5)	3.2 (0.7, 5.7)	3.1 (1.3, 4.9)
Pork	3.5 (0.0, 7.2)	3.1 (0.1, 6.1)	3.2 (0.8, 5.6)	2.1 (0.0, 4.3)	2.0 (0.0, 4.0)	2.0 (0.5, 3.5)
Poultry	3.1 (0.0, 6.6)	2.3 (0.0, 4.9)	2.6 (0.5, 4.7)	2.5 (0.2, 4.8)	1.9 (0.0, 3.9)	2.2 (0.7, 3.7)
Dairy products	2.2 (0.0, 5.2)	1.7 (0.0, 4.0)	1.9 (0.1, 3.7)	2.0 (0.0, 4.1)	2.8 (0.4, 5.2)	2.4 (0.8, 4.0)
Cakes and muffins	2.1 (0.0, 5.0)	1.2 (0.0, 3.1)	1.6 (0.0, 3.3)	2.1 (0.0, 4.2)	1.9 (0.0, 3.8)	2.0 (0.6, 3.4)
Savoury sauces and condiments	1.5 (0.0, 3.9)	1.4 (0.0, 3.5)	1.4 (0.0, 3.0)	1.9 (0.0, 4.0)	1.6 (0.0, 3.4)	1.8 (0.4, 3.2)
Biscuits	0.9 (0.0, 2.8)	0.9 (0.0, 2.6)	0.9 (0.0, 2.2)	1.2 (0.0, 2.8)	1.2 (0.0, 2.8)	1.2 (0.1, 2.3)
Puddings and desserts	1.3 (0.0, 3.6)	0.9 (0.0, 2.6)	1.1 (0.0, 2.5)	1.2 (0.0, 2.9)	1.0 (0.0, 2.4)	1.1 (0.0, 2.2)
Eggs and egg dishes	1.2 (0.0, 3.4)	1.1 (0.0, 2.9)	1.1 (0.0, 2.5)	0.9 (0.0, 2.3)	0.9 (0.0, 2.3)	0.9 (0.0, 1.9)
Grains and pasta	0.7 (0.0, 2.4)	1.0 (0.0, 2.7)	0.9 (0.0, 2.1)	0.8 (0.0, 2.1)	1.2 (0.0, 2.8)	1.0 (0.0, 2.0)
Pies and pasties	1.0 (0.0, 3.1)	0.9 (0.0, 2.6)	1.0 (0.0, 2.3)	1.1 (0.0, 2.7)	0.6 (0.0, 1.7)	0.9 (0.0, 1.9)
Lamb and mutton	1.5 (0.0, 4.0)	0.8 (0.0, 2.4)	1.1 (0.0, 2.5)	0.7 (0.0, 1.9)	0.7 (0.0, 1.9)	0.7 (0.0, 1.5)
Sausages and processed meats	1.3 (0.0, 3.6)	0.7 (0.0, 2.2)	1.0 (0.0, 2.3)	0.8 (0.0, 2.1)	0.7 (0.0, 1.9)	0.7 (0.0, 1.6)
Sugar and sweets	0.6 (0.0, 2.2)	0.8 (0.0, 2.4)	0.7 (0.0, 1.8)	0.9 (0.0, 2.3)	0.6 (0.0, 1.7)	0.8 (0.0, 1.7)
Alcoholic beverages	0.8 (0.0, 2.6)	0.5 (0.0, 1.7)	0.6 (0.0, 1.6)	1.3 (0.0, 3.0)	0.6 (0.0, 1.7)	0.9 (0.0, 1.9)
Nuts and seeds	0.2 (0.0, 1.0)	0.5 (0.0, 1.7)	0.3 (0.0, 1.1)	0.5 (0.0, 1.6)	1.0 (0.0, 2.4)	0.8 (0.0, 1.7)
Cheese	0.2 (0.0, 1.1)	0.3 (0.0, 1.2)	0.2 (0.0, 0.9)	0.3 (0.0, 1.2)	0.4 (0.0, 1.3)	0.4 (0.0, 1.0)
Other meat	0.6 (0.0, 2.2)	0.3 (0.0, 1.3)	0.4 (0.0, 1.3)	0.0 (0.0, 0.2)	0.0 (0.0, 0.1)	0.0 (0.0, 0.1)
Butter and margarine	0.2 (0.0, 1.1)	0.2 (0.0, 0.9)	0.2 (0.0, 0.8)	0.2 (0.0, 0.8)	0.2 (0.0, 0.8)	0.2 (0.0, 0.6)
Bread-based dishes	0.3 (0.0, 1.4)	0.1 (0.0, 0.7)	0.2 (0.0, 0.8)	0.0 (0.0, 0.3)	0.1 (0.0, 0.6)	0.1 (0.0, 0.4)
Snack bars	0.0 (0.0, 0.0)	0.0 (0.0, 0.4)	0.0 (0.0, 0.2)	0.2 (0.0, 0.9)	0.1 (0.0, 0.4)	0.1 (0.0, 0.5)
Snack foods	0.0 (0.0, 0.1)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.0 (0.0, 0.2)	0.0 (0.0, 0.1)	0.0 (0.0, 0.1)
Fats and oils	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)