Dietary Calcium Intake and Food Sources in Older Adults Living in Auckland, New Zealand

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

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Chaitra Arya Gubbi Kotewodeyar

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ABSTRACT

BACKGROUND

The New Zealand population is aging. Aging notably affects bone health, and maintaining healthy bones is essential for overall mobility and physical function. Maintaining bone health can help alleviate conditions such as osteoporosis and osteoarthritis. Calcium intake is crucial for preserving bone density, muscle function, nerve impulse transmission, and hormonal activities. For older adults, adequate calcium intake is particularly important to mitigate the risk of osteoporosis and fractures, which are common in this age group. Despite its importance, many older adults often fail to meet the recommended dietary intake of calcium, leading to significant health implications.

Dietary calcium can be obtained from various food sources, including dairy products, leafy green vegetables, nuts, seeds, and fortified foods. Among these dairy products are the most significant contributors to calcium intake in Western diets. However, there is limited data regarding calcium intake and food sources of calcium in older New Zealand adults.

AIM

This research aims to investigate calcium intake and to identify the main food items contributing to calcium intake in community-dwelling older adults (65 to 74 years) living in Auckland, New Zealand.

METHODS

This sub-study was undertaken as part of the REACH (Researching Eating, Activity and Cognitive Health) study, a cross-sectional study investigating dietary patterns, cognitive health and metabolic syndrome in older adults aged 65-74 years living in Auckland, New Zealand. A 4-day food diary was used to assess dietary calcium intake, and food sources contributing to calcium intake.
Socio-demographic details, such as age, gender, ethnicity, education, were comprehensively recorded. Anthropometric data was collected including height and weight. Body Mass Index (BMI) was subsequently calculated based on the formula weight (kg) / height (m^2).

RESULTS

The REACH study encompassed 371 individuals, with food diaries available for 330 participants (114 males, and 216 females). The average energy intake for males was 9374 kj/day, whereas for females, it was 7450 kj/day. Calcium intake was 877mg/day for females and 997 mg/day for males, compared with the Estimated Average Requirement (EAR) of 1100mg/day. For females 65-69 years, 30% consumed less than the EAR. This percentage was 21% for females 70-74 years, and 10 % and 12% for males 65-69 and 70-74 years, respectively. The main food source of calcium was milk and milk products for the total population (providing 273mg/day in females and 342mg of calcium/day in males), followed by cheese (157mg/day in females and 173mg/day in males), and yogurt (93mg/day in females and 127mg/day males).

CONCLUSION

Findings from this study reflect a high prevalence of inadequate dietary calcium intakes, particularly in females aged 65 to 74 years living in Auckland, New Zealand. Dairy products provided the most calcium within these participants' diets. Further research is needed to determine appropriate ways to optimize the calcium intake in older adults who have a low intake of calcium.

ACKNOWLEDGEMENTS

First and foremost, thanks to God, for his showers of blessings throughout my research work to complete the research successfully.

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LIST OF ABBREVATIONS

REACH	Researching Eating, Activity and Cognitive Health
BMD	Bone Mineral Density
NRV	Nutrient Reference Values
SACN	Scientific Advisory Committee on Nutrition
IOM	Institute of Medicine
EFSA	European Food Safety Authority
AI	Average Intake
EAR	Estimated Average Requirement
RDI	Recommended Dietary Intake
RDA	Recommended Dietary Allowance
UL	Upper Level of Intake
AR	Average Intake
PRI	Population Reference Intake
BMD	Bone Mineral Density
Hrqol	Health-Related Quality of Life
PTH	Parathyroid Hormone
ECF	Extracellular Fluids
IPAQ	International Physical Activity Questionnaire
SD	Standard Deviation
NZANS	New Zealand Adult Nutrition Survey
Kj	Kilo Joules
QALYs	Quality Adjusted Life Years
<	Less than
≤	Equal to or less than
>	Greater than
≥	Equal to or greater than

CHAPTER 1 – INTRODUCTION

1.1 BACKGROUND

As the global population ages (1), the health and well-being of older adults becomes increasingly significant. The concept of aging is complex and multi-faceted, encompassing not only biological changes but also psychological and social dimensions (2). Aging is associated with a range of physiological changes that can impact nutritional requirements and nutrient absorption (3). Older adults are often faced with declining appetites, altered taste perceptions, and reduced digestive capacities, all of which can influence their dietary choices and nutrient intake (4). It is vital to pay special attention to the nutritional needs of older adults, as their bodies become less efficient at absorbing and utilizing nutrients (5).

One crucial determinant of health in older adults is their nutritional status, particularly their intake of essential nutrients like calcium. The aging process significantly impacts bone health, and calcium plays a vital role in preserving robust and well-maintained bones. Bone mass, a key factor in determining bone strength, naturally diminishes with age, giving rise to conditions like osteopenia and osteoporosis (6). These conditions make older individuals more susceptible to fractures, especially in areas such as the hip, spine, and wrist. Osteoporotic fractures not only cause physical pain but can also result in a loss of independence, decreased mobility, and elevated mortality rates (7, 8). Maintaining adequate calcium intake is critical for preserving bone density and minimizing the risk of fractures, particularly in post-menopausal women and older adults.

Calcium is a crucial mineral, with its importance lying in the maintenance of bones and teeth, the control of muscle functions, the transmission of nerve impulses, and the facilitation of crucial hormonal and enzymatic activities. It predominantly resides in teeth and bones, where it offers structural integrity and fortification. Ensuring sufficient calcium intake is of utmost importance as individuals age, especially for post-menopausal women, as it plays a vital role in safeguarding bone density and minimizing susceptibility to bone-related issues like osteoporosis and fractures (9). Like many other countries, New Zealand is experiencing a demographic shift towards an aging population, thereby heightening the importance of understanding the dietary habits, calcium intake and sources of calcium among its older adults.

Data from the 2008/2009 Adult Nutrition Survey conducted in New Zealand, revealed that the median usual daily intake of calcium was 919 mg for males and 745 mg for females. In males, those aged 31 – 50 years had the highest intake of calcium, whereas males aged 51 – 70 years and 71+ years had the lowest lower intakes of calcium. Females aged 31–50 years had higher intakes than females aged 71+ years, while females aged 15–18 years were the lowest calcium consumers. The estimated prevalence of inadequate intake of calcium was 45% for males and 73% for females (10). Individuals aged 51 years and older predominantly derived their dietary calcium from milk and bread. Specifically, among men aged 51 to 70 years, approximately 30% identified milk as their primary calcium source, while this figure increased to 34% among men aged 71 years and older. Similarly, for women aged 51 to 70 years and 71 years and older, 29.2% and 31.7% respectively reported milk as their main calcium source. Consumption of milk, yogurt, and cheese, foods rich in calcium, slows bone loss (11). For individuals with a calcium intake of 500-900mg per day, increasing their intake by 500-1000mg per day has been found to have a positive impact on their bone mineral density (BMD) (12).

This study explores dietary calcium intake and food sources of calcium among older adults residing in Auckland, New Zealand. By examining calcium intake and the predominant food sources contributing to calcium consumption, this research seeks to enhance our understanding of the dietary practices of older adults in Auckland and potentially provide insights into their overall health outcomes. This study is motivated by the lack of research on calcium intake, especially for older adults residing in New Zealand.

1.2 STATEMENT OF THE PROBLEM

While the importance of calcium intake in older adults is well-recognized, there is limited information available regarding the major food sources contributing to calcium consumption among older adults in New Zealand. It is crucial to ascertain whether older adults are meeting their calcium requirements through their diet. Additionally, understanding the specific food sources that provide calcium among older adults can help to guide targeted dietary recommendations and interventions that promote and improve bone health.

1.3 AIM

The aim of this research is to investigate the amount of calcium community-dwelling older adults (65-74 years) living in Auckland, New Zealand consume in their diet and identify the main food items that contribute to calcium intake.

1.4 OBJECTIVES

This research has two primary objectives. Firstly, it aims to comprehensively compare the dietary calcium intake of older adults and the Nutrient Reference Values for calcium intake established for older adults aged 65 to 74 years in New Zealand. This comparison will provide insights into the extent to which the dietary calcium intake of older adults aligns with the recommended guidelines. Secondly, this study focuses on identifying food sources contributing to dietary calcium consumption among older adults living in Auckland, New Zealand.

1.5 STRUCTURE OF THE THESIS

This thesis is organized into four main chapters that collectively address the research aim, objectives and contribute to the existing body of knowledge regarding calcium intake and food sources among older adults living in New Zealand.

Chapter 1 introduces the research topic, highlighting the importance of calcium intake for older adults' health, and outlining the study's background, a problem statement, aims, objectives, and overall structure of the thesis. Chapter 2 presents a comprehensive literature review that delves into various aspects of aging, calcium metabolism, and calcium recommendations for older adults. This review further explores the existing literature on dietary calcium intake among older adults living in New Zealand, as well identifies food sources of calcium. Chapter 3 is presented in manuscript format and describes the methodology employed in this study, including the study design, participant recruitment, data collection methods, and statistical analyses conducted. It offers insight into how the research objectives were operationalized and data were collected to answer the research questions. Chapter 3 presents the findings of the study, which include a

detailed analysis of dietary calcium intake among older adults in Auckland, New Zealand, and the identification of major food sources contributing to their calcium consumption. Chapter 4 presents a discussion and conclusion, with the findings discussed in the context of the thesis aims and existing literature.

1.6 RESEARCH CONTRIBUTIONS

Table 1. Contribution of each researcher to the completion of the study.

Researcher	Roles and Contributions to Thesis
Chaitra Arya Gubbi Kotewodeyar	Primary researcher and author of present study (secondary data analysis). Interpretation of data, writing, editing, and final preparation of thesis and manuscript.
Professor Kathryn Beck	Professor, School of Sport, Exercise and Nutrition, Massey University. Primary supervisor of the study. Principal investigator of the REACH study. Application for research ethics, development of questionnaires, assistance with data collection and interpretation of the data. Assistance with reading, editing and final preparation of the thesis.
Professor Cathryn Conlon	Professor, School of Sport, Exercise and Nutrition, Massey University. Co-investigator of the REACH study. Assistance with data collection and interpretation of data, development of REACH study protocols. Assistance with reading and editing of thesis.
Dr Karen Mumme	Data management and statistical analysis. Assistance with data collection.

Chapter 2 - Literature Review

2.1 The aging population internationally and in New Zealand

Aging as defined by World Health Organization states that “At the biological level, aging results from the impact of the accumulation of molecular and cellular damage over time” (13). The global population is experiencing a rapid aging trend. In 2022, there were approximately 771 million individuals aged 65 years and older worldwide, constituting nearly 10% of the total global population. This demographic group is expanding at an accelerating pace and is projected to reach 16% by 2050, with further estimates indicating it could reach 24% by the year 2100 (14). As the world's population gets older, the 34th Census of Population and Dwellings in New Zealand on March 6th, 2018, revealed a resident population of 4,699,755. A notable portion of this population consists of older adults, with 715,200 people aged 65 and over, making up approximately 15.2% of the total population (15). As of 2018, Auckland was home to 189,177 permanent residents aged 65 years and above. It's worth noting that there were more older females than older males in Auckland, with a ratio of 117 females for every 100 males (16). The older population constituted 12% of the entire Auckland populace. Figure 1 presents data regarding the demographic composition of individuals aged between 65 and 74 years in New Zealand across an 11-year time frame, spanning from 2012 to 2022. The figure demonstrates a persistent and uninterrupted growth pattern in the population segment aged 65 to 74 years (15).

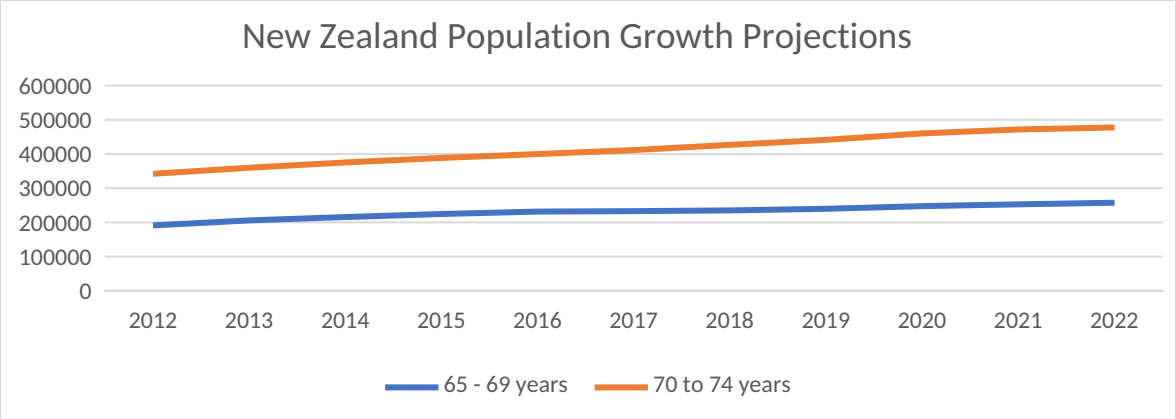

Figure 1 New Zealand population growth projections.

2.2 Nutritional health of older people

The aging process brings about health, physiological, and functional changes that can affect nutritional requirements and nutrient consumption (17). Human aging constitutes an irreversible progression characterized by alterations in morphology, functionality, and biochemistry within the human organism, encompassing the musculoskeletal system (18), which often results in a combination of factors that tend to contribute to less favorable dietary habits (19).

The progressive decline in muscle mass and function, known as sarcopenia, along with the reduction in bone mass denoted as osteopenia or osteoporosis, as individuals age, presents a considerable health concern among older adults. If unaddressed, these conditions can significantly impact independence during the later stages of life (6).

2.3 Bone Health

The activity of bone cells shapes the bone structure and composition through the processes of modeling and remodeling (20). Three main cell types are involved in these processes: osteoblasts, which produce the mineralized bone matrix; osteoclasts, which resorb the bone matrix; and osteocytes, which regulate both modeling and remodeling (20). Bone remodeling is a continuous and coordinated cycle where osteoclasts remove old bone and osteoblasts deposit new bone in response to microdamage and mechanical stress. This process occurs throughout life (21). During the first three decades, bone turnover is tightly regulated to maintain a balance between bone resorption and formation, achieving peak bone mass around ages 15-20 years in women and later in men (22). During this period, bone mass attainment determines skeletal strength and BMD into adulthood (23). Consequently, any factors that negatively affect bone acquisition during childhood or adolescence can have long-term detrimental effects on bone health, increasing the likelihood of osteoporosis and fractures later in life (24). Later in life, menopause in women significantly increases bone resorption over formation due to low levels of estrogens thus inducing accelerated bone loss.(21)

Mineral salts play a crucial role in the body's structure and function. They are involved in skeletal and soft tissue functions, as well as in regulatory processes such as neuromuscular transmission, blood clotting, oxygen transport, and enzymatic activity. Some of the primary minerals found in

bones are calcium, phosphorus and magnesium. Calcium is the most abundant mineral in the human body, making up 1.5 to 2% of the total body weight. Phosphorus, along with calcium, is essential for calcification of bones (85% of body phosphorus is found in the skeleton). Of total body magnesium, 60 to 65% is found in bone and 27% is located in muscles (25).

2.4 Importance of calcium in older adults including health implications of inadequate or excess calcium intake

Calcium plays a pivotal role not only in maintaining optimal bone health but also in facilitating neuromuscular functions, blood coagulation, and normal cardiac activity (26). Older individuals have an increased need for calcium because their bodies experience a heightened rate of bone breakdown with advancing age. It becomes especially crucial for post-menopausal and older women to ensure they are obtaining sufficient calcium as they face the highest risk of developing osteoporosis and experiencing fractures (26). From middle age onwards, both men and women encounter age-related bone loss, typically occurring at a rate of 0.5–1.0% per year (27). However, during a specific period spanning 5–10 years, which includes the menopausal transition and the subsequent years, women tend to lose bone at an accelerated pace, with an annual rate of loss of around 2–3% (12, 28). This heightened bone loss in women during this phase can be primarily attributed to the decline in estrogen levels during menopause. This hormonal shift leads to reduced calcium absorption in the intestines, increased calcium excretion in the kidneys, heightened secretion of parathyroid hormone (PTH), and increased bone resorption (29). Importantly, for post -menopausal women, there is evidence suggesting that a high calcium intake can help mitigate the rate of bone loss and potentially reduce the risk of fractures (30). The average concentration of calcium in the blood is 2.1 - 2.55 mmol/L (31).

Inadequate dietary calcium intake can have detrimental effects on bone metabolism, potentially leading to the development of osteopenia or osteoporosis (32). Osteopenia, characterized by a reduction in bone mass, often progresses to osteoporosis, a condition marked by significantly lowered bone mineral density and an increased rate of bone loss (33). The primary driver of osteopenia is the natural aging process, which accelerates skeletal aging, particularly in women, compared to men. This acceleration is primarily attributed to hormonal changes that occur post-

menopause (33). Osteoporosis frequently leads to bone fractures, resulting in substantial morbidity, especially among older individuals in Australia and New Zealand, with postmenopausal women being particularly vulnerable to this condition (34). Among these fractures, hip fractures are of utmost concern due to their significant impact on morbidity and mortality rates (32). It is estimated that the global incidence of hip fractures will rise from 1.66 million in 1990 to a staggering 6.26 million by the year 2050 (35). Osteoporosis and osteoporotic fractures impose a substantial burden on New Zealand's health system (36). In 2007, New Zealand saw an estimated 84,354 osteoporotic fractures, resulting in a loss of 11,249 QALYs (Quality Adjusted Life Years) and a total direct cost of $NZ330 million(37). Although many patients tend to experience improvements in their Health Status (HS) and Health-Related Quality of Life (HRQoL) within the first six months following a fracture, their overall well-being often does not fully return to its pre-fracture state. A hip fracture can have enduring effects on the physical, social, and emotional dimensions of a patient's functioning (38).

A study (39) of 197,848 community-dwelling postmenopausal women (7784 blacks, 1912 Asians, 6973 Hispanics, and 1708 Native Americans) from the United States, found that after adjusting for BMD, weight, and other factors, white and Hispanic women had the highest fracture risks, followed by Native Americans, blacks, and Asians. The findings suggested the need for ethnic-specific clinical recommendations due to varying absolute fracture risks (39).

A New Zealand study (40) done in 1995 observed an average of 733 hip fractures per year, affecting 710 individuals. Age-adjusted incidence rates were 571.5 per 100,000 for women and 318.2 per 100,000 for men. Individuals of European descent accounted for 97.0% of hip fractures, with Māori and Pacific Island populations having rates 25-50% lower. Incidence rates among Māori and Pacific Island populations were similar for men and women (40).

The process of aging significantly influences bone mineralization, and this effect may be further compounded by lactose malabsorption. As individuals age, there tends to be a growing prevalence of lactose intolerance, primarily attributed to a gradual reduction in the functionality of lactase, the enzyme responsible for metabolizing lactose found in milk and dairy products (41). This intolerance can significantly impact the nutritional well-being of older adults, potentially leading to challenges in meeting the recommended dietary intake of essential nutrients like calcium and vitamin D, crucial for maintaining bone health and overall well-being. Within New Zealand,

lactose malabsorption tends to manifest more frequently among older women, while it remains relatively uncommon among younger adults (42). In cases where individuals have lactase deficiency, lactose malabsorption does not significantly affect calcium absorption (41). However, the influence of lactose on calcium absorption in older adults remains a topic of debate, with inconclusive evidence. Schuette et al (43) conducted a study using a single isotope calcium test, which revealed that the inclusion of 12g of lactose in a non-carbohydrate milk formula led to increased calcium absorption in postmenopausal women. In contrast, Obermayer-Pietsch et al (44) demonstrated that calcium absorption in postmenopausal women with a genetic predisposition to lactose maldigestion was 56% lower when they consumed water containing 50g of lactose compared to water alone. Hence, the impact of lactose on calcium absorption may vary depending on the specific food source and the dosage of lactose.

2.5 Calcium physiology in older adults

Calcium is an elemental substance that cannot be synthesized by any biological mechanisms. It is exclusively introduced into the body via dietary means. Calcium holds a significant function in the mineralization of the skeleton. Over 99% of the body's calcium is stored in bones as calcium hydroxyapatite, contributing to skeletal fortitude, and functioning as a reservoir for calcium release into the bloodstream (45). Less than 1% is found in extracellular serum calcium (9). Hormones play a pivotal role in preserving the balance of calcium within the body by regulating its movement in the gut, kidneys, and bones. The three key hormones responsible for this regulation are parathyroid hormone (PTH), 1,25-dihydroxyvitamin D-3 (Vitamin D3), and calcitonin (45).

Calcium homeostasis is regulated through two distinct pathways: the activation of one pathway occurs in response to subnormal serum calcium concentrations, while the initiation of the other pathway is prompted by elevated serum calcium levels (46). The skeletal system serves as a reservoir for calcium, wherein the body stores calcium within bones in response to excessive blood levels and liberates calcium when blood levels experience depletion (46). If there is a decline in serum calcium levels, the parathyroid hormone (PTH) signals the release of calcium from the bones into the bloodstream. This hormone can also trigger the activation of vitamin D to enhance calcium absorption within the intestines. Concurrently, PTH prompts the kidneys to diminish the

excretion of calcium in the urine. Conversely, when the body maintains sufficient calcium levels, an alternative hormone, calcitonin, operates contrarily: it mitigates blood calcium levels by restraining the release of calcium from bones and directing the kidneys to augment calcium excretion through urine (47). Dietary intake is essential to fulfill the body's calcium requirements, as calcium is continually lost through processes such as urination, bowel movements, perspiration, hair shedding, and skin exfoliation (48). Calcium absorption depends on vitamin D, phosphorus, alkaline agents and thiazide diuretics. Conversely, acidifying agents, sodium, protein, caffeine, the occurrence of oxalates, fiber, and phytic acid contribute to heightened renal excretion, thereby diminishing calcium absorption (23).

2.6 Dietary calcium recommendation for New Zealanders and other global populations

Table 2 provides dietary calcium recommendations for males and females in two age categories (51 to 70 and more than 70 years), specifying values for Estimated Average Requirement (EAR), Recommended Dietary Intake (RDI), and Tolerable Upper Intake Level (UL) for calcium in milligrams per day (mg/day), according to the Nutrition Reference Values for Australia and New Zealand (49).

Table 2. Nutrition Reference Values for older Australian and New Zealand adults.

Gender	Age	Calcium mg/day		
		EAR (mg/day)	RDI (mg/day)	UL (mg/day)
Male	51-70 years	840	1000	2500
	>70 years	1100	1300	2500
Female	51-70 years	1100	1300	2500
	>70 years	1100	1300	2500

Abbreviations: EAR (Estimated Average Requirement) – this represents the estimated amount of calcium that meets the needs of about half of the individuals in a specific gender and age group. It is the minimum amount required to prevent deficiency; RDI (Recommended Dietary Intake) – the RDI represents the recommended daily intake of calcium for maintaining good health in the majority of individuals in a specific gender and age group. It has a higher value than EAR and is generally used for planning diets; UL (upper level of intake) - the UL represents the highest daily intake of calcium that is unlikely to cause adverse health effects in almost all individuals. It serves as a safety threshold to avoid excessive calcium intake, which could potentially lead to health problems (49).

Table 3 depicts the list of recommended intakes of calcium from overseas health organizations for males and females aged 51-70 years and >70 years. These groups account for the fact that calcium needs may change as individuals get older. This table provides dietary reference values for calcium intake recommendations for different gender and age groups from various organizations or regions, including Australia and New Zealand (NRV - Nutrient Reference Value), the UK (SACN - Scientific Advisory Committee on Nutrition), the USA and Canada (IOM - Institute of Medicine), FAO- Food and Agriculture Organization/WHO – Word Health Organization, NIH – National Institute of Health, and European (EFSA - European Food Safety Authority). While taking into account recommendations from different sources, it is important that individuals aim for at least the RDI or RDA to ensure adequate calcium intake for maintaining healthy bones and other bodily functions (50).

Table 3. Global recommended daily calcium intake by older adults.

Sex	Age (years)	Australia and New Zealand (NRV)		UK (SACN)		USA and Canada (IOM)		FAO/WHO		NIH	European (EFSA)	
		EAR (mg/d)	RDI (mg/d)	EAR (mg/d)	RDI (mg/d)	RDA (mg/d)	EAR (mg/d)	EAR (mg/d)	RDI (mg/d)	RDI (mg/d)	AR (mg/d)	PRI (mg/d)
Male	51-70	840	1000	525	700	1000	800	840	1000	1000	750	950
	>70	1100	1300	525	700	1200	800	840	1000	1200	750	950
Female	51-70	1100	1300	525	700	1200	1000	840	1000	1200	750	950
	>70	1100	1300	525	700	1200	1000	840	1000	1200	750	950

Abbreviations: All the values are mg/day. NRV: Nutrient Reference Value, SACN: Scientific Advisory Committee on Nutrition. IOM: Institute of Medicine. FAO: Food and Agriculture Organization/WHO: World Health Organization, NIH: National Institute of Health, EFSA: European Food Safety Authority; AI: Average Intake EAR: Estimated Average Requirement; RDI: Recommended Dietary Intake; RDA: Recommended Dietary Allowance; UL: Upper Level of Intake; AR: average requirement - this indicates calcium intake values within which most individuals' needs are likely to be met; PRI:- Population Reference Intake - this refers to the intake value recommended for the entire population, taking into account individual variations in requirements.

2.7 Dietary calcium intake in older adults

Most populations of countries surveyed in South, East, and Southeast Asia exhibit low dietary calcium intake, typically falling below 400 mg/day (51). Most of the surveyed nations in Africa and South America demonstrate moderately low calcium intake, ranging from 400 to 700 mg/day (51). Countries in Northern Europe tend to record a mean calcium intake exceeding 1000 mg/day (51).

The findings of the 2008/2009 New Zealand Nutrition Survey states that the median usual daily intake of calcium was 919 mg for males and 745 mg for females (Figure 2). Males aged 51 – 70 years and 71+ years had lower intakes of calcium than males in younger age groups. Across all age groups, females had a lower intake of calcium than males.

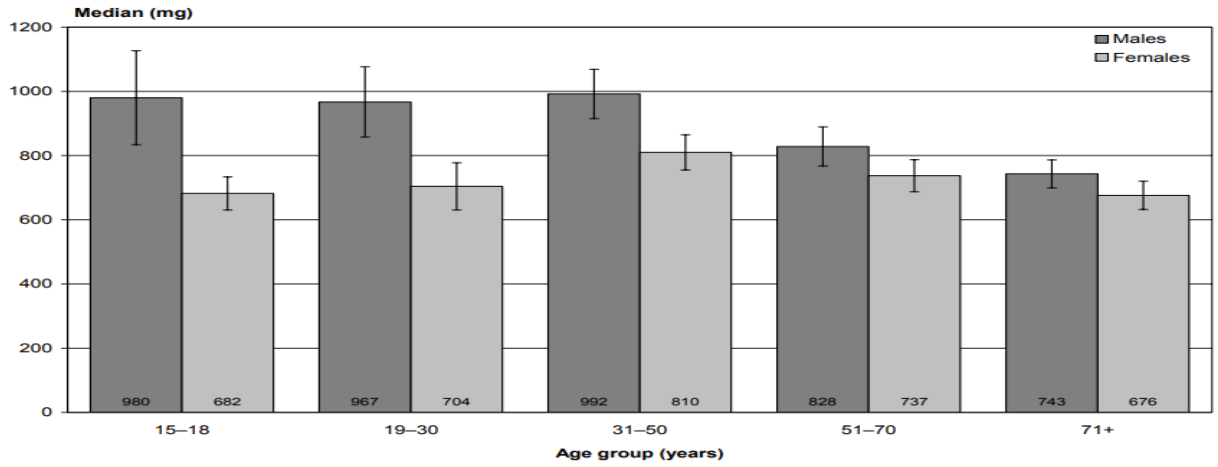

Figure 2. 2008/2009 New Zealand Nutrition Survey dietary calcium intake among different age groups.

2.8 Dietary sources of calcium in older New Zealanders

Table 4 presents data regarding the mean daily consumption of calcium from various food categories in the entire population of New Zealand categorized by age (51-70 years and those aged 71 years and older) and sex, as documented in the 2008/2009 New Zealand Adult Nutrition Survey. Milk was the largest single contributor of calcium to the diet (27%), followed by bread and non-alcoholic beverages (each 10%), cheese (8%), vegetables and dairy products (each 6%) and bread -based dishes (5%) (52).

Table 4. Dietary source of calcium percent (95% CI) by age group and sex.

Food Group	Total Population percent (95% CI) of all age groups	Male		Female	
		51-70 years percent (95% CI)	71+ years percent (95% CI)	51-70 years percent (95% CI)	71+ years percent (95% CI)
Milk	26.8 (25.8 - 27.8)	30 (26.9 - 33.1)	34 (31.7 - 36.2)	29.2 (26.7-31.7)	31.7 (29.5-34)
Bread	9.9 (9.4 - 10.3)	11.1 (9.5-12.7)	12.4 (11.1 - 13.7)	9.4 (8.3 - 10.4)	11.8 (10.3 -13.3)
Non-alcoholic beverages	9.6 (9.1 - 10.2)	7.5 (6.1 - 8.9)	5 (4.3 - 5.7)	10.5 (9.1 - 11.9)	6.5 (5.7 - 7.4)
Cheese	7.7 (7 - 8.4)	6.4 (4.7 - 8.1)	6.2 (4.9 - 7.5)	7.4 (5.7 - 9)	6.7 (5.4 - 8)
Vegetables	5.8 (5.5 - 6.2)	5.7 (4.9 - 6.6)	7 (6.3 - 7.8)	8.3 (7.2 - 9.4)	7.4 (6.6 - 8.2)
Dairy products	5.8 (5.2 - 6.3)	5 (3.7 - 6.3)	4.8 (3.8 - 5.8)	7.5 (6.1 - 9)	7.8 (6.5 - 9)
Bread based dishes	5 (4.4 - 5.6)	4.4 (2.7 - 6)	1.3 (0.8 - 1.8)	2 (1.3 - 2.6)	1.4 (0.7 - 2)
Grains & pasta	3.6 (3.1 - 4)	3.4 (2.3 - 4.6)	2.5 (1.7 - 3.3)	1.6 (1.2 - 2)	2.4 (1.5 - 3.3)
Fruit	2.5 (2.3 - 2.6)	2.1 (1.7 - 2.5)	3.4 (2.9 - 3.9)	3.3 (2.9 - 3.7)	3.7 (3.3 - 4.1)
Cakes & muffins	2.2 (1.9 - 2.5)	2.7 (1.7 - 3.7)	2 (1.6 - 2.4)	2.2 (1.5 - 2.8)	2.8 (2 - 3.6)
Fish & seafood	1.9 (1.7 - 2.1)	2.8 (1.7 - 3.8)	2.5 (1.8 - 3.2)	2.6 (1.8 - 3.4)	1.8 (1.3 - 2.3)
Breakfast cereals	1.9 (1.6 - 2.1)	2.8 (1.8 - 3.8)	2 (1.5 - 2.5)	1.9 (1.4 - 2.4)	2.6 (2.1 - 3.1)
Sugar & sweets	1.9 (1.6 - 2.1)	1.3 (0.6 - 2)	1.2 (0.8 - 1.5)	1.2 (0.8 - 1.7)	1 (0.7 - 1.2)
Potatoes, kumara & taro	1.8 (1.6 - 2)	2 (1.3 - 2.7)	1.7 (1.4 - 2)	1.2 (1 - 1.4)	1.3 (1.1 - 1.6)
Pies & pasties	1.7 (1.4 - 2)	1.2 (0.6 - 1.7)	1 (0.6 - 1.4)	1.1 (0.5 - 1.7)	1.2 (0.5 - 1.8)
Eggs & egg dishes	1.6 (1.4 - 1.8)	1.9 (1.4 - 2.4)	1.9 (1.4 - 2.5)	1.4 (1 - 1.8)	1.7 (1.2 - 2.1)
Alcoholic beverages	1.5 (1.3 - 1.7)	1.9 (1.4 - 2.5)	1.6 (1 - 2.1)	1 (0.6 - 1.3)	0.6 (0.4 - 0.8)
Savory sauces & condiments	1.2 (1.1 - 1.4)	1.4 (0.8 - 2)	1.2 (0.8 - 1.6)	1.1 (0.7 - 1.5)	1 (0.7 - 1.3)
Poultry	1.2 (1 - 1.3)	1 (0.6 - 1.3)	0.6 (0.4 - 0.8)	0.7 (0.4 - 0.9)	0.6 (0.4 - 0.9)
Soups & stocks	0.9 (0.7 - 1.1)	0.6 (0.3 - 1)	1.7 (1.1 - 2.3)	1.3 (0.7 - 1.9)	1.4 (0.9 - 1.8)
Puddings & desserts	0.8 (0.7 - 1)	0.6 (0.3 - 1)	2.3 (1.1 - 3.4)	0.9 (0.5 - 1.4)	1.1 (0.7 - 1.5)
Biscuits	0.8 (0.7 - 0.9)	0.7 (0.5 - 0.9)	1 (0.8 - 1.3)	0.8 (0.6 - 1)	0.8 (0.7 - 1)
Beef & veal	0.7 (0.6 - 0.8)	0.8 (0.5 - 1.1)	0.7 (0.5 - 1)	0.6 (0.4 - 0.9)	0.6 (0.4 - 0.7)
Sausages & processed meats	0.6 (0.5 - 0.8)	0.5 (0.3 - 0.7)	0.4(0.3 - 0.5)	0.6 (0.3 - 0.9)	0.4 (0.2 - 0.5)
Dietary supplements	0.6 (0.4 - 0.8)	0.1 (0 - 0.3)	0(0 - 0.1)	0.1 (0 - 0.2)	0.5 (0 - 1)
Nuts seeds	0.5 (0.4 - 0.6)	0.6 (0.1 - 1.1)	0.3(0.2 - 0.5)	0.7 (0.4 - 1)	0.3 (0.2 - 0.5)
Pork	0.5 (0.4 - 0.5)	0.7 (0.3 - 1.1)	0.6(0.4 - 0.8)	0.3 (0.2 - 0.4)	0.3 (0.2 - 0.4)
Snack bars	0.4 (0.3 - 0.4)	0.2 (0 - 0.4)	0.1(0 - 0.2)	0.5 (0.2 - 0.7)	0.1 (0 - 0.2)
Snack foods	0.3 (0.2 - 0.4)	0.1 (0 - 0.1)	0(0 - 0)	0.1 (0 - 0.2)	0 (0 - 0)
Lamb & mutton	0.3 (0.2 - 0.4)	0.4 (0.1 - 0.7)	0.2(0.1 - 0.3)	0.4 (0.1 - 0.6)	0.2 (0.1 - 0.3)
Butter & margarine	0.1 (0.1 - 0.2)	0.2 (0.1 - 0.2)	0.2(0.2 - 0.2)	0.2 (0.1 - 0.2)	0.2 (0.2 - 0.2)

Other meat	0 (0 - 0.1)	0.1 (0 - 0.2)	0.1(0 - 0.1)	0 (0 - 0.1)	0.2 (0 - 0.5)
Fats & oils	0 (0 - 0)	0 (0 - 0)	0(0 - 0)	0 (0 - 0)	0 (0 - 0)

Analysis of calcium sources revealed differences based on age and sex. In the case of males aged 51+ years and females aged 31+ years, milk played a more significant role in their calcium intake compared to their younger counterparts (Figure 3). The data is further segmented by age group (51 -70 years and those aged 71 years and older) and sex (male and female). The numbers in the table represent the percentage of individuals within each category who predominantly consume a particular type of milk (10).

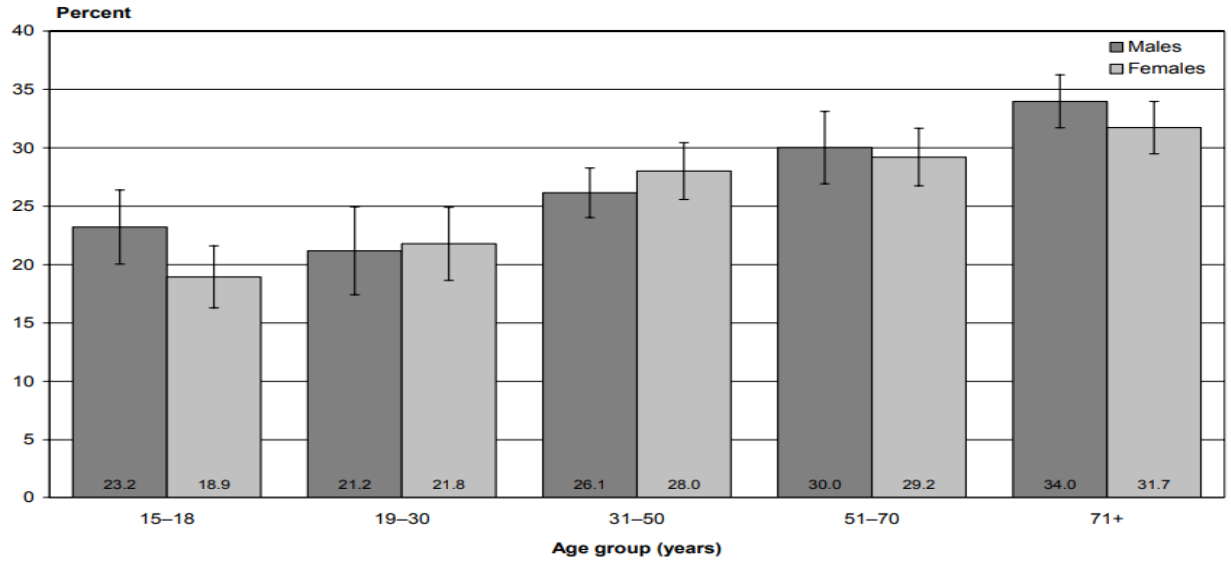

Figure 3 - Percent calcium intake from milk, by age group and sex.

Table 5 provides insights into the patterns of milk consumption, specifically focusing on the type of milk most frequently used among individuals aged 51 years and older. Whole milk and reduced fat or skimmed milk were the most consumed type of milk among male and female.

Table 5 consumption of different types of Milk (Type of milk used most of the time) by total population aged above 51 years.

Age group (years)	No milk consumed. (prevalence), (95% CI)	Whole or standard[a] (prevalence), (95% CI)	Reduced fat[b] (prevalence), (95% CI)	Skim or trim[c] (prevalence), (95% CI)	Soy milk (prevalence), (95% CI)	Other[d] (prevalence), (95% CI)	Reduced fat + skim or trim (prevalence), (95% CI)
Male							
51-70	7.7 (3.9-11.5)	41.7 (35.3-48.1)	20.8 (5.7-25.8)	27.7 (22.4-33.1)	2.1(0.7-4.8)	0(0-0.20)	48.5(42.6-54.4)
71+	3.9(2.1-6.5)	38.1(33.1-43)	26.2(222-30.4)	29.5(24.1-35)	1.4(0.6-2.9)	0.9(0.2-2.3)	55.8(50.6-60.9)
Female							
51-70	7.80(4.6-11)	27.6(22.7-32.4)	20.5(15.1-25.8)	38.9(33.6-44.1)	4.7(2.50-8)	0.6(0.1-1.6)	59.3(53.2-65.5)
71+	4.7(2.9-7.1)	31.6(27-36.2)	25.7(20.8-30.5)	36.2(31.5-40.8)	0.9(0.3-2)	1(0.3-2.4)	61.8(57.2-66.5)

a - Dark Blue or Silver, b - Light Blue, c - Green or Yellow, d - Includes rice and goats milk (10).

2.9 Calcium rich food sources

Calcium, the body's most prevalent mineral, can be sourced from various foods, incorporated as fortification in certain food items, included in specific medications like antacids, and obtained through dietary supplementation (53).

The primary sources of calcium are milk and dairy products, which are known for their high calcium bioavailability (54). Skimmed milk, powdered skimmed milk, and yogurt are excellent choices, preserving nearly all the original calcium content found in raw milk before processing. In contrast, hard cheeses like Cheddar retain approximately 80% of the calcium content present in milk, while butter contains only about 18% (55).

Calcium absorption rates are estimated at around 30% for dairy and fortified foods, including items like orange juice, tofu, and soy milk but, the absorption rate nearly doubles for specific leafy greens such as bok choy, broccoli, and kale (50). However, vegan sources (soy milk or any nut milk) of calcium may exhibit reduced bioavailability, potentially making it challenging for individuals to

meet their recommended calcium intake levels (42). Bioavailability is influenced by factors like effective solubilization of calcium and the presence of compounds that can either facilitate or hinder absorption. Foods containing oxalic acid and phytic acid, which impede calcium absorption or form insoluble calcium salts, are considered poor sources of calcium. Consumption of spinach and milk together has been observed to reduce calcium absorption from milk due to spinach's high oxalic acid content (35). Furthermore, fortified soy products are often promoted as dairy substitutes and are significant components of the diets of many vegetarians and vegans. While unfortified soy products naturally contain lower levels of calcium compared to milk, fortified soy products typically match the calcium levels found in milk. Research suggests that the bioavailability of calcium from soybeans is estimated to be around 30–40%, a rate comparable to that of milk and certain dark green leafy vegetables, and it exceeds that of many commonly consumed beans (56). Table 6 classifies food high in calcium according to the New Zealand food composition data commonly prepared and eaten in New Zealand (57).

Table 6 – The New Zealand food composition tables displaying foods rich in calcium from The Concise New Zealand Food Composition Tables (57).

Food source	Calcium content for 100 grams	Per serving size	Calcium content per serving size (mg)
Coffee mix, instant, dry powder, Cafe Menu Cappuccino, Nescafe®	400	1 tsp (5ml, 2.3g)	9
Energy food drink, dry powder, Chocolate Frothy Classic & Extreme Choc, Jarrah	920	1 tsp (5ml)	19
Liquid breakfast, assorted flavors, Fast Start™, Anchor™, fortified vitamins A, B1, B2, B3, B6, B12, D & folate	163	1 cup (250ml, 268g)	437
Liquid breakfast, assorted flavors, Up&Go™, Sanitarium™, fortified vitamins A, B1, B2, B3, B6, B12, B6, C & folate	167	1 cup (250ml, 267g)	446
Milo® powder, fortified vitamins B2, B3, B6, B12, C & D, Ca, Fe and P	1050	1 tsp (5ml, 2.3g)	24
Light 'n' Tasty™, Apricot, Sanitarium™, fortified vitamins B1, B2, B3, E & folate, Ca & Fe	820	1 cup (250ml, 77.5g)	636
Light 'n' Tasty™, Apricot, Sanitarium™, fortified vitamins B1, B2, B3, E & folate, Ca & Fe	820	1 cup (250ml, 77.5g)	636
Light 'n' Tasty™, Berry, Sanitarium™, fortified vitamins B1, B2, B3 & folate, Ca & Fe	420	1 cup (250ml, 82.4g)	346
Light 'n' Tasty™, Peach & Raspberry, Sanitarium™, fortified vitamins B1, B2, B3, E & folate, Ca & Fe	620	1 cup (250ml, 75.7g)	469
Special K®, Forest Berries, Kellogg's®, fortified vitamins B1, B2, B3, B6 & folate, Ca, Fe & Zn	667	1 cup (250ml, 40g)	267
Special K®, Original, Kellogg's®, fortified vitamins B1, B2, B3, B6 & folate, Ca & Fe	780	1 cup, (250ml, 41.5g)	324

Soy drink, soy milk, So Good™ Essential, Sanitarium™, fortified vitamins A, B1, B2, B3, B6, B12, E & folate, Ca, Fe, Mg & P	127	1 cup (250ml, 260g)	330
Cheese, Camembert	547	1 cube (2cm, 8g)	41
Cheese, Cheddar Mild	780	1 cube (2cm, 8g)	62
Cheese, Cheddar tasty	845	1 cube (2cm, 8g)	68
Cheese, Cheddar, light, Mainland™	1000	1 cube (2cm, 8g)	80
Cheese, colby	810	1 cube (2cm, 8g)	65
Cheese, Edam	940	1 cube (2cm, 8g)	75
Cheese, Mozzarella	714	1 cube (2cm, 8g)	57
Cheese, blue vein	489	1cube (2cm, 3.5g)	17
Cheese, feta, from cows' milk, traditional	440	1cube (2.5cm,17.8g)	78
Cheese, haloumi, from cows' milk	640	1cube (2.5cm,17g)	109
Cheese, parmesan, from cows' milk, ungrated	1100	1cup (82.4g)	906
Cheese, processed, sliced, reduced fat	635	1slice (20.7g)	131
Milk, A2, cow, lite, fluid, fresh	118	1 cup (250ml, 254g)	297
Milk, A2, cow, standard, fluid, fresh	119	1 cup (250ml, 254g)	302
Milk, `Calci Kid', enriched, Meadow Fresh	153	1 cup (258g)	361
Milk, cow, lite, fluid, fresh	120	1 cup (250ml, 252g)	302
Milk, cow, lite, fluid, ultra-heat treated (UHT) 1	116	1 cup (250ml, 251g)	291
Milk, cow, low fat 0.2%, fluid, ultra-filtered, Sun Latte®, fortified vitamin D	133	1 cup (250ml, 258g)	343
Milk, cow, powder, instant, skim	1220	1 cup (250ml, 128g)	1560
Milk, cow, powder, instant, whole	960	1 cup (250ml, 135g)	1300
Milk, cow, trim, fluid, fresh, fortified Ca	180	1 cup (250ml, 255g)	459
Milk, cow, trim, fluid, fresh, fortified Ca & vit D	173	1 cup (250ml, 255g)	441
8 Milk, cow, trim, fluid, ultra-heat treated (UHT), fortified vitamin D	140	1 cup (250ml, 252g)	353
Milk, cow, whole 4% fat, fluid, non-homogenized	116	1 cup (250ml, 260g)	300
Milk, cow, whole, evaporated, fluid	275	1 cup (250ml, 266g)	732
Milk, sheep, whole, fluid, fresh	183	1 cup (250ml)	476
Milk, goat, whole, fluid	102	1 cup (250ml, 258g)	263
Protein powder, whey & vanilla flavored, 100% Whey Protein WPC/WPI, Balance	340	1 cup (250ml, 87.5g)	298
Yoghurt dessert, Greek-style, chocolate flavored, sweetened, premium	123	1 cup (250ml, 261g)	321
Yoghurt smoothie, assorted fruits, sweetened	137	1 cup (250ml, 272g)	373
Yoghurt, Fresh'n Fruity™, Lite, assorted fruits, non-fat, fortified Ca, vitamins A & D	189	1 cup (250ml, 258g)	488
Yoghurt, Fresh'n Fruity™, assorted fruits, regular fat, fortified Ca, vitamins A & D	189	1 cup (250ml, 261g)	493
Yoghurt, Greek-style, full-fat	175	1 cup (250ml, 273g)	457
Yoghurt, Greek-style, low fat, Fresh'n Fruity™	167	1 cup (250ml, 273g)	456
Yoghurt, Greek-style, low fat, Cyclops®	185	1 cup (250ml, 260g)	481
Yoghurt, Meadow Fresh Yoghurt, assorted fruits, low fat, sweetened, Meadow Fresh®, fortified Ca, low fat, assorted fruits fortified Ca	167	1 cup (250ml, 260g)	434
Yoghurt, Meadow Fresh®, Live lite, assorted fruits, non-fat, fortified Ca, vitamins A & D	148	1 cup (250ml, 260g)	385
Yoghurt, Symbio Probalance™, assorted fruits, low fat, fortified Ca, vitamins A & D	182	1 cup (250ml, 259g)	471
Yoghurt, Yoplait, Delite, assorted fruits, low fat	150	1 cup (250ml, 260g)	390
Yoghurt, Yoplait, assorted fruits, regular fat	127	1 cup (250ml, 261g)	331
Yoghurt, plain, low fat, unsweetened	160	1 cup (250ml, 257g)	411

Yoghurt, plain, unsweetened	120	1 cup (250ml, 241g)	289
Yoghurt, premium, assorted fruits	151	1 cup (250ml, 261g)	394
Mackerel, canned in oil, drained	320	1 cup (250ml, 182g)	582
Mackerel, canned in oil, undrained	240	1 cup (250ml, 257g)	617
Mackerel, canned in tomato sauce, undrained	280	1 cup (250ml, 242g)	678
Salmon, pink or red, flesh, canned in spring water, drained	270	1 cup (250ml, 251g)	678
Sardines, canned in oil, drained	320	1cup (250ml, 170g)	540
Sardines, canned in oil, undrained	250	1 cup (250ml, 255g)	638
Sardines, canned in tomato sauce, undrained	290	1 cup (250ml, 255g)	740
Sardines, canned in water, drained	340	1 cup (250ml, 163g)	554
Seed, poppy	1440	1 cup (250ml, 148g)	2130
Kale, chopped, frozen, steamed, no salt added	168	1 cup chopped (201g)	338
Kale, fresh, sautéed with oil, no salt added	455	1 cup chopped (54.9g)	250
Tofu, soybean curd, regular, firm, stir-fried, no salt added	246	1 piece, (18.1g)	44

2.10 Calcium supplements

In light of the limited availability of calcium-rich foods and suboptimal dietary habits, it can be challenging for individuals to attain sufficient dietary calcium (58). Consequently, calcium supplementation may assume a critical role, especially for individuals with inadequate dietary calcium intake. Widely adopted across diverse age groups, calcium supplementation is extensively promoted to enhance bone density (51). While it is widely believed that increasing calcium intake promotes stronger bones and reduces fracture risk, taking calcium supplements may actually lead to adverse effects such as cardiovascular events, kidney stones, gastrointestinal problems, and hospitalizations due to acute gastrointestinal issues (59). However, research consistently demonstrates that calcium supplements can reduce bone turnover by approximately 20%, ultimately mitigating bone loss post menopause (52). A longitudinal study established a correlation between elevated total calcium intake (from food and supplements) and a diminished risk of incident atherosclerosis (53). However, it is essential to acknowledge that calcium supplementation might elevate the risk of incident coronary artery calcification (53).

It is worth noting that there is a significant correlation between the source of calcium and its effect on the body. When calcium is obtained from natural food rather than supplements, there are no harmful effects associated with dietary calcium intake. This is because the body absorbs smaller amounts of calcium more gradually when it is obtained from food containing protein and fat. As a result, the time it takes for calcium to pass through the digestive system is slowed down (59).

2.11 Dietary assessment

Dietary assessment is a process used to evaluate an individual's dietary intake and habits. It plays a crucial role in understanding the relationship between nutrition and health outcomes. Conventional approaches to dietary assessment encompass techniques such as food diaries, food frequency questionnaires, 24-hour recalls, and screening instruments; there are also digital and mobile applications that harness technology to facilitate these established methodologies (60). Dietary assessment tools play a pivotal role in nutrition research and monitoring. The selection of an assessment method is primarily influenced by factors such as the research objectives, study design, participant demographics, and sample size. Table 7 below offers a concise overview of dietary assessment methods, highlighting their respective advantages and disadvantages (61). Food diaries can be estimated or weighed. A weighed food diary offers precise information on actual intake but may be burdensome to participants. Biomarkers provide an objective measures of nutrient intake and can be obtained from biological samples, such as blood, urine, or hair, reflecting recent dietary intake or nutrient status (62), but are often invasive.

Table 7. Illustrations of various global methods of dietary assessment.

Method	Description	Advantages	Disadvantages
Food Diary or Food Record	Participants record food and beverage consumption as they consume them for several days (typically 3-7 days). - Can be estimated or weighed	- Can be more accurate for culture-specific or rarely consumed foods. - Less reliant on memory.	- High respondent burden affecting record diligence over time. - High respondent burden impacting food or quantity selection.
24-Hour Dietary Recall	A trained interviewer elicits a list of foods, their quantity, brand names, and preparation, reflecting the previous 24 hours.	- Can be conducted face-to-face or by telephone. - Applicable to both literate and illiterate populations. - Reflects intake of the previous day, reducing alteration of eating behaviors.	- Requires skilled interviewers. - Dependent on good memory skills. - Prone to reporting errors, seasonal variations, and day-of-the-week effects.

Food Frequency Questionnaire	Participants rate the frequency of food consumption (e.g., daily, weekly, monthly) based on a list of foods (short or extensive). Portion size and usage are sometimes reported as small, medium, or large.	- Relatively easy and cost-effective to administer through various means. - Various types available targeting specific nutrients or food groups. - Effective at ranking individuals within a group.	- Requires a certain level of literacy. - Heavily reliant on long-term recall. - Less effective at determining absolute nutrient intake. - May lack culture-specific or condition-relevant foods.
Biomarkers	Biochemical tests such as plasma nutrient levels, gene expression, urinary metabolites, or doubly labeled water.	- Free from patient bias or reporting errors. - Can be associated with intake of specific foods or food groups. - Relatively low participant burden.	- Some tests may be expensive, invasive, or time-consuming. - Plasma nutrient levels may be influenced by factors beyond intake.

CHAPTER 3 - MANUSCRIPT

3.1 Abstract

The aging population is significantly impacting health and nutritional paradigms, with New Zealand exemplifying this trend. Aging significantly affects bone health, with calcium intake playing a vital role in preserving bone density, muscle function, nerve impulse transmission, and hormonal activities.

Aim

This research aims to investigate the calcium intake and to identify the main food items contributing to calcium intake of community-dwelling older adults (65 to 74 years) living in Auckland, New Zealand.

Methods

This sub-study was undertaken as part of the REACH (Researching Eating, Activity, and Cognitive Health) study, a cross-sectional study investigating dietary patterns, cognitive health and metabolic syndrome in older adults aged 65-74 years living in Auckland, New Zealand. A 4-day food diary was used to assess dietary calcium intake, and food sources contributing to calcium intake.

Results

The REACH study encompassed 371 individuals, with food diaries available for 330 participants (114 males, 216 females). The average energy intake for males was 9374 kj/day, whereas for females, it was 7450 kj/day. Calcium intake was 877mg/day for females and 997 mg/day for males, compared with the Estimated Average Requirement (EAR) of 1100mg/day. For females 65-69 years, 30% consumed less than the EAR. This percentage was 21% for females70-74 years, and 10 % and 12% for males 65-69 and 70-74 years, respectively. The main food source of calcium was milk and milk products (providing 342mg of calcium/day and 273mg/day in females), followed by cheese (173mg/day (males) and 157mg/day (females)), and yoghurt (127mg/day (males) and 93mg/day (females)).

Conclusion

Findings from this study reflect a high prevalence of inadequate dietary calcium intakes, particularly in females aged 65 to 74 years living in Auckland, New Zealand. Dairy products provided the most calcium within these participants' diets. Further research is needed to determine appropriate ways to optimize the calcium intake in older adults who have low intake of dietary calcium.

3.2 Introduction

As the global population undergoes a demographic shift towards an aging society, it becomes increasingly essential to understand the dietary intake of calcium and food sources contributing to calcium intake within this demographic to promote their overall health and well-being. Serum calcium can be categorized into three fractions: ionized calcium, which is biologically active and constitutes approximately 50% of the total; protein-bound calcium, making up around 40%; and a small fraction of calcium complexed primarily with phosphate, citrate, and bicarbonate ions, accounting for about 10%. The remaining 1% (approximately 10-12 grams in an adult) of the body's calcium is distributed within extracellular fluids (ECF), intracellular structures, and cell membranes. Bone mineral acts as the primary reservoir for the calcium that circulates within the ECF (63).

The adequate intake of dietary calcium plays a pivotal role in maintaining bone strength and mass, consequently preventing various bone-related health conditions such as osteoporosis, brittle bones, arthritis, and fractures (26). Calcium is not only a fundamental element for the development and upkeep of the skeletal system but also a critical component for the proper functioning of neuromuscular and cardiac systems. It is primarily stored in teeth and bones, where it contributes to structural integrity and strength. Insufficient calcium consumption has been linked to conditions like osteoporosis, a prevalent issue in Western cultures that significantly heightens the risk of bone fractures. Osteoporosis represents a major source of morbidity, particularly among older individuals in Australia and New Zealand, notably postmenopausal women (34).

While calcium intake throughout one's life plays a significant role in the onset of osteoporosis, other factors, including adequate vitamin D levels and physical activity, also contribute to this complex health concern (64). The current New Zealand and Australian Estimated Average Requirement (EAR) for dietary calcium for both men and women is 1100mg per day and the Recommended Dietary Intake is 1300mg per day. The New Zealand Adult Nutrition Survey data is 15 years old and predicts low calcium consumption among older people. Little is known about whether older adults in New Zealand are achieving these recommendations or which food sources contribute to the calcium intake of older adult New Zealanders

This study provides a detailed overview of a cross-sectional research project conducted as part of The Reach (Researching Eating, Activity and Cognitive Health) Study. This investigation focuses on calcium intake and food sources of older adults aged 65-74 years residing in Auckland, New Zealand.

3.3 Methods

3.2.1 Study Design

The data used in this cross-sectional study was obtained from The Reach (Researching Eating, Activity and Cognitive Health) Study (65) The cross-sectional study involved 372 community-dwelling individuals aged 65-74 years residing in Auckland, New Zealand. Data collection took place for a period of 12 months, from Autumn to Summer and was concluded in 2018.

3.2.2 Participants

For eligibility, participants needed to fall within the age range of 65 to 74 years, possess proficiency in English, and maintain independent living. Exclusion criteria included color blindness, conditions such as dementia, or any of the following conditions that might impair cognitive function (stroke, traumatic head or brain injury, neurological or psychiatric conditions). Exclusion also extended to those taking medication capable of impacting cognitive function. Another criterion for exclusion was the occurrence of significant events within the past two years that had a considerable impact on dietary intake and cognitive function, such as the death or illness of a family member. Only one person per household was eligible to participate in the study.

Participants were recruited throughout the wider Auckland region via several channels including the Human Nutrition Research Unit, Massey University participant database; media, through radio interviews and press releases; posters and flyers at local libraries, community centers, recreation centers, sports and hobby clubs, Citizens Advice Bureaus, retirement villages, and second-hand shops; inclusion in relevant newsletters, e.g. Age Concern New Zealand; and online promotion on appropriate social media pages e.g. Grownups, Office for Seniors Facebook page. The REACH study had a website where potential participants were directed for further information and to register interest (65)**.** Participants who expressed an interest in the study were provided with an information sheet to undergo a screening interview (66) via telephone or email, to ensure inclusion criteria were met.

3.2.4 Data Collection:

Eligible participants visited Massey University for a single appointment. A written informed consent form was obtained at the research facility prior to data collection. During this visit, data were gathered concerning their health, demographics and lifestyle, through in-person administration of written questionnaires (Table 8).

Socio-demographic details, such as age, gender, ethnicity, education, were comprehensively recorded. Additionally, anthropometric data was collected, covering measurements of height and weight. Height was measured using a stadiometer, while weight measurements were recorded in kilograms using the Tanita Electronic Scale. Body Mass Index (BMI) was subsequently calculated based on the formula weight (kg) / height (m^2). To maintain data integrity, meticulous reviews were conducted to ensure the questionnaires were both complete and accurate.

Table 8. Outcome measures and testing methods used for The REACH data collection.

Variables	Methods
Questionnaires	
Health and Demographics	Written questionnaire developed by the researchers – questions regarding socio-demographic, health and lifestyle factors.
Anthropometry	
Height and Weight	International Standards for Assessment of Kinanthropometry (ISAK) (Marfell-Jones M, Stewart A, De Ridder J (2012). Stadiometer, Tanita Electronic Scales
Body Mass Index (BMI)	BMI was calculated by using the formula weight (kg) / height (m^2).
Dietary Intake	
Estimated 4-day food diary	Paper Form (Appendix - 1)

3.2.5 Four Day Food Diary

An estimated 4-day food diary was collected from participants. Participants completed the 4-day food diary within one month of the study visit. The 4-day food diary covered four consecutive days including at least one weekend day. Prior to completing the 4-day food diary, participants viewed an instructional video that explained the need to record all foods and beverages consumed including type, brands, and cooking methods. Participants were taught how to estimate quantities using pictures (67), household measures, and measuring scales. The 4-day food diary was processed by four trained nutritionists using Foodworks 9 (Xyris Software, 2017). A register of common food items was kept ensuring consistency in data entry among the four nutritionists. Additionally, all food diaries entered were audited for accuracy and consistency by a New Zealand Registered Dietitian.

3.2.6 Analysis of Dietary Data

The information from food diaries was entered into the Food Works system. Food Works, a comprehensive dietary analysis software, supported by the New Zealand food composition database. Food Works was used to extract the values of macro and micronutrients for each participant. To analyze the distribution of macro/micronutrients across different food groups, each food entry in Food Works was categorized into specific food groups: meat (red meat; poultry; fish and shellfish; processed meat; animal fat); eggs; milk (milk; cheese; yogurt) and plant foods (all remaining food groups – see Table 11). This categorization helped in determination of calcium contribution from each food group contributing to the participants calcium intake.

3.2.7 Statistical Analysis

Continuous variables such as age (years) and daily calcium intake (mg/day) were presented using means and standard deviations. For categorical data like ethnicity, the participant counts in each group along with the corresponding percentage was displayed. Group comparisons, such as between males and females, were conducted using a Wilcoxon rank-sum test for continuous variables and Pearson's Chi-squared test for frequency data. In cases where the group sizes were

limited, a Fisher's exact test was employed. Significance differences between groups were determined at a threshold of $p < 0.05$.

3.2.8 Budget

Funding was provided by the Health Research Council of New Zealand, Grant 17/566.

3.3 Results

Data was collected from 371 participants, with 330 individuals completing the 4-day food diary. Table 9 provides an overview of participant characteristics, including sex, age, ethnicity, education, BMI, energy intake, and calcium intake. Predominantly, the participants were female, constituting 65% of the total population. The mean age of all participants was 69.77 (SD 2.58) years. The mean age of males was slightly higher at 70.27 years (SD 2.45), while females had a mean age of 69.51 years (SD 2.61) ($p=0.012$). Nearly all (95%) of the participants identified as European, followed by Māori/Pasifika (2.4%) and Asian or other (2.7%) participants. The p-value (>0.9) suggests there are no statistically significant differences in ethnicity between males and females. Seventy-four participants (22%) highest level of education was secondary school, 138 participants (42%) had post-secondary education and 118 participants (36%) were university-educated.

Approximately 45% of participants fell into the overweight category, with less than 1% falling into the underweight category and 42% participants having a healthy weight. Notably, the total energy intake for all participants was 8,115 (SD 1911) kJ/day. Males had a higher mean energy intake of 9,374 (SD 1992) kJ/day compared to females of 7450 (SD 1489) kJ/day who had a significantly lower energy intake.

The dietary intake of calcium averaged 919 mg/day, (SD 332) which is below the recommended dietary intake of 1300 mg/day and the estimated average requirement of 1100 mg/day. Males had a significantly higher mean dietary calcium intake of 997 (SD 331) mg/day, compared to females having a slightly lower mean dietary calcium intake of 877 (SD 325) mg/day.

Table 9 – Participant sociodemographic, anthropometric, and dietary characteristics.

Characteristic		Total (n[1])	Males (n[1])	Females (n[1])	P-value[2]
Sex n (%)		330	114 (35%)	216 (65%)	
Age in years	Mean ± SD	69.77 (2.58)	70.27 (2.45)	69.51 (2.61)	0.012
	65 – 70	178 (54)	54 (47)	124 (57)	
	70 – 74	152 (46)	60 (53)	92 (43)	
Ethnicity n (%)					>0.9
	European	313 (95)	108 (95)	205 (95)	
	Māori/Pasifika	8 (2.4)	3 (2.6)	5 (2.3)	
	Asian / other	9 (2.7)	3 (2.6)	6 (2.8)	
Education n (%)					0.001
	Secondary	74 (22)	15 (13)	59 (27)	xx
	Post-secondary	138 (42)	45 (39)	93 (43)	
	University	118 (36)	54 (47)	64 (30)	
BMI (kg/m^2)	Mean±SD	26.0 (4.3)	26.6 (3.9)	25.7 (4.5)	0.012
BMI n (%)	Below 18.5 kg/m^2 (underweight)	2 (0.6)	1 (0.9)	1 (0.5)	xx
	18.5–24.9 kg/m^2 (healthy weight)	138 (42)	36 (32)	102 (47)	
	25.0 – 29.9 kg/m^2 (overweight)	147 (45)	62 (54)	85 (39)	
	Above 30.0 kg/m^2 (obese)	43 (13)	15 (13)	28 (13)	
Energy (Kj/day)		8115 (1,911)	9,374 (1992)	7450 (1489)	<0.001
Calcium(mg/day)		919 (332)	997 (331)	877 (325)	<0.001

[1] - Mean (SD); n (%)-Number percentage
[2] - Wilcoxon rank sum test; Fisher's exact test; Pearson's Chi-squared test.
BMI – Body mass index
kJ – Kilojoules

Table 10 presents data on average energy and calcium intakes. The table is segmented by sex (male/female) and age groups (65-70 years, 70-74 years), and displays the average daily calcium intake (in milligrams) for each group. The Nutrient Reference Values for Australia and New Zealand set the standards for Recommended Dietary Intake (RDI) and Estimated Average Requirement (EAR) for calcium, which are respectively set at 1300 mg/day and 1100 mg/day for both male and female aged 65 to 75 years. Table 10 indicates that 10 and 12% of males aged 65-69 and 70-74 years respectively did not meet the EAR for calcium. In females, 30% and 20.9% did not meet the calcium EAR for those aged 65-69 and 70-74 years respectively.

Table 10 – Energy and dietary calcium intake in relation to the Nutrient Reference Values for Australia and New Zealand.

Sex	Age	Energy intake Mean (SD) kJ/day	Calcium intake mg/day Mean (SD)	Recommended Dietary Intake for calcium (mg/day)	Estimated Average Requirement for calcium (mg/day)	n (%) of participants below the EAR	n (%) of participants below the RDI
Male	65 - 69 years	9515 (2011)	1018 (316)	1300	1100	33 (10%)	44 (13%)
	70 – 74 years	9247 (1983)	978 (346)	1300	1100	42 (12%)	47 (14%)
Female	65 - 69 years	7353 (1415)	856 (287)	1300	1100	99 (30%)	114 (34%)
	70 – 74 years	7582 (1582)	906 (370)	1300	1100	69 (20.9%)	79 (23.9%)

A comprehensive breakdown of dietary calcium intake is shown in Table 11. Vegetables (100% of participants), milk (99%), non-alcoholic beverages (97%), fruits (98%), bread (95%), sauces and spices (94%) were consumed by nearly all participants. Males consumed more milk (835 g/day) than women (779 g/day), which resulted in higher calcium intake for men. The main food source of calcium was milk and milk products (providing 342mg calcium/d in males and 273mg/day in females), followed by cheese (173mg/day (males) and 157mg/day (females)), and yoghurt (127mg/day (males) and 93mg/day (females)).

Table 11 – The calcium intake from food sources among older adult males residing in Auckland, New Zealand.

Food Group		Total participants consuming	Total		Males		Females	
			Mean consumption g/day	Dietary calcium intake mg/day	Mean consumption g/day	Dietary calcium intake mg/day	Mean consumption g/day	Dietary calcium intake mg/day
Meat	Red meat	245 (74%)	64	8	80	10	55	7
	Poultry	216 (65%)	56	9	62	11	52	8
	Fish and shellfish	239 (72%)	55	28	60	30	52	27
	Processed meat	213 (64%)	52	23	63	24	45	23
	Animal fat	246 (%)	12	5	13	5	11	5
Eggs	Eggs and eggs products	261 (%)	42	25	40	23	43	25
Milk	Milk	327 (99%)	799	297	835	342	779	272
	Cheese	283 (85%)	23	162	24	173	22	157
	Yoghurt	210 (63%)	64	103	78	127	58	93
Plant	Bread	314 (95%)	81	63	91	71	75	59
	Breakfast cereal	260 (78%)	60	57	68	65	55	53
	Vegetables	330 (100%)	227	69	219	62	232	73
	Soups and bouillon	129 (39%)	160	27	167	29	157	26
	Fruits	326 (98%)	230	33	238	32	225	34
	Potato, kumara, taro, and other root vegetables	292 (88%)	86	10	107	13	75	9
	Pasta, rice, other grains	220 (66%)	64	9	75	9	57	9

	Plant – based milk and cream	53 (16%)	91	77	89	70	92	81
	Soy products	23 (6%)	33	41	30	41	34	41
	Nuts and seeds	237 (71%)	20	28	24	32	18	26
	Biscuits	164 (49%)	17	10	19	11	16	9
	Cakes and desserts	229 (69%)	54	32	58	31	52	33
	Snacks	228 (69%)	18	8	21	9	16	7
	Sugar and confectionery	286 (86%)	17	14	21	17	15	12
	Alcoholic beverages	214 (64%)	184	11	253	13	146	10
	Non - alcoholic beverages	322(97%)	899	19	873	19	912	19
	Sauces and spices	313(94%)	25	11	32	13	22	11

Figure 4 offers further insights into the various food sources of calcium. Milk and milk products, like milk, cheese, and yogurt, contributed significantly to the total intake. Of these, milk was the primary contributor to calcium intake. Females obtained more calcium from plant-based milk and vegetables than males.

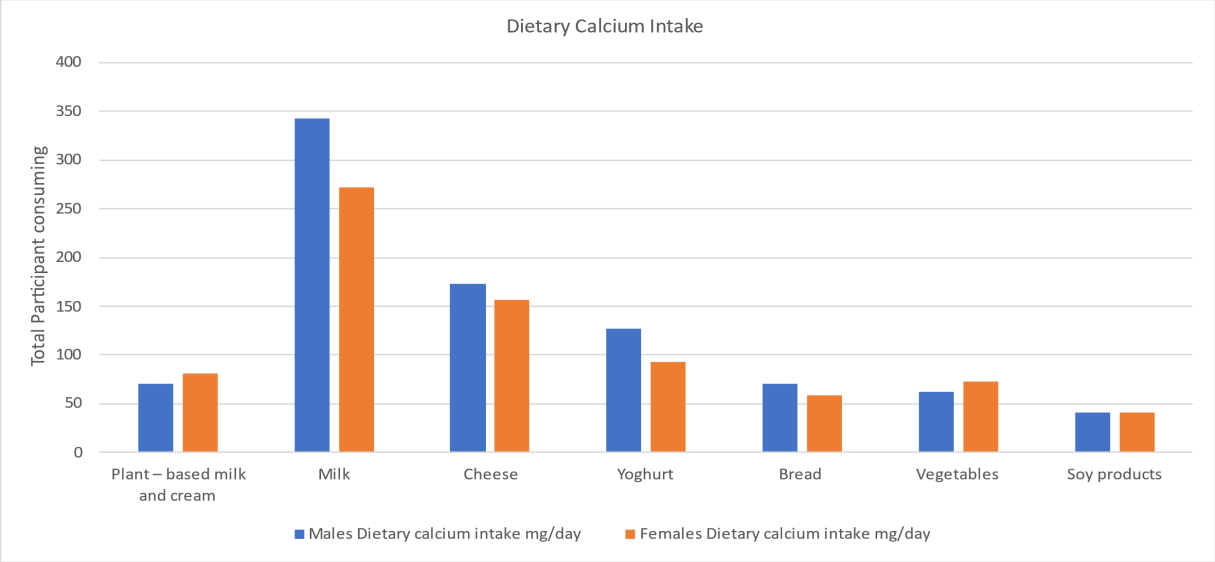

Figure 4 – High food sources of dietary calcium intake for male and female participants.

3.4 Discussion

This research explores the dietary calcium intake among male and female older adults in Auckland, New Zealand, focusing on age groups 65-74 years. With an EAR of 1100mg/day, the study reveals a significant gap, with an average calcium intake of 877 mg/day (SD 325) for females and 997 mg/day (SD 331) for males, falling short of recommendations, notably in females aged 65-69 years (30% below the EAR). The main food source of calcium was milk and milk products (providing 342mg calcium/day in males and 273mg/day in females), followed by cheese (173mg/day (males) and 157mg/day (females)), and yoghurt (127mg/day (males) and 93mg/day (females)).

According to the 2008/2009 New Zealand Adult Nutrition Survey (NZANS) (10), the median calcium intake for males aged 51-70 years was 828mg per day, while males aged 71 years and above consumed 743mg per day. For females aged 51-70 years, the median calcium intake was 737mg per day, while females aged 71 years and above consumed 676mg per day. These findings from the NZANS aligns with this research and highlight the ongoing concern of inadequate calcium intake. Median daily intake for men was 997mg and 877mg for women, both below the recommended levels according to table 10 where females consumed only 877mg per day, signaling a serious nutritional shortfall. These consistent trends underscore the urgency for targeted interventions to address this issue. Calcium is crucial for older women for several reasons, during menopause, estrogen levels drop significantly, leading to increased bone loss (68). Calcium is vital during this phase to counteract accelerated bone resorption and maintain bone strength. As women age, especially post-menopause, the risk of osteoporosis increases due to hormonal changes that affect bone mass (69). This research has similar findings to that of a study in New Zealand adolescents (23). Adolescents aged 15-18, exhibited median calcium intakes of 935 mg/day for males and 711 mg/day for females, reflecting intakes below recommendations (23). These parallels underscore potential long-term consequences, with inadequate calcium intake during adolescence potentially contributing to osteoporosis in later years. As many participants fell short of meeting the recommended calcium levels, there is a need for tailored dietary recommendations to increase calcium intake.

The analysis unearthed a complex web of food choices showcasing calcium consumption across various food groups including vegetables (330 participants), milk (327 participants), fruits (326

participants), and non-alcoholic beverages (322 participants). Milk emerged as the primary dietary source of calcium. Cheese and yoghurt also contributed substantially to calcium intake. Despite this, only 85% and 63% of the total participants consumed cheese and yogurt, respectively, despite them being high sources of calcium, in part contributing to the insufficient dietary calcium intake observed in the study. According to the Adult Nutrition Survey, Milk was the largest single contributor of calcium to the diet (27%), followed by Bread and Non-alcoholic beverages (each 10%), Cheese (8%), Vegetables and Dairy products (each 6%) and Bread-based dishes (5%).

To ensure a calcium rich diet, interventions can be implemented such as nutritional education, food fortification and ensuring adequate access to calcium rich food sources. Nutritional education involves educating people about the importance of calcium for bone health and overall well-being, as well as emphasizing sources calcium-rich foods and their benefits. This may include the provision of meal plans and recipes that are rich in calcium, as well as appealing, affordable, and culturally appropriate or offering personalized dietary counseling sessions tailored to individual needs and preferences. It is important that people are able to access to a diverse range of calcium-rich foods, especially in underserved communities. This may involve collaboration with local food banks, farmers' markets, and community gardens to increase the availability and affordability of fresh produce and dairy products. Alternatively, fortifying staple foods with calcium like bread, cereals, and plant-based milk alternatives may help to increase calcium intake, especially among those who do not consume traditional dairy products. By implementing these interventions in a coordinated and multidisciplinary manner, it is possible to empower older adults to make informed choices and adopt habits that support optimal calcium intake and bone health throughout their lifespan.

3.6 Strengths

This study was able to identify variations in dietary calcium intake between genders, providing insights into potential nutritional disparities among male and females. Additionally, the study aimed to determine if the targeted population met their daily calcium requirements by identifying key calcium-rich food sources. By investigating these aspects, the study aimed to contribute to a deeper understanding of dietary patterns and nutritional needs, fostering knowledge that could be

pivotal in formulating tailored interventions or recommendations for optimal calcium intake in the specified population.

3.7 Limitations

One limitation of the study was the difficulty in categorizing foods. Other limitations included the accuracy of recording the 4-day food intake, as well as the honesty and precision of the participants in reporting the exact numbers and measurements of the food they consumed. In addition, as our participants were a convenience population, the findings from the study cannot be generalised to other populations or groups.

In conclusion, this research serves as a vital tool for policymakers, and healthcare professionals, involved in the well-being of older adults. The identified gaps in calcium intake, especially among females, demand targeted interventions and a serious approach to ensuring adherence to dietary recommendations. By laying a robust foundation for future studies, this research contributes significantly to the understanding of calcium intake in older adult populations, paving the way for informed public health initiatives. The study's findings not only shed light on the challenges but also provide a roadmap for interventions to ensure optimal calcium intake, thereby promoting overall health and well-being in the aging population.

CHAPTER 4 - CONCLUSION

In conclusion, this thesis has provided a comprehensive examination of dietary calcium intake among older adults living in Auckland, New Zealand. The findings highlight the critical importance of adequate calcium consumption for maintaining overall health and well-being, particularly in the context of an aging population. The study has shed light on the prevalence of insufficient calcium intake, especially among females in the 65 to 69 year age group.

The data presented in this research indicates a notable gap between the actual calcium intake and the Nutrient Reference Values, emphasizing the need for targeted interventions and public health initiatives to increase calcium intake. As evidenced by the higher prevalence of inadequate calcium intake among females, tailored strategies addressing gender-specific dietary habits and nutritional education programs may prove beneficial.

Moreover, the identification of milk as the primary source of dietary calcium highlights the need for diversified nutritional approaches, considering alternative sources for those with dietary restrictions or preferences. This research highlights the necessity of promoting awareness and education regarding the importance of calcium-rich foods, especially within the older adult demographic. Given that milk is among the most consumed foods, as also indicated by the 2008/2009 Adult Nutrition Survey (10), a proposed strategy is to fortify it with calcium. This aims to augment the calcium content and fulfill the necessary requirements for recommended dietary intake.

As we move forward, bridging the calcium intake gap in older adults requires a multifaceted approach involving healthcare professionals, policymakers, and the community at large. Implementing strategies to enhance dietary diversity, fortifying food products, and increase awareness of calcium-rich food sources can collectively contribute to improving the nutritional status of older adults. Ultimately, these efforts can translate into enhanced bone health, reduced risk of chronic diseases, and an overall improvement in the quality of life for the aging population.

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Appendix 1

MASSEY UNIVERSITY
COLLEGE OF HEALTH
TE KURA HAUORA TANGATA

The REACH (Researching Eating Activity and Cognitive Health) Study

4 Day Food Record

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

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

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

What to do?

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

_____

_____

_____

_____

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

Describing Food and Drink

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

General description	Food record description
Breakfast example – cereal, milk, sugar	1 cup Sanitarium Natural Muesli 1 cup Pam's whole milk 1 tsp Chelsea white sugar
Coffee	1 tsp Gregg's instant coffee 1 x 200ml cup of water 2 Tbsp Meadow fresh light green milk

Pasta	1 cup San Remo whole grain pasta spirals (boiled)
Pie	Big Ben Classic Mince and Cheese Pie (170g)

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

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

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

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

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

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

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

Recording the amounts of food, you eat

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

- By using household measures – for example, cups, teaspoons and tablespoons. E.g. 1 cup frozen peas, 1 heaped teaspoon of sugar.

- By weight marked on the packages – e.g. a 425g tin of baked beans, a 32g cereal bar, 600ml Coke

- Weighing the food – this is an ideal way to get an accurate idea of the quantity of food eaten, in particular for foods such as meat, fruits, vegetables and cheese.

- For bread – describe the size of the slices of bread (e.g. sandwich, medium, toast) – also include brand and variety.

- Using comparisons – e.g. Meat equal to the size of a pack of cards, a scoop of ice cream equal to the size of a hen's egg.

- Use the food record instructions provided to help describe portion sizes.

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

- If you go out for meals, describe the food eaten in as much detail as possible.

- ***Please eat as normally as possible - don't adjust what you would normally eat just because you are keeping a food record and be honest! Your food record will be identified with a number rather than your name.***

Example day

Time and place food was eaten	Complete description of food (food and beverage name, brand, variety, preparation method)	Amount consumed (units, measures, weight)
Example7:55 am at home	Sanitarium weetbix	2 weetbix
" "	Anchor Blue Top milk	150ml
" "	Chelsea white sugar	2 heaped teaspoons
" "	Orange juice (Citrus Tree with added calcium – nutrition label attached)	1 glass (275 ml)
10.00am In car	Raw Apple (gala)	Ate all of apple except the core, whole apple was 125g (core was ¼ of whole apple)
12.00pm At home	Homemade pizza (recipe attached)	1 slice (similar size to 1 slice of sandwich bread, 2 Tbsp tomato paste, 4 olives, 2 rashers bacon (fat removed), 1 Tbsp chopped spring onion, 3 Tbsp mozzarella cheese)
1.00pm At work	Water	500ml plain tap water
3.00pm At work	Biscuits	6 x chocolate covered Girl Guide biscuits (standard size)
6.00pm At home	Lasagne	½ cup cooked mince, 1 cup cooked Budget lasagne shaped pasta, ½ cup Wattie's creamy mushroom and herb pasta sauce, ½ cup mixed vegetables (Pam's carrots, peas and corn), 4 Tbsp grated Edam cheese
6.30pm At home	Banana cake with chocolate icing (homemade, recipe attached)	1/8 of a cake (22cm diameter, 8 cm high), 2 Tbsp chocolate icing
" "	Tip Top Cookies and Cream ice cream	1 cup (250g)
7.30pm At home	Coffee	1 tsp Gregg's instant coffee 1 x 300ml cup of water 2 Tbsp Meadow fresh blue top milk 2 tsp sugar

Date_____ DAY 1

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

Date_____ DAY 1 continued

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

Recipes (Day 1)

APPENDIX 2

Food groups used in the 2008/2009 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)
Bread	All types of bread (rolls, pita, foccacia, garlic), bagels, crumpets, sweet buns
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
Bread-based dishes	Sandwiches, filled rolls, hamburgers, hotdogs, pizza, nachos, doner kebabs, wontons, spring rolls, stuffings
Puddings and desserts	Milk puddings, cheesecake, fruit crumbles, mousse, steamed sponges, sweet pies, pavlova, meringues
Milk	All milk (cow, soy, rice, goat and flavored 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
Fats and oils	Canola, olive, sunflower and vegetable oils, dripping, lard
Eggs and egg dishes	Poached, boiled, scrambled and fried eggs, omelets, self-crusting quiches, egg stir-fries
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
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
Other meat	Venison, rabbit, goat, liver (lambs fry), pâté (liver), haggis
Sausages and processed meats	Sausages, luncheon, frankfurters, saveloys/cheerios, salami, meatloaf and patties
Pies and pasties	All pies including potato top, pasties, savories, sausage rolls, quiche with pastry
Fish and seafood	All fish (fresh, frozen, smoked, canned, battered, fingers, etc.), shellfish, squid, crab, fish/seafood dishes (pies, 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), taro roots and stalks
Snack foods	Corn chips, popcorn, extruded snacks (burger rings etc.), grain crisps
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 (pestos)
Sugar and sweets	Sugars, syrups, confectionery, chocolate, jam, honey, jelly, sweet toppings and icing, ice blocks, artificial sweeteners

Soups and stocks	All instant and homemade soups (excluding noodle soups), stocks and stock powder
Savory sauces and condiments	Gravy, tomato and cream-based sauces, soy, tomato and other sauces, cheese sauces, mayonnaise, oil & vinegar dressings, chutney, marmite
Non-alcoholic beverages	All teas, coffee and substitutes, hot chocolate drinks, juices, cordial, soft drinks, water, powdered drinks, sports and energy drinks
Alcoholic beverages	Wine, beer, spirits, liqueurs and cocktails, ready-to-drink alcoholic sodas (RTDs)
Supplements providing energy*	Meal replacements, protein supplements (powders and bars)
Snack bars*	Muesli bars, whole meal fruit bars, puffed cereal bars, nut and seed bars