Dietary Supplement use in Community Dwelling Older Adults Living in New Zealand

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Abstract

Background

The population within New Zealand and internationally is aging. Research from overseas suggests many older adults use dietary supplements (DS). The most recent data regarding DS use of older adults in New Zealand (NZ) was undertaken in 2008/2009 and found that 39.8% of males and 52.6% of females 51 to 70 years old were considered DS users. International research suggests there are associations between sociodemographic, lifestyle and health characteristics and DS use, however, in the NZ older adult population these are currently. Therefore, the aim of this study was to explore DS use in older community dwelling adults living in NZ.

Methods

Community dwelling older adults aged 65 to 74 years and living in Auckland took part in this cross-sectional study. Data on DS use and sociodemographic, lifestyle and health characteristics was collected using a health and demographic questionnaire, a short international physical activity questionnaire, four-day estimated food record (4DFR), and anthropometric measurements. Chi-squared tests and independent *t*-tests were used to compare the characteristics of DS users versus non-DS users. Types of dietary supplements taken by female versus male DS users were also investigated using Chi-square tests.

Results

Among the 371 participants (64.2% female; 93.5% European; mean age 69.7 ± 2.6), 64% were considered DS users. The most consumed DS was oil (25.9%), single vitamins (25.1%), single minerals (23.5%), and multivitamins (19.7%). Dietary supplement use was higher among females (70.6%) compared to males (52.6%) ($p<.001$). Most DS users took one (37%) or two (23.9%) supplements, with 15% taking five or more DS. Male DS users were significantly more likely to adhere to the Ministry of Health alcohol intake guidelines ($p=.008$), have a higher self-reported level of health ($p=.016$), and a higher Index of Multiple Deprivation (IMD) ranking compared to male non-DS users ($p=.045$). There was no significant difference in characteristics between DS users and non-DS users in females.

Conclusion

DS use among older community dwelling adults living in NZ is high, and more common in females. In males, DS use was higher in those consuming alcohol within recommended guidelines, in those who had higher reported level of health, and those living with greater deprivation compared to male non-DS users. Further research on a more diverse and representative population group is required to better understand the DS use prevalence and predictors of use for the older adult population across NZ.

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Ēhara tāku toa, he takitahi, he toa takitini

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List of Abbreviations

4DFR	Four-day estimated food record
AA	African American
AICR	American Institute for Cancer Research
ARTG	Australian Register of Therapeutic Goods
BMI	Body mass index
Ca	Calcium
CSS	Cross-sectional study
CVD	Cardiovascular disease
DS	Dietary supplement(s)
FDA	Food and Drug Administration
FFQ	Food frequency questionnaire
GI	Gastrointestinal tract
HNRU	Massey University Human Nutrition Research Unit
Hr	Hour
IMD	Index of multiple deprivation
IPAQ	International physical activity questionnaire
KNHNES	Korea National Health and Nutrition Examination Survey
MeSH	Medical subject headings
MET	Metabolic equivalent of a task
MoH	New Zealand Ministry of Health
MVM	Multivitamin-mineral
NA	Not assessed in study
NCD	Non-communicable diseases
NHANES	National Health and Nutrition Examination Survey
NHS	National Health Survey
NNS	National Nutrition Survey
NZ	New Zealand
NZD	New Zealand dollar
NZDep2006	New Zealand Deprivation Index 2006
PA	Physical activity
REACH	Researching Eating, Activity and Cognitive Health
RDI	Recommended daily intake

SD	Standard deviation
TGA	Therapeutic Goods Act
UK	United Kingdom
US	United States of America
Vit	Vitamin
Vs	Versus
WCRF	World Cancer Research Fund
Yrs	Years

<	Less than
≤	Equal to or less than
>	Greater than
≥	Equal to or greater than

Chapter 1. INTRODUCTION

1.1 Scope and justification for research

Dietary supplements, also called nutraceuticals or supplements, are commonly defined as products that are taken orally with the intent to supplement the diet (Beattie, 1985, National Institutes of Health, 1994). The dietary supplement market is a growing industry. The dietary supplement and natural health product industry is estimated to have an annual turnover of $1.4 billion New Zealand Dollar (NZD) in New Zealand (NZ) alone (Ministry for Primary Industries, 2020). Globally, there is lack of regulation of dietary supplementations on the market and unlike prescription medication, individuals are free to take supplements at their own accord. While physicians and pharmacists check prescribed medication drug-drug interactions, drug-nutrient or nutrient-nutrient interactions with dietary supplements consumed by individuals can often go undetected (Aznar-Lou et al., 2019).

The older adult population is growing, and the number of people living to over 60 years of age is increasing (The World Health Organisation, 2021). As people are living longer, they are not necessarily doing so in good health (Minister of Health, 2016). There are several changes that naturally occur during the aging process both physiologically, cognitively, and socially that impact older adults' ability to achieve optimum nutritional adequacy. In addition, older adults have a higher risk of non-communicable diseases such as heart disease, diabetes, and arthritis. Some of the most prevalent health conditions that affect older adults in NZ are arthritis, chronic pain, heart disease, and stroke (Ministry of Health, 2016).

In situations where adequate nutrition is challenging to achieve, dietary supplementation can be considered beneficial. Dietary supplementation can increase nutrient intake and decrease the prevalence of specific nutrient inadequacy (Blumberg et al., 2017). At an individual level, achieving nutritional adequacy can prevent associated complications of nutrient deficiencies. Specifically in older adults' dietary supplements have demonstrated the ability to manage, reduce risk, or improve symptoms of various health complications that older adults commonly face such as cardiovascular disease (CVD), dementia, and muscle loss (Siscovick et al., 2017, Ammann et al., 2017, Hooper et al., 2017, Li et al., 2022, Hill and Aspray, 2017, Bailey et al., 2015, Rautiainen et al., 2016). However, there are several concerns regarding DS use in older adults including high cost, potential detraction from intake of a high-quality diet, or potential negative nutrient-nutrient or drug-nutrient interactions that may occur.

There is evidence that dietary supplement (DS) use among the older adult population is higher than the younger population (Burnett et al., 2017, Cowan et al., 2018, Mishra et al., 2021, O'Brien et al., 2017, Parnell et al., 2006, Kantor et al., 2016). Research from the US suggests that the high DS use among older adults is increasing (Kantor et al., 2016). There has been limited studies that have explored DS use in NZ older adults. Internationally research has found associations between sociodemographic, lifestyle and health characteristics and DS use (Burnett et al., 2017, Cowan et al., 2018, Harris et al., 2017). However, the associations between characteristics and DS use in NZ older adults is unknown.

1.2 Aims and objectives

Aim

To explore DS use in older community dwelling adults living in New Zealand using data from the Researching Eating, Activity and Cognitive Health (REACH) study.

Objectives

To identify the type of DS taken by older adults in New Zealand.

To explore the differences in sociodemographic, lifestyle, and health characteristics between DS users and non-DS users.

1.3 Structure of thesis

This thesis is comprised of four chapters. Chapter one presents the purpose of the research and provides the background information on the scope of the study. Chapter two reviews the literature on the aging population and associated nutritional challenges older adults face, the definitions and regulatory process for DS available in NZ, DS use prevalence, and the characteristics of DS users. Chapter three presents as a manuscript including an abstract, introduction, methodology, results, discussion, and conclusion of the findings from this research. The final chapter focuses the strengths and limitations, and the concluding recommendations from this research, alongside suggestions where further research is needed.

1.4 Research contributions

Table 1.1. Contribution of each researcher to the completion of the study.

Researcher	Role and Contributions to Thesis
Brooke Tamepo	Master of Science student, Nutrition and Dietetics. Primary researcher and author of present study (secondary data analysis). Statistical analysis and interpretation, writing, editing, and final preparation of thesis and manuscript.
Associate Professor Kathryn Beck	Associate Professor, School of Sport, Exercise and Nutrition. 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. Reading and editing of thesis.
Associate Professor Cathryn Conlon	Associate Professor, School of Sport, Exercise and Nutrition. Co-supervisor of the study. Co-investigator of the REACH study. Assistance with data collection and interpretation of data. Reading and editing of thesis.
Dr Karen Mumme	Assistance and guidance with data management and statistical analysis. Assistance with data collection.

Chapter 2. LITERATURE REVIEW

2.1 Introduction

Relevant literature was sourced using database searching (PubMed, Google Scholar, Science Direct, Discover Massey University library database), citation searching, and handsearching through key journals and publication platforms of interest (e.g. *Nutrients*). Terms and keywords used during searches are included in table 2.1.

All relevant literature retrieved from the search were saved and exported to EndNote® (version 20.4.1) for referencing. The search focused on literature published after 2010, however due to limited literature on DS use among older adult population specifically, the search involved literature also published prior to this date. The search was limited to those published in English.

Table 2.1. Keywords and terms used in literature search strategy based on key concepts of study.

Concept	*MeSH terms* [a]	*Keywords*
Dietary supplement	Dietary supplements	"dietary supplement*" OR supplement* OR "food supplement*" OR nutraceutical* OR nutraceutical* OR neutraceutical* OR "herbal supplement*" OR "vitamin supplement*" OR "mineral supplement*" OR "nutrient supplement*" OR "nutrition supplement*"
Older population	Aged, middle aged, adult, 80 and over, age factors, aging.	"old age" OR "old* adult*" OR "old* population" OR "old* people" OR "aged 50" OR "aged 60" OR "aged 65" OR "elderly" OR "elderly people" OR "elderly population" OR "senior"
Prevalence of use	Prevalence, trends.	"use*" OR "usage" OR "prevalence" OR "trend*"
Sociodemographic subgroups	Socioeconomic factors, economic factors, economic status, income, educational status, employment, occupations,	"sex" OR "gender" OR "age" OR "age group*" OR "social class*" OR "education" OR "socioeconomic factors" OR "socioeconomic status" OR "income" OR "employ*" OR "deprivation area"

	social class, social factors, family characteristics, marital status, social conditions, home environment, independent living, ethnicity.	OR "deprivation index" OR "area* of deprivation" OR "marital status" OR "living alone" OR "living arrangement" OR "independent living" OR community dwelling*" OR "ethnicity" OR "ethnic group*" OR "nationalit*"
Lifestyle characteristics	Lifestyle, healthy lifestyle, healthy aging, health, diet, food, nutritional requirements, nutritional status, alcohol drinking, smoking, exercise, anthropometry, body mass index, waist-hip ratio	"lifestyle factor*" OR "lifestyle characteristic*" OR "health" OR "health factor*" OR "health characteristic*" OR "diet*" OR "nutrition* requirement" OR "diet* requirement" OR "nutrition* status" OR "diet quality" OR "alcohol intake*" OR "alcohol consumption" OR "smoking" OR "exercise*" OR "physical activit*" OR "body mass index" OR "BMI" OR "waist-hip ratio"

[a] used in PubMED

Abbreviations: BMI, body mass index; MeSH, medical subject headings.

This literature review explores the nutritional challenges that the older population face, dietary supplement (DS) use for older adult population, its definitions and regulatory processes, its prevalence, and the characteristics of users with a focus on the older population.

2.2 The aging population

People are living longer, and the aging population is growing. According to The World Health Organisation, by 2030 the population of adults aged 60 years and over is estimated to increase from 1 billion to 1.4 billion. That number is expected to exceed 2.1 billion by 2050 (The World Health Organisation, 2021). The New Zealand (NZ) population aged 65 years and over is estimated to increase from 0.79 million in 2020 to 1.36 to 1.51 million in 2048, and 1.61 to 2.22 million in 2073 (Statistics New Zealand, 2020). Not only is this an expected growth in size but also an expected increase in proportion of older adults in the population (Statistics New Zealand, 2020, The World Health Organisation, 2021, United Nations, 2017).

Even though people are living longer, they are not necessarily living in good health (Minister of Health, 2016). As people age there is an increased risk of non-communicable diseases (NCD). Close to 80% of adults over the age of 65 years have one chronic condition and the prevalence of multimorbidity increases with age (Stanley et al., 2018, Bernstein and Munoz, 2012). Therefore, there is increased pressure on healthcare systems to promote healthy aging to reduce the risk and rate of NCD. The demographic shift towards an aging population is also expected to increase the demand for long-term residential care and palliative care (United Nations, 2017). The increased pressures and costs associated with an increasing aging population highlights the importance of promoting health and quality of life of older adults (De Luca d'Alessandro et al., 2011).

There are several physiological, social, and physical changes that occur with the aging process that can impact nutritional status. The normal aging process causes molecular and cellular damage over time. This damage can result in the deterioration of physical and mental capacity, and increased risk of disease development (The World Health Organisation, 2021). While aging itself is not a disease, it does increase vulnerability for disease (Seals et al., 2016).

2.2.1 Physiological and physical changes in aging and its effect on nutritional requirements

Nutritional requirements of older adults can vary vastly depending on the presence of illness or disease, and their physiological or physical condition. Physiological changes in older adults can occur from both the normal aging process, but also from NCDs such as heart disease, diabetes, and arthritis (Raymond and Morrow, 2020). The decline in physiological function can be attributed to a number of different factors including but not limited to genetics, degree of illness, socioeconomic status, and lifestyle (Seals et al., 2016, Raymond and Morrow, 2020). These changes influence the diet and nutrient requirements of the older adult population.

Part of the normal aging process is the progressive loss of muscle mass and strength. This deterioration in quality of muscle fibres, peak power, and elasticity overall leading to poor muscular function is referred to as sarcopenia (Cruz-Jentoft and Landi, 2014). The factors that may contribute to sarcopenia in older adults include neurological decline, hormonal changes, decline in physical activity, presence of chronic illness, fatty infiltration, and poor nutrition (Walston, 2012). Sarcopenia is associated with increased frailty, increased risk of falls, fatigue, reduced functionality, loss of independence, and early mortality (Visser and Schaap, 2011, Walston, 2012, Cruz-Jentoft and Landi, 2014). Due to changes in metabolism older adults may produce less muscle mass compared to younger adults from the same amount of dietary protein (Kerstetter et al., 2003). Considering decline in muscle mass production and

the need for muscle preservation, the protein requirements for older adults are higher and increase with age, with people over the age of 70 years requiring 25% more protein than younger adults (Ministry of Health, 2013).

During the aging process, there are several changes throughout the gastrointestinal (GI) tract that occur that can affect nutrient status. The neuronal conduction between the GI tract and the brain slows, and the concentration of hormones change resulting in decreased hunger sensations and decreased appetite (Pitchumoni and Chaudhari, 2021, Raymond and Morrow, 2020). The rate of body metabolism declines, and nutrient absorption, storage, utilisation and excretion becomes less efficient (Raymond and Morrow, 2020, Soenen et al., 2016). Changes in body composition leads to a reduction in basal metabolic rate and subsequent reduced energy requirements (Leslie and Hankey, 2015). With reductions in daily energy requirements, reduced appetite, early satiety, taste alterations and reduced access to food, older adults tend to eat smaller volumes and portions of food (Leslie and Hankey, 2015, Giezenaar et al., 2016). These physiological changes contribute to decreased energy and protein intake and further increase the risk of protein-energy malnutrition (Sieber, 2019).

Physical changes also influence the nutritional status and intake of older adults. Oral health declines and a reduction in muscular strength makes the mechanical breakdown of foods more difficult (Kiesswetter et al., 2019). Poor dentition or xerostomia (dry mouth) can also make chewing and swallowing more difficult, and often leads to avoidance of certain foods (Leslie and Hankey, 2015, Ministry of Health, 2013). These factors all can contribute to decreased oral consumption and nutrient availability at the cellular level, making the older population at greater risk of nutrient deficiencies.

2.2.2 Social changes in aging

There are several social and psychological changes that occur in the aging process that have an impact on nutritional status. With increasing age, many older adults experience a narrowing of social networks, a change in living situation, more frequent bereavement, and partake in fewer social activities (Charles and Carstensen, 2010). This decrease in social contact, alongside age related disease or disabilities can influence an individual's motivation and ability to select, prepare and consume a diet that meets their nutritional requirements (Leslie and Hankey, 2015, Wham et al., 2011). The increased loneliness that results from the social changes in aging has been found to be associated with poor oral consumption and increased risk of malnutrition (Iizaka et al., 2008, Ramic et al., 2011, Ferry et al., 2005). Considering the physiological changes associated with reduced appetite alongside social

isolation, loneliness, and grief, older adults are at greater risk of poor nutritional and health status compared to younger adults.

2.2.3 Medications and interactions

With an increase in health complications and diseases with increasing age, older adults tend to have a higher prevalence of prescribed medicines (Tomlin et al., 2020). Not only is there an increased use of medication, but there is also an increased prevalence of polypharmacy (taking >5 medications) with increased age. The increasing number of individuals with numerous prescribed medications, for several health conditions, is of concern. Not only does adherence to medication regimes become more difficult with polypharmacy, but polypharmacy raises the potential for drug-drug interactions, drug-nutrient interactions, and risk of adverse events (Cross et al., 2017, Tomlin et al., 2020).

An increased number of medications, or polypharmacy, has been associated with poorer nutritional status in older adults (Heuberger and Caudell, 2011). There are also a number of medications that interact with foods and can cause side effects such as nausea, decreased appetite and xerostomia (Heuberger and Caudell, 2011). These side effects can cause a reduction in oral food consumption and negatively impact nutritional status of older adults.

2.2.4 Dietary supplement use in older adults

Alongside polypharmacy, DS use among older adults may also be of concern. There are several reasons an individual may use dietary supplements. Some of the key motivators for older adults using DS include chronic disease/illness prevention, recommendations from health professionals, or for site-specific symptom management and potential curative benefits (Albright et al., 2012, Bailey et al., 2013). Dietary supplementation contributes to increased intake of nutrients and may decrease a populations prevalence of specific nutrient inadequacy (Blumberg et al., 2017). Specifically for older adults there is evidence of the associations and potential benefits of omega-3 polyunsaturated fatty acids in reducing cardiovascular disease (CVD) or dementia risk (Siscovick et al., 2017, Ammann et al., 2017, Hooper et al., 2017), protein supplementation with exercise in muscle preservation (Liao et al., 2017, Li et al., 2022), vitamin D and calcium supplementation in supporting bone health (Hill and Aspray, 2017), or long-term multi-vitamin use in reducing risk of major CVD events (Bailey et al., 2015, Rautiainen et al., 2016). Given the challenge older adults face achieving nutritional adequacy from diet, dietary supplementation can play an important role in preventing inadequate nutrient intakes and the associated complications of deficiencies.

There are however several concerns for DS use in older adults including high cost, potential misleading claims in product marketing, detraction from intake of a high-quality diet, or potential negative nutrient-nutrient, nutrient-drug, or supplement-drug interactions (Bushra et al., 2011, Temple, 2013). One of the major concerns around DS use in older adults is the potential interactions with prescribed medications. In a study of older adults attending a memory clinic, DS users had an increased prevalence of polypharmacy, that is consumption of ≥5 or more medications, compared to non-DS users. Of the DS users 11.1% of DS had potential drug-supplement interactions (Cross et al., 2017). While for prescribed medications, drug-drug interactions are usually checked by physicians and pharmacists, interactions with dietary supplements that individuals take on their own accord can go undetected (Aznar-Lou et al., 2019). The outcome of these interactions can possibly lead to adverse drug reactions, alter the body's ability to utilise a particular food or drug, or cause serious side effects (Bushra et al., 2011). Involvement of a physician or pharmacist in the decision of supplementing a patient's diet and medication regime with a DS is therefore crucial for the patient's best interest and safety (Ronis et al., 2018). However, this is problematic due to the nature of the DS market and associated regulatory processes.

2.3 Defining dietary supplements

2.3.1 The market

The DS market is a steadily growing industry, with new supplements and brands entering constantly. In 2019, in the United States (US) alone, the nutraceuticals and supplement market was reported to be worth almost $353 billion USD (Lordan, 2021). In NZ, it is estimated that the natural health products industry, that is made up largely of DS, has an annual turnover of $1.4 billion NZD and is increasing (Ministry for Primary Industries, 2020). At the consumer level, DS are becoming more and more accessible and available for purchase not only at health stores and pharmacies, but also at supermarkets and via the internet (Low et al., 2017).

2.3.2 Definition and regulations

Dietary supplements have several different definitions. Denison et al. (2012) noted that comparing prevalence of supplement use across literature can be difficult due to different definitions used by researchers (Denison et al., 2012). Therefore, it is important to identify the differences in these definitions and specify the definition used when investigating research regarding the prevalence and determinants of DS use in older adults. Often the definitions used in the literature stem from the national organisations and bodies that define and regulate DS.

In the US, DS are regulated by the Food and Drug Administration (FDA) under the Federal Food, Drug and Cosmetic Act (Thakkar et al., 2020, The U.S. Food and Drug Administration, 2015). This is amended by the Dietary Supplement Health and Education Act of 1994 that defines dietary supplements as "a product, other than tobacco, intended to supplement the diet that bears or contains one or more of the following dietary ingredients: a vitamin; a mineral; a herb or other botanical; an amino acid; a dietary substance for use by man to supplement the diet by increasing the total dietary intake; or a concentrate, metabolite, constituent, extract, or combination of any ingredient described previously" (National Institutes of Health, 1994). The federal law requires all DS to be labelled as such however does not require all DS on the market to be proven safe by the FDA (Thakkar et al., 2020, The U.S. Food and Drug Administration, 2015)

In Australia, DS are considered complementary medicines which accompany medicines under the Therapeutic Goods Act (TGA) 1989 (Therapeutic Goods Administration, 2013). Under this act, complementary medicines include traditional herbal medicines, some nutritional supplements, vitamins and minerals, homeopathic preparations, aromatherapy preparations, traditional Chinese medicines and Ayurvedic medicines (Therapeutic Goods Administration, 2020). The regulation of complementary medicines in Australia operates under a risk-based approach, where medicines deemed to be high risk must register on the Australian Register of Therapeutic Goods (ARTG). Those deemed to be lower risk, such as certain homeopathic medicine preparations, are exempt from the requirement to be listed on the ARTG (Therapeutic Goods Administration, 2013). Similarly, to the FDA, the TGA do post-market regulatory checks on DS and other complementary medicines to monitor the safety, quality, and efficacy of products on the market. However in contrast to the US, registration of most DS as therapeutic goods is required prior to entering the Australian market (Therapeutic Goods Administration, 2013, The U.S. Food and Drug Administration, 2015).

Unlike Australia, in NZ there are two distinguished categories of products that are either classified as DS or medicines. Dietary supplements are regulated under the Dietary Supplements Regulations 1985, which falls under the Food Act 2014 (New Zealand Medicine and Medical Devices Safety Authority, 2021). The NZ Dietary Supplements Regulations originally published in 1985 continues to be extended, with the latest extension of regulation occurring in 2021 for an additional five years (Verrall, 2021). According to the 1985 Dietary Supplements Regulations of NZ, DS are defined as something that fulfills all the following:

1) Is an amino acid, edible substance, herb, mineral, synthetic nutrient, or vitamin
2) Is sold by itself or in a mixture

3) Is sold in a controlled dosage form as a liquid, powder, or tablet (cachet, capsule, lozenge, or pastille)
4) Is intended to be ingested orally
5) Is intended to supplement the amount of the amino acid, edible substance, herb, mineral, synthetic nutrient, or vitamin normally derived from food (Beattie, 1985).

Like the situation in the US, DS in NZ do not require pre-approval before entering the market. If the DS do contain ingredients from animal or animal products, they must also comply with the Animal Products Act 1999 or the Food Act 2014 (New Zealand Medicine and Medical Devices Safety Authority, 2021). The reoccurring extension of the NZ 1985 Supplements Regulations continues to provide more time for the development of a new regulatory scheme for natural health products that aims to ensure safety of the consumers as well as support industry development and growth (Ministry for Primary Industries, 2020).

Despite each country having slightly different regulatory process for DS, consumers can purchase DS on the internet from other parts of the world. This has further complicated the regulatory process for supplements, expanded the range of DS available to consumers, and highlights the lack of internationally recognised compendia that ensures safety for the consumer (Low et al., 2017, Thakkar et al., 2020).

2.3.3 Measuring supplement users

As mentioned above, the different methods of defining supplements varies across countries, and this extends to who is considered a supplement user. Parnell et al. (2006) used both the previous 24 hours and the past year to analyse DS prevalence use in the NZ population. Dietary supplement prevalence reduced with age when considering DS users as those that had used a DS in the past year, however prevalence increased with age when considering use in the past 24 hours. Use in previous 24 hours is commonly used in studies overseas and makes comparisons of DS prevalence between countries more feasible. Defining DS users as those who consumed dietary supplements within that past 24 hours does not consider people who take dietary supplements weekly, monthly, on occasion, or any other frequency less than daily. However, caution should be taken when making comparisons and conclusions about prevalence due to differing definitions of a DS and potential misrepresentation when supplements were taken over time spans greater than 24 hours (Bailey et al., 2019, Denison et al., 2012).

2.3.4 Categorising dietary supplements

As well as defining the term DS, the method of categorising DS varies across the literature. A study looking at DS use among Australian adults categorised supplements as "multi-vitamins, single vitamins, single minerals, herbal supplements, oil supplements and any other dietary supplementation" that did not fit within previous categories (Burnett et al., 2017). In comparison to Burnett et al. (2017), a NZ study conducted in 2006, based on results of the 1997 National Nutrition Survey (NNS), categorised DS into multivitamins and minerals, vitamin C, vitamin B-complex, garlic, iron, calcium, evening primrose, selenium, bee products, and zinc (Parnell et al., 2006). This supplement categorisation gives a more comprehensive analysis of the specific types of supplements taken and identified a significant difference between the type of DS used and age due to the high number of participants (n=4636). However, it is important to note that the type of categories researchers chose to highlight when examining the types of DS can be dependent on the DS marketing and societal trends during the data collection time. Additionally, the cultural practices and beliefs regarding health from the country where the research is taking place may also influence DS categories used(Omori and Dempsey, 2018, Albright et al., 2012).

2.4 Dietary supplement prevalence

To understand patterns of DS use, prevalence of DS use across different population groups needs to be explored. Table 2.2 summarises the findings and methods of several international studies that primarily examined the prevalence of DS use. These cross-sectional studies were conducted in developed countries. Eight of the 14 studies used DS data collected from national surveys, and four of the studies specifically looked at the older adult population.

When assessing prevalence of use in adult populations, DS use in the US was the highest, with over half of all US adults taking one or more DS (Cowan et al., 2018, Mishra et al., 2021, Kantor et al., 2016). Generally a lower prevalence was observed in adults residing in other countries such as Australia (43.2%), the Netherlands (42%), Canada (38%), South Korea (34.2%), Greece (31.4%), Sweden (30.5%), and Spain (9.3%) (O'Brien et al., 2017, van Rossum et al., 2020, Keshavarz et al., 2021, Kang et al., 2014, Rontogianni et al., 2021, Skeie et al., 2009, Rovira et al., 2013). However, comparing the prevalence between countries is difficult due to the vast range of definitions of DS across the studies as highlighted in table 2.2. Dietary supplement user definitions were also different with definitions ranging from use of a DS in the past 24 hours, past week, past two weeks, past 30 days, past winter season, past year, or past year on a weekly basis (table 2.2).

In NZ, Parnell et al. (2006) analysed the DS data from the NNS conducted in 1997 and found that 59% of adults had consumed ≥1 DS within the previous year. The most recent NZ DS data, that explores DS prevalence and all types of DS taken nationwide, is from the 2008-2009 NNS. Results from this national survey showed similar prevalence figures as Australia with 47.6% of participants using a DS within the last year (Ministry of Health and University of Otago, 2011). The reason for this change in DS prevalence in NZ is not known. The 2008-2009 NNS DS data is the most recent National DS data and may not be representative of current DS prevalence in NZ.

2.4.1 Dietary supplement prevalence in older adults

Evidence indicates that DS use among the older adult population is higher than the younger adult population (Burnett et al., 2017, Cowan et al., 2018, Mishra et al., 2021, O'Brien et al., 2017, Parnell et al., 2006, Kantor et al., 2016). From the NZ 2008-2009 NNS 39.8% of males and 52.6% of females 51 to 70 years old consumed any DS within the past year. Interestingly the highest prevalence of DS use was among the participants in the 31 to 50 year age group. A more recent study, the Life and Living in Advanced Age Cohort Study New Zealand (LiLACS NZ) also investigated DS prevalence among adults aged 80 to 90 years. They found that 86% of participants were considered DS-users (Wham et al., 2016).

With the growing aging population, the DS trends and prevalence of the older population group becomes more of interest. Data from the National Health and Nutrition Examination Survey (NHANES) in the US suggests that DS prevalence among those aged ≥65 years of age has been trending upwards (Kantor et al., 2016). No trends have been examined in the NZ population. This is likely because there has not been another NNS examining DS use since 2008-2009.

In most of these populations, the types of DS taken have been explored. Multivitamins are commonly one of the most popular DS taken by the older adult population (Brownie and Rolfe, 2005, Mishra et al., 2021, Shade et al., 2019, Tan et al., 2022). Data from the NZ 2008-2009 NNS found multivitamin prevalence among adults ≥71 years of age was lower than those aged 31-50 years (Ministry of Health and University of Otago, 2011). The prevalence of oil DS, most commonly fish oil, is often within the top three types of DS taken by the older adult population (O'Brien et al., 2017, Mishra et al., 2021, Brownie and Rolfe, 2005, Tan et al., 2022, Shade et al., 2019, Denison et al., 2012). In the 2008-2009 NZ NNS glucosamine was the second most common DS taken by those ≥71 years of age after oil DS (Ministry of Health and University of Otago, 2011). Due to the difference in type categorisation across studies, it is difficult to assess if this trend is also observed internationally. Interestingly, in a study

conducted in Japan, the researchers identified vinegar as a DS sub-category which was the second most popular DS (12.6%) used among the 55-75 year old DS user (Hirayama et al., 2008). Vinegar was not considered a DS or reported in other studies explored in the literature review. Omori and Dempsey (2018) discussed the beliefs that Japanese have around consumption of certain foods such as vinegar and their associated health benefits with anti-aging. This demonstrates how reporting of the types of DS used may differ from countries due to cultural beliefs and different definitions of dietary supplementation.

Table 2.2. Summary of studies assessing prevalence of dietary supplement use amongst difference population groups

DS prevalence in adult populations				
Author, year, Country	*Study design, population size, age*	*DS and DS user definition*	*Method of data collection*	*Findings* *Prevalence, most common DS type*
Parnell et al., 2006; NZ	CSS, n = 4636, ≥15 yrs.	DS – Any product intended for ingestion as a supplement to the diet. No DS-user definition specified.	NNS 1997, face-to-face interview.	59% of adults had taken ≥1 DS in the previous year. 40.5% males ≥65yrs, 58.4% females ≥65 yrs had taken a DS in previous year.
Burnett et al., 2017; Australia	CSS, n = 4895, >19 yrs.	No DS definition specified. DS user: took ≥1 DS on either of 2x 24hr dietary recalls.	National Nutrition and Physical Activity Survey 2011-2012, DS data was collected via 24hr dietary recall.	34% of males and 47% of females were DS users. DS use was highest amongst those 71-85 yrs (52.7%)
O'Brien et al., 2017; Australia	CSS, n = 19257, ≥18 - ≥70 yrs.	DS – Complementary Medicines under the Therapeutic Goods Administration. DS user: used a DS within past 2 weeks	NHS 2014-2015, face-to-face interviews.	43.2% of adults (34.9% males, 50.3% females) were DS users. Highest among those aged ≥70 yrs (40% males, 58% females). Most common DS in 30-49 yrs: MVM (22.3%; males 17.8%, females 25.8%). Most common DS in 50-69 yrs: Fish oil (males 13.2%, females 16.1%).
Mishra et al., 2021; US	CSS, n = 16211, ≥20 yrs	No DS definition specified. DS user: used a DS in the past 30 days.	National Health and Nutrition Examination Survey (NHANES) 2017-2018. Interview style.	57.6% DS users (63.8% females, 50.8% males). DS use higher in those ≥60 yrs (80.2% females, 67.3% males) Most common DS used ≥60 yrs: MVM (39.4%), vit D (36.9%), omega-3 (21.8%).
Cowan et al., 2018; US	CSS, n = 11024, 19 - ≥71 yrs	No DS or DS-user definition specified.	NHANES Survey 2011-2014. Interview style.	52% took at least 1 DS in 30-day period (59% females, 45% males). DS was highest in those ≥71 yrs.
Kang et al., 2014; South Korea	CSS, n = 16031, ≥20 yrs	No DS definition specified. DS user: used a DS for ≥2 weeks or on a continuously in past year.	Korea National Health and Nutrition Examination Survey (KNHANES) 2007-2009. Interview style.	34.2% were DS users (27.4% males, 40.8% females). Most consumed DS was MVM (39%), vit (19%), and omega-3 (11.4%)
Rontogianni et al., 2021; Greece	CCS, n = 1237, 25-70 yrs	DS – Concentrated sources of nutrients with nutritional/physiological effect, intended to supplement the diet.	Epirus Health Study 2019-2021. Interview style.	31.4% of all adults were DS users (37.3% females, 22.4% males). In females age was positively associated with DS use until 51-70yrs, where DS use declined afterwards.

		DS user: used a DS in past week.		
Van Rossum et al., 2020; Netherlands	CSS, n = 4000+, 1-79 yrs	No DS definition specified. DS user: used a DS in winter and/or the rest of the year.	Dutch National Food Consumption Survey 2012-2017. Data collected through questionnaire and 24hr dietary recall.	30% of males and 52% of females 19-79 yrs had taken DS. Most consumed DS was MVM (19% males, 32% females), vit C (11% males, 19% females), and vit D (6% males, 15% females)
Rovira et al., 2013; Spain	CSS, n = 6352, 35-80 yrs	No DS or DS-user definition specified	Cross-sectional survey in Girona Spain in 2005. DS data was collected from food-frequency questionnaire.	9.3% of adults were considered DS users.
Skeie et al., 2009; Europe	CSS, n = 36034, 35-74 yrs	DS – Concentrated sources of nutrients with nutritional/physiological effect, intended to supplement the diet.	European Prospective Investigation into Cancer and Nutrition 1995-2000. DS data collected via 24hr food recall.	DS use per country follows: Denmark: 51% males, 65.8% females. Sweden: 30.5% males, 42.4% females. Germany: 20.7% males, 27% females. The Netherlands: 16% males, 32.1% females. Italy: 6.8% males, 12.6% females. Spain: 5.9% males, 12.1% females
DS prevalence in older adult populations				
Author, Year, Country	*Population sample size, age*	*DS and DS user definition*	*Method of data collection*	*Findings Prevalence, most common DS type*
Brownie et al., 2005; Australia	CSS, n = 1263, ≥65 yrs	DS – Any capsule, tablet, or liquid preparation that contained predominantly vitamins, minerals, herbal products, or other health preparations. No DS user definition	Random selection from Australian Electoral Commission in 2001. Participants completed a questionnaire.	43% used at least 1 DS (52% females, 35% males). Majority of users reported regular use. vit C 26%, MVM 17%, fish oil 17%, vit E 16%, Ca 13%, garlic 11%
Tan et al., 2020; US	CSS n = 6045, ≥50 yrs	No DS definition specified. DS user: used a DS at least once weekly	Health and Retirement Study 2012-2014 (national survey). DS data collected via questionnaire.	84.6% of population group were DS users. Mean ± SD of 3.2 ± 0.1 DS, 41.9% taking ≥4. MVM 57.7%, vit D 37.4%, fish oil 31.1%, Ca 26.1%, vit C 19.8%, vit B12 14.%.

Shade et al., 2019; US	138, ≥65 yrs	DS – Product that contains one or more dietary ingredients, with the intent to supplement the diet. DS user – anyone who had consume a DS in the past month.	Recruited via clinic in Midwest. All community-dwelling adults that used ≥3 prescribed medications. DS data collected via interview.	83% used at least 1 DS. 29% used ≥5 DS. Vit D 46%, MVM 40%, Ca 37%, fish oil 19%, vit C 14%. Common for those taking MVM to take additional single vit.
Denison et al., 2012; UK	CSS, n = 3217, 59-73 yrs	No DS definition specified.	The Hertfordshire Cohort Study (HCS) 1998 – 2004. Home visits/interview style.	45% were taking ≥1 DS (45.4% males, 57.5% females). Commonly consumed DS: oils (fish), herbal products (garlic), MVM, and single minerals.
Hirayama et al., 2008; Japan	CSS, n = 572 55-75 yrs	No DS definition specified. DS user: used ≥1 DS weekly for ≥1 year	Interviews on DS use took place in 2006 at community/health centres in middle and southern Japan. Interview style.	45.8% were DS users (41.7% males, 52.5% females). Mean ± SD number of DS used was 1.77 ± 1.2. Commonly consumed DS: vinegar (12.6%), MVM (7%), energy drinks (7%), vit C (5.6%)

Abbreviations: Ca, Calcium; CSS, cross-sectional study; DS, dietary supplement; hr, hour; KNHNES, Korea National Health and Nutrition Examination Survey; MVM, multivitamin-mineral; NNS, National Nutrition Survey; NHANES, National Health and Nutrition Examination Survey; NHS, National Health Survey; NZ, New Zealand; UK, United Kingdom; US, United States; vit, vitamin; yrs, years

2.5 Characteristics of dietary supplement users

Exploring the characteristics of DS users, such as the sociodemographic, lifestyle, and health characteristics, is a crucial part of DS research. Understanding who is currently using dietary supplements will help guide future health interventions, initiatives, and potentially drive the need for DS regulation reviews. Most of the larger studies that explore DS intake in NZ have been undertaken through the analysis of data collected from National Nutrition Surveys (Parnell et al., 2006, Burnett et al., 2017). As dietary supplementation is only a small section of the survey, these larger studies tend to not explore the relationship between DS use and characteristics in depth. Therefore, the key literature that explores the characteristics of DS use includes those researched in other countries, or those that include a larger age range.

It is also important to recognise that reasons or characteristics of use can extend far beyond the factors explored below. Individuals perception of importance, recommendations made by health professionals, and the presence or perceived risk of specific disease or medical problems related to the individual can be common reasons why DS are taken (Albright et al., 2012). Dietary supplement users are often motivated to take supplements for preventative reasons, mental and physical health enhancement, and curative benefits (Pajor et al., 2017, Brownie and Rolfe, 2005). While exploring the motives and reasons for use of DS use is important, it is beyond the scope of this literature review. Selected sociodemographic, lifestyle, and health characteristics are explored.

2.5.1 Sociodemographic characteristics

Table 2.3 summarises the sociodemographic characteristics associated with DS use across several international studies. Majority of the studies included in the table were cross-sectional, and nationally representative studies conducted in developed countries. The studies included in the table were not limited to the older adult population, with five out of seven studies including adult populations with the youngest including participants 15 years of age.

Table 2.3. Summary of studies comparing sociodemographic characteristics of dietary supplement users versus non-dietary supplement users.

Sociodemographic characteristics associated with DS use				
Author, Year, Country [1]	*Age, sex*	*Ethnicity*	*Education*	*Socioeconomic*
Parnell et al., 2006; New Zealand	DS use in females was higher than in males across all age groups. Younger adults had a higher prevalence of episodic use, but lower daily use compared with older age groups.	DS use in previous 24hr was highest in NZ European and others, followed by Māori and then Pacific.	NA	NA
Burnett et al., 2017; Australia	DS use was higher in females compared to males. DS use was highest among females aged 71-85 yrs.	NA	DS use was higher in those with higher levels of education.	DS use was higher in those living in areas with the least socio-economic disadvantage
O'Brien et al., 2017; Australia	Increasing age and female sex were significant predicators of DS use.	Being born overseas in non-English speaking countries was a significant predictor of DS use	Adults with a higher education were more likely to be DS users	NA
Tan et al., 2022; US	DS use was highest among those ≥75 yrs and female.	"White/Caucasian" had higher DS use compared to "Black/AA, or Other"	DS use was associated with higher	NA
Cowan et al., 2018; US	DS use highest in those ≥71 yrs and female sex. DS use increased linearly with age.	Non-Hispanic whites, and non-Hispanic Asians had a higher DS use compared to non-Hispanic Blacks or Hispanics.	DS use was associated with a higher education attainment.	DS use was associated with higher income and higher food-security.
Denison et al., 2012; UK	DS use was higher in females compared to males.	NA	NA	Those taking oil DS were more likely to be in lower social classes. In male DS users, those who took glucosamine, single vitamin, or MVM tended to be of a higher social class.
Rontogianni et al., 2021; Greece	DS use was higher in females compared to males. Male DS users were more likely to be young, female DS users were more likely to be older.	NA	No association found between education and DS use.	No association found between income and DS use

[1]Information on study design, population, and method of data collection found on table 2.2.

Abbreviations: AA, African American; DS, dietary supplement; hr, hour; MVM, multivitamin-mineral; NA, not assessed in study; UK, United Kingdom; US, United States; vs, versus; yrs, years.

Sex and dietary supplement use

The association between sex and DS use was observed across almost all the literature. All seven studies in table 2.3 found that DS use was significantly higher among females compared to males. Denison et al. (2012) looked specifically into the characteristics of different clusters of adults according to the type of DS used. They found when looking at the female DS users, the oldest DS users were those in the glucosamine cluster group.

Interestingly Parnell et al. (2006) found that even though prevalence of use was higher in females compare to males, the prevalence of female DS users decreased with age. More specifically the types of supplements used that reduced with age included multivitamins and minerals, vitamin B-complex, iron, and zinc. The reason for this was not explored within this study however reductions in the use of supplements such as iron, could be related to age related changes like menopause resulting in less iron deficiency and less need for dietary supplementation.

There is limited literature that explores the potential reasons why females are more likely to take dietary supplements. Conner et al. (2001) used the Theory of Planned Behaviour to develop a questionnaire that investigated the beliefs of females regarding DS use. They unveiled that the high value on health that females tend to have made them more likely to use dietary supplementation. The beliefs and attitudes around dietary supplement's ability to prevent disease and illness, or improve overall health is prominent among DS users (Albright et al., 2012, Bailey et al., 2013, Pajor et al., 2017).

Ethnicity and dietary supplement use

The association between ethnicity and DS use was not commonly explored across the literature. Three out of seven studies in table 2.3 explored ethnicity and DS use (two from the United States and one from NZ). Cowan et al. (2018) and Tan et al. (2022) found that DS use was higher in those who reported being white/Caucasian or non-Hispanic Asian, compared to those who reported being Black/African American or Hispanic.

The previous NNS in NZ, 1997 and 2008-2009, have explored the difference in DS use among ethnicities in NZ. Outlined in table 2.3, the 1997 NNS found that DS use within that past 24 hours was highest among those who identified as NZ European and all other ethnicities, followed by Māori and Pacifika (Parnell et al., 2006). Data from the 2008 to 2009 NZ NNS

demonstrated similar findings (Ministry of Health and University of Otago, 2011). When looking specifically at the Māori population group ≥51 years of age, Māori had lower prevalence of use compared to the total population group with only 36.6% of Māori men and 34.2% of Māori females being DS users. Those of Pacifika ethnicity had an even lower prevalence of DS use, with 12.3% of Pacifika males, and 14.8% of Pacifika females ≥51 years of age being DS users. This was significantly lower than the percentages of the total population group that were DS users, 39.8% of males and 52.6% of females (Ministry of Health and University of Otago, 2011). The prevalence of DS use among all other ethnicities was not published in the report. Similar findings were shown in the more recent LiLACs NZ study, where 65% of Māori participants were considered DS users, where as 98% of non-Māori participants were DS users (Wham et al., 2016).

The reasons for differences in DS prevalence across different ethnic groups has not been extensively explored. Albright et al. (2012) researched the motives and reasons for DS use amongst adults across numerous ethnicities in the US. They found that African Americans and Native Hawaiians were three times more likely, and Latinos six times more likely, to "report supplements being as important as prescription medications" compared to individuals who consider themselves of a white ethnicity. Albright et al. (2012) theorised that the historical cultural practices of collectivism, versus individualism, contributes to a greater use and support of alternative, contemporary or holistic forms of medicine. However, there were no differences found between different perceptions of DS and the number of DS taken. More research is required to understand the reason for differences in DS prevalence among different ethnicities in a population group.

Socioeconomic status, education, and dietary supplement use

The method of measuring socioeconomic status of participants, differs across studies. When looking specifically at the older adult population, measuring socioeconomic status can be complex. Over the course of life, the representation of socioeconomic status from wealth, rather than income, becomes increasingly more important. As individuals accumulate assets and retirement impacts their income, the income value become less representative of socioeconomic status (Galobardes et al., 2007).

Four out of seven of the studies explored in table 2.3 compared the socioeconomic status of DS users vs non-DS users. Each used a different measure of socioeconomic status including income, food-security, social class (based on occupation), or level of socio-economic disadvantage (based on level of deprivation in residing area). Two of these studies found that DS use was higher in those with least socio-economic disadvantage (Cowan et al., 2018, Burnett et al., 2017). Denison et al. (2012) specifically examined the relationship of social class and types of DS used. They found that DS users that took glucosamine, single vitamin, and vitamin and mineral dietary supplements tended to be of a higher social class compared to those that took herbal and oil products. In contrast, Rontogianni et al. (2021) found no association between income and DS use. In terms of education, four out of five studies explored in table 2.3 found that DS use was associated with higher levels of education among adults (O'Brien et al., 2017, Tan et al., 2022, Cowan et al., 2018, Burnett et al., 2017).

The socioeconomic characteristic of adult DS users from the 2008 to 2009 NZ NNS was analysed using the New Zealand Deprivation Index 2006 (NZDep2006). The NZDep2006 is a 10-point scale that describes the general socioeconomic deprivation in an area where an individual lives. It was collapsed in the 2008/2009 NNS and is reported as quintiles where 1 is the least deprived and 5 is the most deprived (White et al., 2008). The Ministry of Health and University of Otago (2011) found that adult DS use within the last year decreased with increasing neighbourhood deprivation. Specifically, the female adult group had higher DS prevalence among those in the NZDep2006 quintiles 1, 2, and 3 compared to those in quintile 5.

Several studies have discussed the potential reasons for higher socioeconomic status and higher education levels observed in DS user groups. One of the main theories is that those with higher socio-economic status or higher levels of education are more likely to be more health conscious and engage in healthy behaviours thus have a higher motivation to take more dietary supplements (Oude Groeniger et al., 2019, Kofoed et al., 2015).

2.5.2 Lifestyle characteristics

Table 2.4 explores the lifestyle and health characteristics associated with DS use. Seven of the eight studies explored in table 2.3 were also explored in table 2.4. These studies included adults as well as older adult population.

Table 2.4. Summary of studies comparing lifestyle and health characteristics of dietary supplement users vs non-dietary supplement users.

Lifestyle and health characteristics associated with DS use					
Author, Year, Country [1]	*Physical activity*	*Alcohol & Smoking*	*Dietary intake*	*Health measures& Dietary Intake*	*Anthropometrics*
O'Brien et al., 2017; Australia	Being physically active was a significant predictor of DS use.	Being a non-smoker/previous smoker was a significant predictor of DS use. No association between alcohol and DS use.	NA	NA	In adults, a healthy BMI category was an independent predictor of DS use compared to those who were in obese category.
Tan et al., 2020; US	Moderate to vigorous PA was associated with higher odds of DS use.	Daily alcohol use (compared to none, frequent, occasional) and being a non-smoker was associated with higher odds of DS use.	NA	Regular medication use (2x more likely to be DS user) and reported presence of arthritis was associated with higher odds of DS use. No association found with self-reported health and DS use.	BMI obese category was associated with low odds of DS use
Cowan et al., 2018; US	NA	Moderate alcohol consumption (1 drink/day), and abstinence from smoking was associated with DS use.	NA	Prevalence of DS use was higher among those who had a self-reported health status of 'excellent' or 'very good' and having private health insurance.	Those in obese category reported less DS use compared to those in the normal and overweight category.
Rontogianni et al., 2021; Greece	Male DS users were more PA compared to male non-DS users. No association between PA and DS use in females.	No association found between alcohol intake and DS use.	NA	Males DS users were more likely to take medications compared to male non-DS users. Female DS users were more likely to report chronic disease and a worse general health status compared to female non-DS users.	Female DS-users had lower BMI, waist circumference and hip circumference compared to female non-DS users

Burnett et al., 2017; Australia	DS use was highest among those who met the PA guidelines.	An association was found between being an ex-smoker/having never smoked and DS use compared to those that reported current smoking. No association was found between alcohol intake and DS use.	DS use was highest among those that met the fruit and vegetable guidelines.	No association was found between self-assessed health and chronic disease and DS use.	No association was found between BMI and DS use.
Denison et al., 2012; UK	NA	Females in the vitamins and mineral group were most likely to exceed the recommended alcoholic units per week compared to other DS users. No significant difference between type cluster groups and smoking status.	In males, those that took herbal DS tended to have the healthiest diet (based on prudent diet scores). Females in the glucosamine cluster tended to have the healthiest diets. For both sexes those in the oil cluster tended to have the least healthy diets.	No significant difference between type cluster groups and self-rated general health or number of medications used for both males and females.	Males in the oil type cluster group had the highest BMI, however the difference between clusters was small. No significant difference was found in the type of DS taken by female DS users and BMI.

[1]Information on study design, population, and method of data collection found on table 2.2.

Abbreviations: BMI, body mass index; DS, dietary supplement; hr, hour; NA, not assessed in study; PA, physical activity; UK, United Kingdom; US, United States; vs, versus; yrs, years.

Physical activity and diet

Four out of the six studies in table 2.4 investigated the relationship between physical activity and DS use and all four found an association. O'Brien et al. (2017), Tan et al. (2022) and Burnett et al. (2017) found that DS was highest among those that were physically active, engaged in moderate to vigorous physical activity, or met the physical activity guidelines respectively. Rontogianni et al. (2021) found that the association between physical activity and DS use was only significant in males and not females although no rationale for this finding was reported.

In terms of diet quality and DS use, only two studies in table 2.2 explored this association. In a study completed by Denison et al. (2012), dietary data was collected using a 129-item food frequency questionnaire (FFQ) and the relative "healthiness" of the diet was defined using a prudent pattern scoring system in line with the healthy eating recommendations in the United Kingdom. Denison et al. (2012) found that overall, DS users had the highest prudent diet score and thus the healthiest diets compared to non-DS users. Furthermore, they examined the relationship between quality of diet and specific types of dietary supplements used by older adult DS users and found that males who took herbal dietary supplements had more prudent diets compared to other DS users, and females that took glucosamine had the healthiest diet compared to other female DS users. For both females and males, those that took oil dietary supplements appeared to have the least healthy diet when compared to other DS users.

Similarly, Burnett et al. (2017) found that meeting the guidelines for fruit and vegetable intake was positively associated with DS use. As well as this, Burnett et al. (2017) also found that DS users were more likely to meet their recommended daily intake (RDI) of nutrients compared with non-DS users. Grieco et al. (2022) found that among a population consisting of female cancer survivors over 65 years old, multivitamin users had a significantly higher healthy eating index score for vegetables, greens and beans, whole fruits and whole grains consumption compared to those that did not take dietary supplements. These finding suggest that DS users tend to have a higher quality diet than non-DS users, thus supporting the theory that DS users tend to be more health-conscious individuals and engage in healthy lifestyle behaviours.

Smoking and alcohol

Five out of six studies in table 2.4 that explored the relationship between smoking and DS use and four found an association. Research that has explored the relationship between smoking

status and DS use, found that those who abstain from smoking had a higher prevalence of taking dietary supplements (Kang et al., 2014, O'Brien et al., 2017). Cowan et al. (2018) found that in the US DS use was higher in people who had never smoked, and former smokers (53.5% and 61% respectively) compared to occasional and current smokers (40.3% and 38.8% respectively).

When looking specifically at the older adult population and the relationship between smoking and DS use, similar trends are observed. Tan et al. (2022) found that in US adults ≥50 years and over, current smoking was associated with lower odds of DS use. This again, supports the theory that DS users are more likely to report better health and participate in healthy lifestyle behaviours.

2.5.3 Health characteristics

Body mass index (BMI), waist circumference and self-reported health status

Six out of the seven studies in table 2.4 explored the association between BMI and DS use. Three studies found that DS use was less prevalent among those in the overweight or obese weight BMI category, compared to those in the healthy BMI category (Cowan et al., 2018, O'Brien et al., 2017, Tan et al., 2022). While BMI is commonly used as a measure of health in adults, it may not be an appropriate measure of health among older adults. Winter et al. (2014) conducted a meta-analysis to determine the association between BMI and all-cause mortality risk in adults ≥65 years old. They found that being overweight was not associated with increased risk of mortality, but rather a BMI <23 was associated with increased mortality. The limitations of using BMI as a health measure is that it does not capture significant body composition changes that occur throughout the aging process, such as reduction in lean body mass and increase in fat mass. Therefore, the use of BMI as a health predictor should be used with caution and in conjunction with other measures of health.

Some literature has explored other measures of health in association to DS use, including waist circumference and self-reported measures of health. Rontogianni et al. (2021) found that female DS users had a lower hip circumference compared to female non-DS users, however no significant association was found in the male population. There are mixed findings when looking at the association between self-reported health and DS use with three studies in table 2.4 finding no significant association and one study finding DS use was higher among those

who had an excellent or very good self-reported health status (Burnett et al., 2017, Cowan et al., 2018, Denison et al., 2012, Tan et al., 2022).

2.6 Conclusion and relevance to New Zealand

While there are benefits of DS use, older adults that take dietary supplements are at greater risk of subsequent nutrient-nutrient, drug-nutrient, or supplement-drug interactions (Bushra et al., 2011, Temple, 2013). Dietary supplements on the NZ market do not require pre-approval before entering the market, and can be taken on an individual's own accord with or without physician or pharmacist oversight (Aznar-Lou et al., 2019, New Zealand Medicine and Medical Devices Safety Authority, 2021). Therefore, from a safety perspective, it is important to understand DS use in the older adult population.

Currently there are minimal studies that have explored DS use in older adults living in NZ. Internationally DS use in older adults is high and increasing (Burnett et al., 2017, Cowan et al., 2018, Mishra et al., 2021, O'Brien et al., 2017, Parnell et al., 2006, Kantor et al., 2016). Literature suggests that those who are female, have a higher socio-economic status and level of education, do not smoke, follow a healthy diet, and overall have a better self-reported health status are more likely to use dietary supplements (Harris et al., 2017, Burnett et al., 2017, Cowan et al., 2018, Rontogianni et al., 2021). There is no recent research on the characteristics of DS users in NZ older adults. Investigations into the prevalence and characteristics of DS use among NZ community-dwelling older adults needs to be explored to better understand the DS use within this population group and help drive necessary interventions.

Chapter 3. MANUSCRIPT

3.1 Abstract

Aim

Little is known about dietary supplement (DS) intake in older adults living in New Zealand. This research aimed to explore DS use in older community dwelling adults living in New Zealand (NZ) using data from the Researching Eating, Activity and Cognitive Health (REACH) study.

Methods

DS use was assessed among community dwelling older adults aged 65 to 74 years. Data on DS use and sociodemographic, lifestyle and health characteristics was collected through a health and demographic questionnaire, a short international physical activity questionnaire, a four-day estimated food record (4DFR), and anthropometric measurements at the Human Nutrition Research Unit at Massey University in Auckland, NZ. Chi-squared tests and independent *t*-tests were used to compare the characteristics of DS users versus non-DS users. Chi-squared tests were also used to compare the types of dietary supplements taken by female versus male DS users.

Results

Among the 371 participants (64.2% female; 93.5% European; mean age 69.7 ± 2.6), 64% were considered DS users. The most consumed DS was oil (25.9%), single vitamins (25.1%), single minerals (23.5%), and multivitamins (19.7%). Dietary supplement use was significantly higher among females compared to males (70.6% of females, 52.6% of males were considered DS users; $p<.001$). Male DS users were significantly more likely to adhere to the Ministry of Health alcohol intake guidelines ($p=.008$), have a higher self-reported level of health ($p=.016$), and a higher Index of Multiple Deprivation (IMD; greater deprivation) ranking ($p=.045$) compared to male non-DS users. There was no significant difference in characteristics between DS users and non-DS users in females.

Conclusions

DS use among older community-dwelling older adults living in Auckland, NZ is high. Dietary supplementation was most prevalent in those that were female. In males, DS use was higher in those who met the alcohol consumption guidelines, those who had higher reported level of health, and those living with greater deprivation compared to male non-DS users. Further research on a more diverse and representative population group is required to better understand the DS use prevalence and predictors of use for the older adult population across NZ.

Keywords
dietary supplement, aged, prevalence, socioeconomic factors, family characteristics, lifestyle, health, New Zealand.

3.2 Introduction

As individuals age, there are a number of physiological, physical, social and psychological changes that can influence their nutritional status (Ministry of Health, 2013). Loss of appetite, increased chewing and swallowing difficulties, and decreased oral intake, can all contribute to increased risk of nutrient deficiencies and malnutrition in the aging population (Ministry of Health, 2013, Tay et al., 2021). In situations where nutritional status is suboptimal, dietary supplementation may be beneficial. Dietary supplementation has also been associated with reduced risk of cardiovascular disease (CVD), dementia, and has been shown to support bone health and muscle preservation in older adults (Walrand, 2018). However, improper or misinformed use of dietary supplements can cause negative drug or nutrient interactions, or even lead to possible nutrient overdose (Harris et al., 2017, Bushra et al., 2011).

According to the New Zealand (NZ) Ministry of Health (MoH), dietary supplements are products that are taken with the intention of supplementing a diet to achieve desired nutritional adequacy (Ministry of Health and University of Otago, 2011). It encompasses, but is not limited to, vitamins, minerals, herbs or botanical supplements, amino acids, and active compounds derived from plants or other biological material (Parnell et al., 2006). Most dietary supplements are in the form of a capsule, pill, powder, or liquid and are ingested orally. All dietary supplements on the NZ market must comply with the Dietary Supplement Regulations 1985 that falls under the Food Act 2014. Any supplements containing ingredients from animal or animal products, must also comply with the Animal Products Act 1999 (New Zealand Medicine and Medical Devices Safety Authority, 2021).

Studies have shown that older adults are more inclined to use dietary supplements compared to younger adults (Parnell et al., 2006, Burnett et al., 2017, Denison et al., 2012). Some studies suggest that the high prevalence of supplement use amongst the older population is increasing (Guo et al., 2009, Harris et al., 2017, Kantor et al., 2016, Keshavarz et al., 2021). In NZ, of those over 65 years of age who had used supplements in the previous year, 73.4% took supplements daily, 15.4% took supplements episodically (regular supplement taking for a

limited time period), and 10.9% took supplements less than daily (Ministry of Health and University of Otago, 2011).

Few studies have investigated the types of dietary supplements older adults in NZ are consuming. Mixed findings, regarding the types of DS used, have been found internationally, with oils/lipids and multivitamins being some of the most commonly consumed DS among the older adult population (Brownie and Rolfe, 2005, Burnett et al., 2017, Denison et al., 2012, Tan et al., 2022). In the 2008-2009 NZ National Nutrition Survey (NNS) those aged 51-70 years consumed mainly oils, followed by glucosamine/chondroitin, and herbal products (Ministry of Health and University of Otago, 2011). Further investigation is required to understand what types of dietary supplementation NZ older adults are currently consuming.

Understanding of the sociodemographic, lifestyle and health characteristics of DS users means that future education and interventions regarding supplement use can be targeted appropriately. Current literature suggests there are differences between some sociodemographic characteristics and supplement use. People that are female, older, who have a higher socio-economic status and level of education, do not smoke, who follow a healthy diet, and overall have a better health status are more likely to use dietary supplements (Harris et al., 2017, Burnett et al., 2017, Cowan et al., 2018, Rontogianni et al., 2021). However, most of the studies that investigate the characteristics of supplement users were conducted in countries outside of NZ and did not focus specifically on the older population.

Limited research has investigated the prevalence of DS use, including the specific types of supplements being taken and characteristics of DS users versus non-users among older adults living in NZ. Therefore, the aim of this study is to explore DS use in older community dwelling adults living in NZ using data from the Researching Eating, Activity and Cognitive Health (REACH) study.

3.3 Methods

3.3.1 Study design and population

To explore DS use in older adults, a secondary data analysis of the cross-sectional Research Eating, Activity and Cognitive Health (REACH) study was conducted. The REACH study's aim was primarily to investigate associations between dietary patterns, cognitive function and metabolic syndrome in community dwelling older adults (Mumme et al., 2019). A total of 371

participants were involved in the REACH study, all 65 to 74 years of age, living independently in Auckland, NZ and all proficient in English. Exclusion criteria included being colour blind, taking medication or having had a diagnosis or condition that affects cognitive function (such as dementia, stroke, trauma to the head, psychiatric condition). People were also excluded if they had experienced any significant event in the previous two years that may have influenced dietary intake or cognitive function. Only one person per household was able to participate.

Between April 2018 and February 2019, participants were recruited through radio interviews and press releases from Massey University, the Massey University Human Nutrition Research Unit (HNRU) participant database, posters and flyers in community centres, recreational centres, and the Citizen Advice Bureaus throughout the Auckland region.

Ethics approval for the REACH study was granted by Massey University Human Ethics Committee (Southern A, Application 17/69). All participants provided written informed consent prior to the initial data collection at the HNRU at Massey University in Auckland, NZ.

3.3.2 Data collection

Following online or telephone screening to confirm eligibility, participants attended a 4 to 5 hour appointment at the HNRU at Massey University in Albany, Auckland. Participants completed several measurements and questionnaires related to the main objectives of the study. Methods of data collection relevant to the objectives of this study included completion of a health and demographic questionnaire, a physical activity questionnaire, and anthropometric measurements. Following this initial assessment participants were asked to complete a complete a four-day estimated food record (4DFR).

<u>Dietary supplement use</u>

Data regarding DS use was extracted from the health and demographics questionnaire (Appendix A). Participants were asked “are you taking any form of supplements, including tablets or drinks?” If yes, they were asked to report the name, brand, dosage and duration of the specified supplement they were taking. In addition, answers recorded in the two medication questions section of the questionnaire were screened for dietary supplements. If these were deemed a DS by definition (see below), they also were included in data analysis.

Socio-demographic and health data

The socio-demographic factors that were explored were age, sex, ethnicity, education level (no qualification; primary; secondary; post-secondary; university), marital status (married/cohabitating/civil union/de facto; divorced/separated; widowed; single), self-reported material standard of living (high; fairly high; low to medium), retirement status (fully; semi; not retired), living situation (with others; alone), and index of multiple deprivation (IMD) ranking. Presence of polypharmacy, defined as taking ≥5 medications, was also collected. This data was collected through the health and demographics questionnaire. IMD ranking was used to assess the level of socioeconomic deprivation. The IMD is categorised into either 1-4 (least deprived), 5-7, or 8-10 (most deprived in accordance with the participant's street address and relative IMD location ranking (Exeter et al., 2017).

At their appointment, trained researchers measured participants body weight, height and waist circumference using standardised procedures. Digital scales (Tanita Electronic Scale) and a stadiometer (Holtain) were used to measure weight and height respectively. Body mass index (BMI) was calculated for each participant (weight (kg) /height $(m)^2$).

Lifestyle data

Data for smoking status (yes/no/former smoker) and alcohol consumption (a frequency, number of standard drinks, number of alcohol-free days) was collected through the health and demographic questionnaire. Participants were asked questions on whether or not they drink alcohol (yes/no), frequency of alcohol intake (daily/weekly/monthly), typical number of standard drinks (in one usual drinking day, and a maximum number in an occasional sitting), and number of alcohol-free days per week (one to seven days). Answers to the alcohol questions were used to calculate the number of Ministry of Health (MoH) alcohol consumption guidelines were met. The four guidelines specified by the MoH include number of standard drinks per drinking day (males ≤3; females ≤2), per week (males ≤15; females ≤10), maximum standard drinks on one occasion (males ≤5; females ≤4), and two or more alcohol free days per week. Answers were also used to calculate the number of standard drinks consumed per week.

The international physical activity questionnaire (IPAQ) was used to measure physical activity levels (Craig et al., 2003). Answers to the questionnaire were used to calculate a physical activity score using metabolic equivalent of a task (MET-minutes). The scores were numerically organised and then split into equal categories of high, medium and low levels of

physical activity for data analysis. This resulted in participants having a relative physical activity score which was used categorically in data analysis.

Dietary data

A 4DFR was completed by participants and collected within one month after the initial appointment. Participants were required to record all food and beverages consumed over four allocated consecutive days including at least one weekend day. Prior to completing the 4DFR, participants were educated on how to record and estimate portions via an instructional video. Participants were asked to record the food type, brand, quantity, and cooking method for all food and beverages consumed. Participants recorded the dietary supplements used on the 4DFR. This was used to cross-check the types and frequency of usage of the supplements reported in the health and demographics questionnaire.

Participants also completed a 109-item food frequency questionnaire (FFQ) (Mumme et al., 2019). The data from the FFQ was used to calculate a score, developed from the 2018 World Cancer Research Fund (WCRF) and American Institute for Cancer Research (AICR) Prevention Recommendations (National Cancer Institute, 2022). The scoring system used includes 8 of the 10 WCRF/AICR recommendations including healthy weight; being physically active; eating a diet rich in whole grains, vegetables, fruit; and beans; limited intake of processed food; red and processed meat; sugar sweetened drinks; alcohol; and optional breastfeeding baby for mothers (Shams-White et al., 2019). Each component mentioned is worth 1 point for fully, 0.5 of a point for partially, or 0 points for not meeting the recommendation respectively. In this study the breast-feeding recommendation was excluded. Therefore, the maximum score for an individual was 7.

3.3.3 Dietary supplement data

Defining dietary supplements

Dietary supplements were identified according to the definition of dietary supplements highlighted in the NZ 1985 Dietary Supplement Regulations (Beattie, 1985, New Zealand Medicine and Medical Devices Safety Authority, 2021). The dietary supplements included any liquid, tablet or powder that is orally ingested for the purpose of supplementing the diet. It included products such as amino acids, edible substances, herbs, minerals, synthetic nutrients, and vitamins (Beattie, 1985, Parnell et al., 2006). Prescription medications were not included under the term dietary supplementation. However, prescribed single vitamins and minerals,

such as cholecalciferol (vitamin D) and iron, were included due to the similarities of over-the-counter purchased products and the intended purpose of these products to supplement the diet.

Categorising types of dietary supplements

Each DS was categorised into one of seven types: amino-acid, herbal, multi-vitamin, oil, single vitamin, single mineral, or other. To determine the category, the brand and product names were searched where necessary using search engines, such as Google, to identify key ingredients and relative categorisation. As many supplements have several active and non-active components to ensure the products are either shelf stable, palatable or easily consumed, the main active ingredients, alongside the supplement's intended purpose was taken into consideration when categorising types of supplements. Each DS taken was assigned to one type of category only.

Multi-vitamins included all products that contained ≥2 vitamins and/or minerals. This did not include products that were predominantly ingredients of herbal or botanical sources. Herbal supplements included products derived from plants, roots, seeds, berries, or flowers such as garlic products, ginkgo biloba, and turmeric. Bee products such as bee pollen and honey products were also considered to be herbal supplements. Supplements that were derived from animal like sources, such as mussel extract or deer velvet, were included in the 'other' type category.

Some products reported under DS questions could have been considered foods/drinks (i.e., kombucha, hibiscus tea). However, as these products met the definition and were reported by the participant as supplementary to the diet, they were included as dietary supplements in the data analysis in the 'other' category. Laxatives were not considered dietary supplements.

Categorising usage of dietary supplements

For each supplement, the use was also classified into the usage category of regular, occasionally, or unknown. Regular usage included dietary supplements that were taken daily, weekly, monthly, or otherwise on a regular occurrence. Occasional usage was any supplements that were reportedly taken occasionally, or those reportedly taken for symptom-based management, i.e., on the onset of a cold symptoms. The frequency of usage was crossed checked with any DS data found on the 4DFR.

3.3.4 Statistical analysis

The statistical software IBM SPSS® version 27 was used to analyse the data. Descriptive statistics were used to describe the demographic, lifestyle and health characteristics of the DS users versus the non-DS users. The data was also used to compare the characteristics of DS users versus non-DS users within female and male groups separately. Categorical variables were collapsed where necessary and reported as numbers and percentages. Continuous variables were reported as means and standard deviations (SD). Independent *t*-tests were used to compare the characteristics of supplement users versus non supplement users for continuous variables. For categorical variables, Chi-squared tests were used to compare the characteristics of supplement users versus non-supplement users and the types of dietary supplements taken by female versus male DS users. The Fisher exact test was used when analysis using Chi-squared tests produced an expected count less than five. A *p*-value of <0.05 signified statistical significance.

3.4 Results

3.4.1 Participant Characteristics

A total of 371 community dwelling older adults completed the health, demographics, and physical activity questionaries and were included in the data analysis. Most participants were female (64.2%) and of European ethnicity (93.5%). The mean ± SD age was 69.7 ± 2.6 years. Most participants were either fully or semi-retired (59.3% and 21.8% respectively), living with others (70.9%), and had a self-reported health level of ‘excellent’ or ‘very good’ (30.0% and 31.9% respectively) (see Table 3.1).

Among the participants, 64% were considered DS users (Table 3.1). DS use was significantly higher among females in comparison to males ($p<.001$) with 70.6% of females, and 52.6% of males considered DS users. No significant differences were found when comparing other sociodemographic, lifestyle and health characteristics of DS users versus the non-DS users group.

Table 3.1. Demographic, lifestyle, and health characteristics of New Zealand community dwelling older adults according to dietary supplement use.

Characteristics	*Study Participants (n=371) Mean ± SD or n (%)*	*DS User (n=238) n (%)*	*Non-DS User (n=133) n (%)*	*P-Value* [a]
Demographics				
Age (years)	69.7 ± 2.6	69.82 ± 2.61	69.42 ± 2.49	.385
Sex				<.001
Female	238 (64.2)	168 (70.6)	70 (52.6)	
Male	133 (35.8)	70 (29.4)	63 (47.4)	
Ethnicity				.361
European	347 (93.5)	220 (92.4)	127 (95.5)	
Asian	12 (3.2)	10 (4.2)	2 (1.5)	
Māori/Pacific	12 (3.2)	8 (3.4)	4 (3.0)	
Education				.06
No qualification/secondary	84 (22.6)	63 (26.5)	21 (15.8)	
Post-secondary	149 (40.2)	92 (38.7)	57(42.9)	
University	138 (37.2)	83 (34.9)	55 (41.4)	
Marital status				.335
Married/cohabiting/civil union/de facto	242 (65.2)	151 (63.4)	91 (68.4)	
Divorced/separated/widowed/single	129 (34.8)	87 (36.6)	42 (31.6)	

Material standard of living [b]				.114
High	81 (21.8)	46 (19.3)	35 (26.3)	
Fairly high	164 (44.2)	103 (43.3)	61 (45.9)	
Low – Medium	126 (34.0)	89 (37.4)	37 (27.8)	
Retirement status				.683
Fully retired	220 (59.3)	142 (59.7)	78 (58.6)	
Semi-retired	81 (21.8)	54 (22.7)	27 (20.3)	
Not retired	70 (18.9)	42 (17.6)	28 (21.1)	
Living situation				.864
Living with others	263 (70.9)	168 (70.6)	95 (71.4)	
Living alone	108 (29.1)	70 (29.4)	38 (28.6)	
IMD Ranking [c]	2192 ± 1444	2234 ± 1451	2117 ± 1435	.592
Lifestyle				
Physical Activity [d]				.252
High	123 (33.2)	86 (36.3)	37 (27.8)	
Moderate	124 (33.2)	76 (32.1)	48 (36.1)	
Low	123 (33.2)	75 (31.6)	48 (36.1)	
Smoking status				.541
No	291 (78.4)	189 (79.4)	102 (76.7)	
Currently/Used to	80 (21.6)	49 (20.6)	31 (23.3)	
Alcohol consumption adheres to MoH guidelines [d,e]				.176

Yes	310 (83.8)	204 (85.7)	106 (80.3)	
No	60 (16.2)	34 (14.3)	26 (19.7)	
Alcohol average weekly consumption [f]	5.08 ± 6.44	4.68 ± 5.91	5.80 ± 7.27	.237
WCRF/AICR score [h]	4.24 ± 1.08	4.25 ± 1.09	4.23 ± 1.05	.592
Health				
BMI (weight (kg) /height $(m)^2$)	26.37 ± 4.61	26.16 ± 4.64	26.74 ± 4.53	.840
Self-report of health [d]				.105
Excellent	111 (30.0)	75 (67.6)	36 (27.1)	
Very Good	118 (31.9)	111 (59.0)	77 (57.9)	
Fair – Good	71 (19.2)	51 (71.8)	20 (15.0)	
Polypharmacy [g]				.460
Yes	31 (8.4)	18 (7.6)	13 (9.8)	
No	340 (91.6)	220 (92.4)	120 (90.2)	

[a] *p*-values comparing supplement users to non-supplement users were determined using Chi-square for categorical variables and *t*-tests for continuous variables. [b] Material standard of living is self-reported by participants, [c] high number = most deprived, range = 11 to 5636. [d] 1 data point missing. [e] 4 Ministry of Health alcohol guidelines include number of standard drinks per day (males ≤3; females ≤2), per week (males ≤15; females ≤10), maximum standard drinks on one occasion (males ≤5; females ≤4), and 2 or more alcohol free days per week. [f] 3 data points missing. [h] 4 data points missing. [g] taking ≥5 medications.

Abbreviations: AICR, American Institute for Cancer Research; BMI, Body Mass Index; DS, dietary supplement; IMD, Index of Multiple Deprivation; MoH, Ministry of Health; WCRF, World Cancer Research Fund.

Table 3.2 displays differences in characteristics of DS users versus non-DS users within the female and male group separately. In males, DS users were significantly more likely to adhere to the four MoH alcohol intake guidelines (p=.008) and have a higher self-reported level of health (p=.016) (Table 2). Male DS users were also significantly more likely to have a higher IMD ranking (i.e., greater deprivation) compared to male non-DS users (p=.045). There was no significant difference in sociodemographic, lifestyle and health characteristics between DS users and non-DS users in females.

When comparing male and female DS users, males were significantly more likely to be married/cohabitating or in a civil union/de facto partnership (p<.001) and living with others (p<.001) compared to females. Males DS users were more likely to have a post-secondary or university qualification (p=.036) and a significantly lower weekly average alcohol consumption compared to female DS-users (p=.010).

Table 3.2. Demographic, lifestyle and health characteristics of New Zealand community dwelling older adults according to sex and dietary supplement use.

	Females (n = 238)			*Males (n = 133)*			
Characteristics	*DS User (n=168) n (%)*	*Non-DS User (n=70) n (%)*	*p-Value [a,b]*	*DS User (n=70) n (%)*	*Non-DS User (n=63) n (%)*	*p-Value [a]*	*DS User Females and Males p-Value*
Demographics							
Age (years)	69.52 ± 2.63	69.11± 2.58	.961	70.53 ± 2.44	69.75 ± 2.35	.749	.268
Ethnicity [b]			.583 [d]			.128	.137
European	159 (94.6)	66 (94.3)		61 (87.1)	61 (96.8)		
Asian	5 (3.0)	1 (1.4)		5 (7.1)	1 (1.6)		
Māori/Pacific	4 (2.4)	3 (4.3)		4 (5.7)	1 (1.6)		
Education			.296			.390	.036
No qualification/secondary	51 (30.4)	15 (21.4)		12 (17.1)	6 (9.5)		
Post-secondary	66 (39.3)	34 (48.6)		26 (37.1)	23 (36.5)		
University	51 (30.4)	21 (30.0)		32 (45.7)	34 (54.0)		
Marital status			.854			1	<.001
Married/cohabiting/civil union/de facto	91 (54.2)	37 (52.9)		60 (85.7)	54 (85.7)		
Divorced/separated/widowed/single	77 (45.8)	33 (47.1)		10 (14.3)	9 (14.3)		
Material standard of living [c]			.568			.050	.544
High	33 (19.6)	12 (17.1)		13 (18.6)	23 (36.5)		

Fairly high	69 (41.1)	34 (48.6)		34 (48.6)	27 (42.9)		
Low – Medium	66 (39.3)	24 (34.3)		23 (32.9)	13 (20.6)		
Retirement status			.514			.983	.811
Fully retired	102 (60.7)	43 (61.4)		40 (57.1)	35 (55.6)		
Semi-retired	38 (22.6)	12 (17.1)		16 (22.9)	15 (23.8)		
Not retired	28 (16.7)	15 (21.4)		14 (20.0)	13 (20.6)		
Living situation			.654			.454	<.001
Living with others	106 (63.1)	42 (60.0)		62 (88.6)	53 (84.1)		
Living alone	62 (36.9)	28 (40.0)		8 (11.4)	10 (15.9)		
IMD Ranking [d]	2178 ± 1387	2440 ± 1431	.983	2368 ± 1595	1758 ± 1363	.045	.060
Lifestyle							
Physical activity [e]			.289			.135	.503
High	57 (33.9)	19 (27.1)		29 (41.4)	18 (28.6)		
Moderate	54 (32.1)	30 (42.9)		22 (31.4)	18 (28.6)		
Low	56 (33.3)	21 (30.0)		19 (27.1)	27 (42.9)		
Smoking status			.250			.615	.362
No	136 (81.0)	52 (74.3)		53 (75.7)	50 (79.4)		
Currently/Used to	32 (19.0)	18 (25.7)		17 (24.3)	13 (20.6)		
Alcohol consumption adheres to MoH guidelines [e,f]			.648			.008	.104
True	140 (83.3)	60 (85.7)		64 (91.4)	46 (74.2)		
False	28 (16.7)	10 (14.3)		6 (8.6)	16 (25.8)		
Alcohol average weekly consumption [g]	5.07 ± 6.30	5.86 ± 7.13	.592	3.72 ± 4.73	5.73 ± 7.48	.070	.010
WCRF/AICR score [h]	4.30 ± 1.12	4.58 ± 1.05	.618	4.12 ±1.02	3.85 ±0.92	.537	.308

Health							
BMI	25.92 ± 4.80	26.52 ± 5.12	.663	26.74 ± 4.22	26.98 ± 3.80	.744	.255
Waist circumference	85.37 ± 11.96	87.87 ± 13.40	.265	96.41 ± 12.06	96.67 ± 10.60	.419	.972
Self-report of health [d]			.080			.016	.499
Excellent	49 (29.2)	26 (37.1)		26 (37.1)	10 (15.9)		
Very Good	81 (48.2)	37 (52.9)		30 (42.9)	40 (63.5)		
Fair – Good	37 (22.0)	7 (10.0)		14 (20.0)	13 (20.6)		
Polypharmacy [i]			.731 [h]			.822	.145
Yes	10 (6.0)	5 (7.1)		8 (11.4)	8 (12.7)		
No	158 (94.0)	65 (93.0)		62 (88.6)	55 (87.3)		

[a] *p*-values comparing supplement users to non-supplement users were determined using Chi-square for categorical variables and *t*-tests for continuous variables. [b] 4 cells in the Chi-square test have expected count less than 5, *p*-value calculated using Fishers-freeman-halton exact test. [c] Material standard of living is self-reported by participants, [d] high number = most deprived, range = 11 to 5636. [e] 1 data point missing. [f] 4 Ministry of Health alcohol guidelines include number of standard drinks per day (males ≤3; females ≤2), per week (males ≤15; females ≤10), maximum standard drinks on one occasion (males ≤5; females ≤4), and 2 or more alcohol free days per week. [g] 3 data points missing. [h] 4 data points missing. [i] taking ≥5 medications.

Abbreviations: AICR, American Institute for Cancer Research; BMI, Body Mass Index; DS, dietary supplement; IMD, Index of Multiple Deprivation; MoH, Ministry of Health; WCRF, World Cancer Research Fund

3.4.2 Types of supplements

A total of 654 supplements were taken among the group of DS users. Thirty seven percent of DS users reported only taking only one supplement, 23.9% took two, 12.6% took three, 11.3% took four and 15% took five or more supplements. The mean ± SD number of DS taken was 2.75 ± 2.34. The maximum number of DS used was 20 however it was unclear whether the list of supplements were separate products or listed ingredients of numerous supplements. Of the 654 dietary supplements taken, 86 (13.1%) were taken occasionally, 373 (57.0%) taken regularly, and 195 (29.8%) had an unknown frequency.

The most common types of dietary supplements used were oil (25.9%), single vitamins (25.1%), and single minerals (23.5%) (Table 3.3). When comparing the frequency of different type of supplements consumed between the male and females, females used a significantly higher proportion of single vitamins (p=.005), vitamin D (p=.003), single minerals (p<.001) and magnesium (p=.002) compared to males. Females also consumed a higher proportion of probiotics (p=.034) than males.

Table 3.3. The most frequently used supplement among New Zealand community dwelling adults according to sex.

	Frequency			
Type of Dietary Supplement	*Total n=371 (%)*	*Female n=238 (%)*	*Male n=133 (%)*	*p-Value* [a]
Oil	96 (25.9)	69 (29.0)	27 (20.3)	.067
Fish	68 (18.3)	46 (19.3)	22 (16.5)	.506
Flaxseed	9 (2.4)	7 (2.9)	2 (1.5)	.499 [b]
Krill	8 (2.2)	7 (2.9)	1 (0.8)	.268 [b]
Lester's	7 (1.9)	6 (2.5)	1 (0.8)	.429 [c]
Single vitamin	93 (25.1)	71 (29.8)	22 (16.5)	.005
Vitamin C	48 (12.9)	35 (14.7)	13 (9.8)	.175
Vitamin D	41 (11.1)	35 (14.7)	6 (4.5)	.003
Vitamin B	32 (8.6)	22 (9.2)	10 (7.5)	.570
Single mineral	87 (23.5)	71 (29.8)	16 (12.0)	<.001
Magnesium	73 (19.7)	58 (24.0)	15 (11.3)	.002

Zinc	10 (2.7)	9 (3.8)	1 (0.8)	.103 [b]
Iron	9 (2.4)	8 (3.4)	1 (0.8)	.108 [b]
Multivitamin	73 (19.7)	47 (19.7)	26 (19.5)	.963
Herbal	67 (18.1)	47 (19.7)	20 (15.0)	.258
Turmeric	30 (8.1)	21 (8.8)	9 (6.8)	.486
Garlic	10 (2.7)	8 (3.4)	2 (1.5)	.505 [b]
Olive leaf	5 (1.3)	5 (2.1)	0 (0)	.165 [c]
Amino acid	67 (18.1)	47 (19.7)	20 (15.0)	.258
Glucosamine	55 (14.8)	38 (16.0)	17 (12.8)	.408
Melatonin	9 (2.4)	8 (3.4)	1 (0.8)	.166 [b]
Other	59 (15.9)	39 (16.4)	20 (15.0)	.733
Antioxidant	23 (6.2)	12 (5.0)	11 (8.3)	.216
Probiotic	17 (4.6)	15 (6.3)	2 (1.5)	.034
Fibre	6 (1.6)	2 (0.8)	4 (3.0)	.193 [c]

[a] *p*-Values were determined using Chi-square for categorical variables. [b] 1 cell in the Chi-square test have expected count less than 5, *p*-value calculated using Fishers-freeman-halton exact test. [c] 2 cells in the Chi-square test have expected count less than 5, *p*-value calculated using Fishers-freeman-halton exact test.

3.5 Discussion

In this study DS use in older community dwelling adults in NZ was examined. The prevalence of DS use, the types of DS used, and the characteristics of DS users versus non-DS users were explored. Of the 371 participants, 64% were considered DS users. The most common type of dietary supplements taken by older adults were oil dietary supplements, followed by single vitamins, single minerals and multivitamins. DS use was higher among females compared to males, and there were no significant differences found in ethnicity, education and socioeconomic variables between DS users and non-DS users. In males, DS users were more likely to adhere to the MoH alcohol guidelines, have a higher self-reported level of health, and have a higher IMD ranking/ be more deprived compared to non-male DS users. No significant difference was found between female DS users and non-DS users.

3.5.1 Prevalence

Sixty four percent of the REACH participants were considered DS users. This is slightly higher than that found in previous research on DS use in older adults in NZ such as Parnell et al. (2006) (40.5% of males, and 58.4% of females >65 years of age), and the Ministry of Health and University of Otago (2011) 2008-2009 NNS (39.8% of males, and 52.6% of females 51-70 years of age). There was a total of 654 supplements taken among the DS users, with 37% of DS users taking one DS, 23.9% taking two, 12.6% taking three, 11.3% taking four, and 15% taking five or more dietary supplements. The average number of DS taken by the sample was 2.75 ± 2.34. This was lower than the average number of DS taken in studies conducted on older adults living in the US of 83% (Shade et al., 2019) and 85% (Tan et al., 2022).

In terms of frequency, just over half of the dietary supplements taken (57.0%) were taken regularly (defined as dietary supplements taken daily, weekly, monthly, or otherwise on a regular occurrence). This finding is lower than previously found, with Parnell et al. (2006) finding that out of all participants that used dietary supplements, 73.4% took DS daily, and 15.4% took dietary supplements episodically. However, it is important to note that due to the questions asked on dietary supplementation in the current study, some assumptions regarding DS frequency were made and 29.8% of dietary supplements taken had an unknown frequency.

3.5.2 Type of dietary supplements

The most commonly consumed types of dietary supplements in this study were oil (25.9%), followed by single vitamins (25.1%), single minerals (23.5%) and multivitamins (19.7%). The literature shows that while prevalence of oil products were commonly in the top three types of dietary supplements taken by older adults, multivitamins were often the most popular type of DS taken by older adults (Brownie and Rolfe, 2005, Denison et al., 2012, Mishra et al., 2021, O'Brien et al., 2017, Shade et al., 2019, Tan et al., 2022). As adults age it is common to see cognitive ability decline (Ministry of Health, 2013). Oil dietary supplementation, such as fish oil products, are high in omega-3 polyunsaturated fatty acids which have been shown to have potential benefits on reducing cognitive decline in older adults (Molfino et al., 2014). As a primary motive for DS use is prevention for disease and illness, it is possible the aging population is more likely to purchase and consume products such as fish oil to prevent and slow down cognitive decline and improve mental performance.

Interestingly this study found the most commonly taken sub-type of herbal supplement was turmeric products (8.1% of all DS taken). Previous literature explored on DS use in older adults did not report high prevalence of turmeric dietary supplements (Brownie and Rolfe, 2005, Denison et al., 2012, Ministry of Health and University of Otago, 2011, Parnell et al., 2006, Tan et al., 2022). While this may be due to differing definitions of dietary supplementation, or different categorisation of types of dietary supplements, it suggests that the overall prevalence of turmeric dietary supplement was low. Turmeric DS products have recently attracted attention with studies suggesting that the active component curcumin may have potential therapeutic antioxidant and anti-inflammatory benefits (Hewlings and Kalman, 2017). With almost 10,000 research articles on curcumin published on Scopus within the past five years, turmeric's popularity in research and as part of the DS market has increased exponentially (Kotha and Luthria, 2019). Therefore, the high use of turmeric products within this present study may be reflective of these changes. Further research on a larger sample will help better understand the true prevalence and trends of specific dietary supplement use, such as turmeric, among the NZ older adult population.

This study also analysed the type of dietary supplements taken by females versus male DS users. It was found that females used a significantly higher proportion of single vitamins and single minerals compared to males, such as vitamin D and magnesium. Females also consumed a higher proportion of probiotics. The reason for this finding is unknown. Bailey et al. (2013)

highlighted the difference between sexes and the motives for DS use. They found that men were more likely to use dietary supplements to improve and maintain health, whereas females were more likely to use dietary supplements to enhance energy, for bone health, or for colon health. While motives for DS use were not investigated in this study, potentially the higher prevalence of symptom targeted dietary supplements among females (i.e. vitamin D, magnesium, probiotics) may be due to differences in DS motives compared to males.

Withing the REACH study, determining the relative type and frequency categories for each DS reported by participants was challenging with many instances of brand, full product name, and/or frequency of dosage missing or incomplete. Where limited information was provided, assumptions were made to best assign the DS to the relative category (Appendix B). The assumptions made may have caused some dietary supplements to be incorrectly assigned thereby affecting the total number of dietary supplements assigned to each type category. This highlights the importance for future DS data collection, and the need to have specific questions that prompt the participant to record the brand name, product name, amount taken, frequency of consumption, and reason for taking the DS.

3.5.3 Characteristics of dietary supplement users

Sociodemographic characteristics of DS users

When examining the sociodemographic characteristics of DS use, this study found that DS use was significantly higher among females (70.6% considered DS users) compared to males (52.6%). This finding is consistent with almost all literature that explores DS use (Burnett et al., 2017, Cowan et al., 2018, Denison et al., 2012, O'Brien et al., 2017, Parnell et al., 2006, Rontogianni et al., 2021, Tan et al., 2022). The literature exploring potential reasons why females are more likely to take dietary supplements is limited. Conner et al. (2001) found that females had a higher value of health and thus more likely to be take dietary supplements to prevent disease and illness, or improve overall health compared to males. Our finding that females were more likely to take targeted vitamins and minerals, such as magnesium and vitamin D, than males suggests females are more inclined to take dietary supplements for more targeted health benefits compared to males. There is a need for further research to explore the motives and reasons for taking dietary supplements in certain population groups, especially among the older adult population.

There was no significant difference found in ethnicity, education and socioeconomic variables between DS users and non-DS users. Research demonstrates mixed findings when analysing associations between ethnicity and DS use. Findings from the 2008-2009 NZ NNS found that DS use among those >51 years of age was significantly lower in Māori (36.6% of males, 34.2% of females were DS users), and Pasifika groups (12.3% of males, 14.8% of females were DS users) compared to NZ European ethnicity group (Ministry of Health and University of Otago, 2011). In terms of education, studies suggest that DS use is associated with higher levels of education (Burnett et al., 2017, Cowan et al., 2018, O'Brien et al., 2017, Tan et al., 2022). In the present study, most participants identified as European. Similarly, the sample was considered highly educated overall with 77% of participants obtaining either a post-secondary or university level of education. It is likely that the lack diversity within the population group meant no significant difference was found between DS use and ethnicity or education status.

Some research suggests there may be a positive association between lower socioeconomic disadvantage and DS use (Burnett et al., 2017, Cowan et al., 2018). In this study no significant difference in socioeconomic status variables was found between DS users and non-DS users. Interestingly, when comparing DS use versus non-DS use in males, DS users had a higher IMD ranking/ were more deprived compared to non-male DS users. The reason for this finding is unknown. However, measuring socioeconomic status in older adults is more complex compared with younger adults. The accumulation of assets and the impacts of retirement on income, means that income becomes less representative of socioeconomic status (Galobardes et al., 2007). As the sample included retired, semi-retired and employed participants, it was decided that income was not to be included as a characteristic in analysis. Using measures such as the IMD ranking also had limitations. The IMD score is based on residential address. As many of the participants in this study were living with others (70.9%), and in many instances living with members of their families, the relative IMD score may not be fully representative of their own financial status but rather their families.

Lifestyle and health characteristics of DS users

There were no significant difference in smoking status or physical activity between DS users and non-DS users in this study. The literature suggests that there is an association between healthier lifestyles and DS use. Studies have shown that adult DS users are likely to be more physically active or meet physical activities guidelines and abstain from smoking (Burnett et al., 2017, O'Brien et al., 2017, Rontogianni et al., 2021, Tan et al., 2022). In this present study,

there was a very small number of participants that were current smokers (1%), therefore may not have shown a statistical significance. Some studies indicate that having a lower BMI was associated with DS use (O'Brien et al., 2017, Tan et al., 2022, Cowan et al., 2018, Rontogianni et al., 2021). However, similar to Burnett et al. (2017), this study found no association between DS use and BMI or waist circumference. Burnett et al. (2017) and Denison et al. (2012) also found that DS use was higher among those that met the fruit and vegetable guidelines, and had a higher prudent diet score respectively. This study found no association between the WCRF/AICR diet-related scoring system and DS use.

When examining the difference in alcohol consumption between DS users and non-DS users in this study, no significant difference was found. The research that has assessed the association between alcohol consumption and DS use appears to demonstrate mixed findings. Cowan et al. (2018) and Tan et al. (2022) found that moderate or daily alcohol intake was associated with higher odds of DS use respectively. Denison et al. (2012) on the other hand found that females who took vitamins and minerals were most likely to exceed the recommended alcoholic units per week compared to males. In contrast to these findings, Burnett et al. (2017) and Rontogianni et al. (2021) found no association between alcohol consumption and DS use. These discrepancies may be due to the differences in quantifying alcohol intake or relative alcohol related category criteria across studies. This study found that male DS users were more likely to adhere to the four NZ MoH alcohol intake guidelines compared to male non-DS users. Male DS users also had a significantly lower weekly average alcohol consumption compared to female DS users. This was a surprising finding as research shows that on average males are heavier-typical quantity alcohol drinkers compared to females (Chaiyasong et al., 2018, Ministry of Health, 2015). These findings suggest that the use of dietary supplementation among the older male population may be higher in those that make healthier lifestyle choices and have a higher perception of health.

3.5.4 Study strengths and limitations

This study was one of only a few that investigated not only the prevalence, but also the characteristics of DS use in the older community-dwelling population in NZ. A wide range of sociodemographic, lifestyle and health variables were collected and able to be analysed in association with DS use. Another strength of this study was the high participant response rate, with 98.9% of participants completing all study requirements.

In terms of limitations, the convenience sample used in this study resulted in a lack of diversity, and limited variability in characteristics making the data less representative of the NZ older adult population. As participants were also volunteers, selection bias may be a limitation of the study, where those that decided to participate in the REACH study may differ from those that chose not to. Due to the volunteer nature of this study, the participant group may be comprised of more health-conscious individuals compared to the general population. Those that are more health-conscious tend to engage in more healthy behaviours and are also more inclined to be DS users. This potential overrepresentation of health-conscious individuals may have resulted in the high prevalence of DS use. There were also limitations to the collection of the DS data, which resulted in missing and incomplete data on products, brands, and frequencies of use. Assumptions had to be made during data processing, introducing a degree of researcher bias.

3.6 Conclusion

In conclusion, DS use among community dwelling older adults living in NZ is high. The most consumed type of DS was oil products, followed by single vitamins, single minerals, and multivitamins. Dietary supplementation was more prevalent in those that were female. In males, DS use was higher in those who met the alcohol consumption guidelines, had a higher reported level of health, and greater deprivation compared to males that did not take dietary supplements. No further associations between other sociodemographic, lifestyle, and health characteristics were found. Considering the limitations to this convenience sample, further research on a more diverse and representative population group is required to better understand the DS use prevalence and predictors of use for the older adults across NZ.

Chapter 4. CONCLUSION AND RECOMENDATIONS

4.1 Study summary

This study investigated the prevalence and characteristics of dietary supplement (DS) use in older community-dwelling adults in New Zealand (NZ). To the authors knowledge, this is one of only a few studies that investigates a wide range of characteristics of DS users versus non-DS users in the older adult population in NZ. Dietary supplement use was high, with 64% of the older adults being DS users, with the most common types of dietary supplement products being oil, single vitamins, single minerals, and multivitamins. Dietary supplement use was significantly higher among female older adults. No significant difference was found between all other sociodemographic, lifestyle, and health characteristics when comparing the total population of DS users versus non-DS users. When specifically looking at the male population, male DS users had significantly more likely to adhere to the MoH alcohol guidelines, have a higher self-reported level of health, and have a higher IMD ranking/ greater deprivation compared to non-male DS users. No significant difference in characteristics were found between female DS users and female non-DS users.

4.2 Study strengths

To the authors knowledge, this is one of the few studies that investigates several sociodemographic, lifestyle and health characteristics associated with DS use in older adults living in NZ. The REACH study involved the collection of numerous sociodemographic, lifestyle, and health characteristics. This meant that a wide range of characteristics, and their association with DS use, could be analysed. This gave insight into the characteristics and sub-population groups of older adults in NZ are consuming DS and can in future help drive relative interventions and healthcare initiatives. Another strength of this study is the high participant response rate, and the focus on a targeted age-group population.

4.3 Study limitations

As the participants were volunteers, there is the study limitation of potential selection bias, meaning those that did participate in the REACH study may be different to those that did not. Given the purpose of the REACH study, it is possible that people who were more health conscious were more inclined to volunteer to participate. As research indicates that DS use is higher among those that engage in healthy behaviours and more health conscious, this may give reason as to why the prevalence of DS in this study was considered high.

The method of data collection on DS use may also be a limitation to this study. Data on the use of dietary supplements was obtained through a self-reporting questionnaire. While the response rate and accuracy of reporting for simple questions were high (i.e. are you taking any form of supplements? Yes or no?), answers to the name, brand, and dosage of DS use were often incomplete and lacking detail. Due to this incomplete data, assumptions on products, brands, assigned type categories, and frequency had to be made. In some cases, the assumption that the list of self-reported ingredients/names were separate products also had to be made. These assumptions may have influenced the results, specifically the prevalence of the different type categories of DS used. While some frequency assumptions were made, 30% of all dietary supplements reported did not have enough information to make an assumption and therefore were reported as an unknown frequency. This meant we were unable to accurately assess the most common frequency of DS use among the older adults.

Another limitation to this study was the convenience sample used. This study sample was largely female (64.2%), identified as European (93.5%), and had a self-reported health level of "excellent" or "very good" (30.0% and 31.9%), either fully or semi-retired (59.3% and 21.8% respectively), and living with others (70.9%). The NZ population of adults more than 65 years of age was comprised of 82.9% European, 6.3% Asian, 5.8% Māori, 2.5% Pacifika, and 2.5% other (Statistics New Zealand, 2019). With 93.5% of the sample identifying as European, 12% Asian, and 12% Māori/Pasifika, this population group is unlikely to be representative of the older community-dwelling adult population across NZ. Interestingly the predicted growth of Māori and Pacifika older adult population is expected to increase faster than non-Māori/non-Pacifika population groups (Lord et al., 2022). As international research suggests, DS use, and views of dietary supplements, may differ across different ethnicities, especially when comparing indigenous groups and those that identify as European (Albright et al., 2012, Cowan et al., 2018, Tan et al., 2022). This highlights the importance for further research on DS use across a wide range of ethnicities.

4.4 Final recommendations

The health and DS market are continuing to grow, and the saturation of DS products on the market is expected to continue to increase. As the DS market evolves at such a fast rate, with new products and new societal trends, it is important that the research on DS use maintains current. Understanding the trends and predictors of DS use will better dictate appropriate interventions for targeted population groups. Researchers should consider including specific,

measurable, and informative questions on DS use within their research. This includes specific sections regarding product name, brand, dosage, frequency of use, duration of use, and reasons for taking for each DS reported to ensure accurate, measurable data is obtained. To ensure a rich dataset on DS use is obtained, researchers could consider interview style questionnaires. By asking the questions in an interview-style appointment, researchers are able to gather specific and complete data on DS use, and further clarify and queries on brand and products specific during the interview. This helps eliminate any potential assumptions and associated researcher bias.

Future research should explore the motives behind DS use in older adults in NZ to better understand the reasons for high prevalence and the influence of the DS market on the older adult population. Exploring morbidities in relation to DS use was beyond the scope of this research. However, it is important to understand that the presence or perceived risk of disease influences can influence an individual's motivation to use dietary supplementation (Pajor et al., 2017, Brownie and Rolfe, 2005). Researchers could also consider analysing the level of influence of different marketing channels, to further understand the motives and what the main sources of information on DS use for older adults are. This could also involve investigations into the level of healthcare professional involvement in the decision of DS use. Understanding and exploring all potential motives for DS use can help researchers better understand the reasons for high DS use among older adults and help direct or guide future health interventions.

Furthermore, analysis into DS use and dietary intake analyses is an important consideration for future research. Understanding whether or not DS users are exceeding recommended levels of nutrient intakes, could give insight into whether or not the current DS use among the older community-dwelling adults living in NZ is safe. This study examined the quality of the diet using FFQ data and relative WCRF/AICR scoring system in association to DS use. Calculating specific nutrient intakes for food records extended beyond the scope of this thesis. However future researchers should consider using food records to calculate nutrient intakes, alongside ingredients of dietary supplements, to analyse the current safety of DS use in NZ older community-dwelling adults.

Overall, this study explored the DS use in NZ community-dwelling older adults. Findings suggest that DS use in older community-dwelling adults in NZ is high. This study suggests that there may be some association between characteristics and DS use, including being female.

Collectively further investigations into DS use in older adult populations will create a better understanding of the DS behaviours, motives and trends in older adults. This will ultimately help drive future policies, education interventions in public health nutrition, and contribute to the review of the current NZ DS regulation legislation.

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APPENDICES.

Appendix A. The REACH study Health and Demographics Questionnaire

The REACH Study - Researching Eating Activity and Cognitive Health

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

What is your gender (please tick)?

- ☐ Male
- ☐ Female
- ☐ Gender diverse

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

_____

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

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

_____

Which country were you born in?

- ☐ New Zealand
- ☐ Australia
- ☐ England
- ☐ China (People's Republic of)
- ☐ South Africa
- ☐ Samoa
- ☐ Cook Islands
- ☐ Other *Please state which country* _____

What is your current living arrangement?

☐ Living alone

☐ Living with others

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

_____

_____

Are you?

☐ Married / cohabiting / civil union / de facto

☐ Divorced / separated

☐ Widowed

☐ Single

☐ Other, please describe

_____

What is your highest educational level (choose one)?

☐ No qualifications

☐ Primary school

☐ Secondary school

☐ Post-secondary certificate, diploma, or trade diploma

☐ University degree

Which of the following best describes your current work situation? (please tick as many as apply)

☐ Paid employment

Occupation and number of hours of paid employment per week?

_____

How long have you worked for your current employer?

_____

☐ Volunteer work

Position and number of volunteer hours per week?

_____

☐ Fully retired

☐ Semi-retired

☐ Other (eg. caregiver, studying, homemaker), please describe

_____

Study Identification Number

The following questions are about your material standard of living – the things that money can buy. Your material standard of living does NOT include your capacity to enjoy life. You should NOT take your health into account.

Generally, how would you rate your material standard of living? (Please tick one box)

☐ High
☐ Fairly high
☐ Medium
☐ Fairly low
☐ Low

Do you smoke cigarettes or a pipe?

☐ Yes

☐ No

☐ Former smoker

If yes, approximately how many cigarettes per day: _____

Do you drink alcohol?

☐ Yes

☐ No

☐ I used to drink alcohol, but no longer drink alcohol

If yes, how often do you usually drink alcohol?

☐ Monthly

☐ Weekly

☐ Daily

How many standard drinks of alcohol do you usually drink in the timeframe selected above?

A standard drink is 1 can of beer (330ml), 1 glass of wine (100ml), 1 Ready to Drink (RTDs), 1 shot/nip of spirits (30ml)

_____

On any one drinking occasion, what is the maximum number of standard drinks you would have?

A standard drink is 1 can of beer (330ml), 1 glass of wine (100ml), 1 Ready to Drink (RTDs), 1 shot/nip of spirits (30ml)

_____

How many alcohol free days do you usually have per week?

☐ 1 day
☐ 2 days
☐ 3 days
☐ 4 days
☐ 5 days
☐ 6 days
☐ 7 days

_____

Are you currently taking any medication prescribed by a medical practitioner?

☐ Yes

☐ No

If yes, please state what medication you are taking, the dosage and why

_____

_____

_____

_____

Are you taking any other medication or substances (e.g. over the counter, homeopathic, drugs other than alcohol, tobacco or prescription medication)?

☐ Yes

☐ No

If yes, please state what medication/substances you are taking, the dosage and why

_____

_____

_____

_____

Are you taking any form of supplements, including tablets or drinks?

☐ Yes

☐ No

If yes, what is the name, brand and dosage of the supplements you are taking?

_____

_____

_____

_____

How would you rate your quality of life (please tick one box)?

☐ Very good

☐ Good

☐ Neither good nor poor

☐ Poor

☐ Very poor

In general, would you say your health is:

☐ Excellent

☐ Very good

☐ Good

☐ Fair

☐ Poor

Appendix B. Assumptions made during dietary supplement data analysis.

Table 4.0. Number of different assumptions made during dietary supplement data analysis.

Assumption category	Number of assumptions made (n)
Frequency	84
Product	30
Type category	12
Prescribed supplement	5
Separate products	5
Excluded	2
Reported as supplement to the diet	1
Medication not dietary supplement	1