Healthy ageing through nutrition: An investigation into Mediterranean diet knowledge and strategies to support healthy eating habits in older people

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“you have only scratched the surface of what you’re capable of,

there are decades of victories ahead of you” – rupi kaur

STATEMENT OF ORIGINALITY

This is to certify that to the best of my knowledge; the content of this thesis is my own work. This thesis contains no material that has been presented for a degree at the University of Sydney or any other University.

I certify that the intellectual content of this thesis is the product of my own work and that all the assistance received in preparing this thesis and sources have been acknowledged.

Ashlee Turner Date: 07 February 2024

ABSTRACT

With an ageing population, promoting healthy ageing strategies is crucial. Older adults often have poor dietary habits, highlighting the need for health promotion interventions that target lifestyle behaviours, including diet. Evidence shows that following an anti-inflammatory dietary pattern, such as the Mediterranean diet, can reduce chronic disease risk factors and ultimately promote healthy ageing. While many factors determine our eating habits and behaviours, having the knowledge of what constitutes a healthy diet is a critical first step in initiating positive behaviour change by increasing awareness and motivating individuals to act. Educational interventions have been shown to improve dietary intake, but many are typically delivered in group-based settings and have not considered the unique barriers for and needs of older adults. Digital health is a promising avenue for nutrition education, that can be designed, developed and delivered according to the needs and preferences of target end users, which in this case is the older adult population. Broadly, the objective of this thesis was to identify and address important gaps in effective strategies for improving dietary knowledge and healthy eating among older adults.

This thesis brings together the fields of behavioural science, nutrition and digital health, and aims to: 1) explore the use of education and other behaviour change strategies in Mediterranean diet interventions for older adults; 2) investigate Mediterranean diet knowledge and nutrition-related attitudes and behaviours of community-dwelling older adults in Australia; 3) qualitatively explore user needs and preferences for an online nutrition education resource; and 4) assess the usability, acceptability and preliminary effectiveness of an existing web-based anti-inflammatory diet education resource.

For the first aim, a systematic scoping review was conducted investigating the use of educational strategies and other behaviour change techniques in Mediterranean diet interventions for older adults (Chapter 2). The review revealed that educational strategies are the most commonly used behaviour change technique, yet none of the included studies measured knowledge as an outcome. Consequently, it remains unclear how these educational strategies impact nutrition knowledge and whether knowledge changes translate into improvements in dietary intake. Additionally, the review highlighted a significant gap in the availability of online interventions, with only three studies utilising digital methods for intervention delivery.

In light of these findings and to address the second aim, a survey was conducted among older adults in Australia (n = 61) to investigate their knowledge of the Mediterranean diet, and identify specific barriers and enablers to adopting such a dietary pattern (Chapter 3). The

findings revealed several substantial gaps in knowledge, particularly relating to the nutrient content of foods less commonly consumed in a standard Australian diet, alcoholic content of different beverages, and cooking methods typical of the Mediterranean diet. However, participants demonstrated strengths in identifying high fibre and high cholesterol foods, as well as meal options that align with the Mediterranean diet. Participants noted a number of barriers to changing their habitual diet to a Mediterranean-style diet, including cost, lack of knowledge, and motivation. It is important to note that the sample's demographic bias toward higher education levels suggests that the actual knowledge gaps and barriers across the broader Australian population are likely to be more pronounced, highlighting the need for targeted educational resources on the Mediterranean diet.

To achieve the third aim, a qualitative participatory design study was conducted with older adults (n = 20) to explore the potential value of an online nutrition education resource and identify desired features and functionalities (Chapter 4). Findings indicated that older adults are actively using various technology devices and frequently access health- and nutrition-related resources online, indicating the feasibility of utilising a digital health resource for nutrition education. The most commonly reported facilitator of technology use and engagement was ease of use. Participants suggested that this could be achieved by creating a resource that utilises large, simple, and dark fonts on a light background, as well as clear categories to enable easy navigation. In terms of content, participants expressed the need to include recipes and general nutrition information (e.g., information on food groups, nutrient groups, foods to combine to maximise nutrient absorption), and practical advice to help them make healthier food choices (e.g., guidance on reading food labels, meal planning resources, recommendations for ordering when dining out).

To achieve the final aim, the usability, acceptability and impact of an existing online anti-inflammatory diet education resource for older adults was assessed (Chapter 5). Twenty-eight participants were invited to engage with the web-based resource naturalistically (i.e., at their own discretion) for a period of 4-weeks. Participants found the website to be user-friendly and easily accessible, suggesting its potential feasibility for providing nutrition education to the broader older adult population. While overall nutrition knowledge did not increase significantly after engaging with the website, participants demonstrated improved competence in identifying foods, patterns, and meal options that align with the Mediterranean diet. Further, this improvement corresponded with an increase in overall adherence to the Mediterranean diet. However, the findings highlighted a number of notable gaps between nutrition knowledge and actual intake. For example, many participants were able to identify that fruits and vegetables, extra virgin olive oil, and legumes are key components of a Mediterranean diet,

however their intake of these foods was well below recommended levels and did not change significantly as a result of engaging with the website content.

Taken together, the findings from this body of work shed light on the use of education in Mediterranean diet interventions, the knowledge gaps among older adults in Australia regarding the Mediterranean diet, and the potential for digital health resources to bridge these gaps. However, these findings also highlight that knowledge is not the only determinant of eating habits. It is clear that dietary behaviour change interventions need to target knowledge gaps and overcome barriers to dietary change more holistically. Importantly, the use of digital health resources that have been designed and developed in collaboration with the target user population are a viable and acceptable method of delivering such interventions. Further advancements in research and intervention development are needed to maximise the impact and effectiveness of nutrition education and dietary behaviour change initiatives targeting this population. Given the link between diet and chronic disease, tools and innovations that incorporate multifaceted approaches to behaviour change to support older adults in adopting and maintaining healthy dietary habits are likely to play a pivotal role in promoting healthy ageing, reducing chronic disease risk, and enhancing quality of life among this population.

AUTHORSHIP ATTRIBUTION

The work presented in this thesis was conducted in collaboration with co-authors (see co-author declarations of contribution) and under the supervision of Professor Victoria M Flood and Dr Haley M LaMonica. All research was approved by the Human Research Ethics Committee at the University of Sydney (protocol numbers 2021/543 and 2022/423).

Chapter 2 of this thesis is published as: **Turner A,** LaMonica HM, Flood VM. Behaviour change techniques used in Mediterranean diet interventions for older adults: A systematic scoping review. *Nutrients.* 2023;15(5):1189. doi: 10.3390/nu15051189

I was responsible for conceptualisation, methodology, formal analysis, investigation, data curation, writing – original draft preparation, and project administration.

H.M.L. and V.M.F. were responsible for conceptualisation, investigation, writing – review and editing, and supervision.

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I was responsible for conceptualisation, methodology, data analysis and interpretation, writing – original draft preparation, and project administration.

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H.M.L. and V.M.F. were responsible for conceptualisation, writing – review and editing, and supervision.

Chapter 5 of this thesis is being prepared for submission.

I was responsible for conceptualisation, methodology, data analysis and interpretation, writing – original draft preparation, and project administration.

H.M.L. and V.M.F. were responsible for conceptualisation, writing – review and editing, and supervision.

In addition to the statements above, in cases where I am not the corresponding author of a published item, permission to include the published material has been granted by the corresponding author.

Ashlee Turner Date: 07 February 2024

As supervisor for the candidature upon which this thesis is based, I can confirm that the authorship attribution statements above are correct.

Professor Victoria Flood Date: 07 February 2024

CO-AUTHOR DECLARATION

We the undersigned acknowledge the following statement:

This thesis principally represents the work of Miss Ashlee Turner.

Prof Victoria M Flood and Dr Haley M LaMonica provided considerable support with empirical studies as well as the preparation of this thesis. Their support was most prominent in study design, overseeing data analyses and interpretation, and in the editing of written work.

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ORAL PRESENTATIONS

2023 Scoping user needs for an online nutrition education resource for older adults
Joint Conference of the Nutrition Societies of New Zealand and Australia; Auckland, New Zealand

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Nutrition Society of Australia, Sydney Regional Group Meeting; Sydney, Australia

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The Australasian Society for Behavioural Health and Medicine, Annual Scientific Conference; Geelong, Australia

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Nutrition Society of Australia, Annual Scientific Meeting; Perth, Australia

2022 Assessment of Mediterranean diet knowledge among older adults in Australia
Nutrition Society of Australia, Sydney Regional Group Meeting; Sydney, Australia

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Healthy Brain Ageing Team Research Meeting; Sydney, Australia

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CHAPTER ONE

INTRODUCTION

1.1 Ageing population

1.1.1 Demography of ageing

Australia's population is ageing. Currently, approximately one in six Australian's are aged 65 or over and it is estimated that older people in Australia will make up almost one-quarter of the population by 2066 [1]. The fastest growing age group within this population is the over 85s, which is projected to increase to 21% of the older adult population in 2066 (2.2 million), up from 13% in 2020 (528,000) [1].

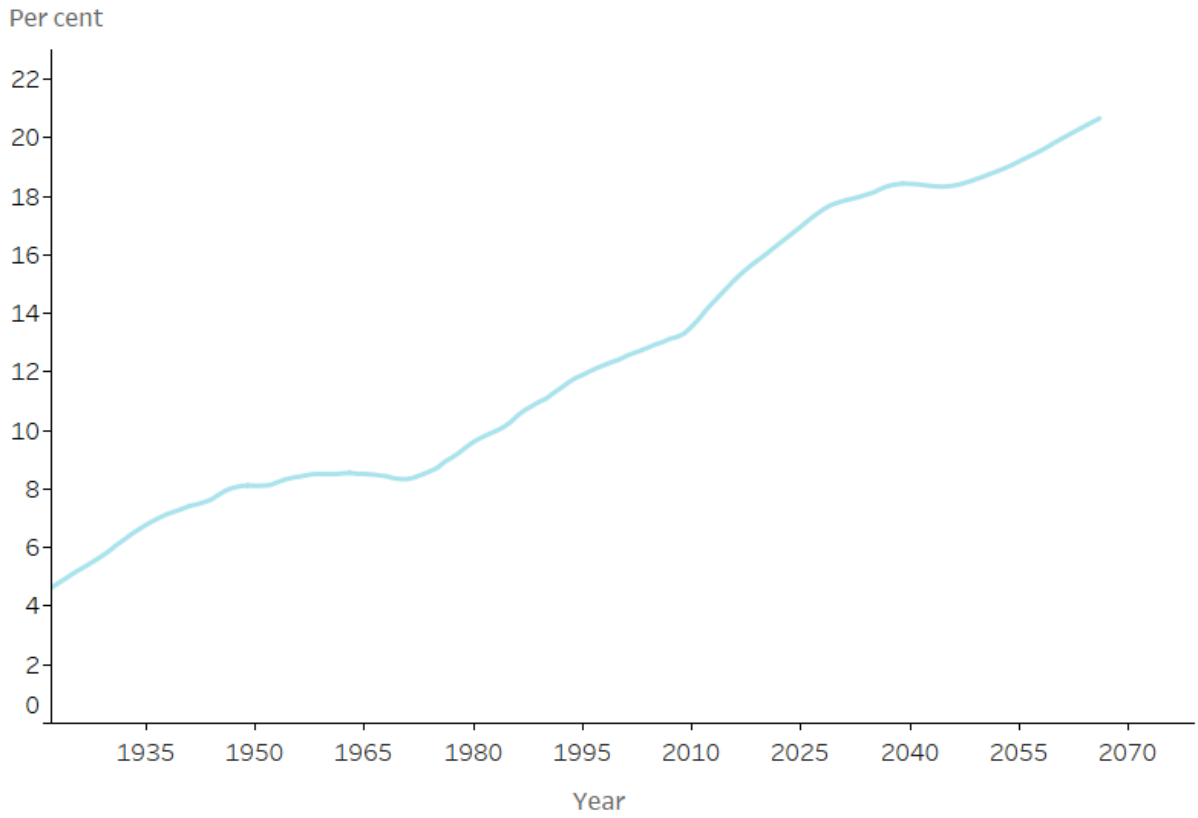

Figure 1.1. Older adult population projections in Australia [1,2]

This trend is consistent across the globe, with estimates that the worldwide share of the population aged 60 years and over will double by 2050, and the proportion of those aged 80 years and older will triple over the next 30 years [3]. Although the proportion of older adults is currently higher in high-income countries, it is expected to grow at a faster rate in low- and middle-income countries, with estimates that 80% of the global population aged over 60 years will live in low- and middle-income countries by 2050 [3]. The global demography of ageing is driven by numerous phenomena, including the ageing of the large post-war "baby boomer" cohort, declining fertility rates, and increasing life expectancy as a result of advancements in healthcare (e.g., immunisations and antibiotics), improved living conditions and healthier

lifestyles [4]. Indeed, life expectancy has improved dramatically in Australia for both males and females and is the third highest life expectancy in the world [5].

1.1.2 The challenges of an ageing population

While it may seem that living longer is universally positive, concerns have been raised around the quality of life lived during the older ages, with a significant disconnect between overall life expectancy and healthy life years. Although healthy life years – the number of years a person can expect to live in good health – has increased gradually to around 70 years over the last 30 years, it has not increased as much as overall life expectancy (83 years) [6]. This means that, although people are living almost 90% of their lives in good health, they are likely to live the last 10 years of their life with poor health and/or disability. Moreover, if healthy life years do not continue to increase at the same rate as overall life expectancy, the time spent living with poor health and diminished quality of life will be lengthier in the future. This will have significant impacts not only on the individual, but also puts substantial demand on public health care services, leading to increased social and economic impacts on the society as a whole [7].

In Australia and worldwide, much of the ill-health and disability in older adults is driven by non-communicable chronic diseases, including cancer, cardiometabolic and cardiovascular diseases, musculoskeletal conditions, mental and substance use disorders and chronic respiratory diseases [8]. Globally, cardiovascular disease (CVD) is the leading cause of disease burden in adults aged 50 years and older [8]. In Australia, CVD is the leading cause of disease burden in men aged 65 and older, the second leading cause for women over the age of 75 [6], and is the primary cause of death of Australians [9]. While some risk factors for chronic conditions are nonmodifiable, such as age, sex, family history, and race; other behavioural risk factors have the potential to be modified through lifestyle changes. The leading risk factors that contribute to CVD burden include high blood pressure, overweight and obesity, and high cholesterol, all of which are common among older adults. Evidence suggests that healthy lifestyle choices, including limiting alcohol consumption, avoiding tobacco use, being physically active and eating a healthy diet, have the potential to reduce the prevalence and severity of CVD and its associated risk factors [10]. However, data demonstrates that older adults tend to have poor lifestyle habits, with only 8% meeting the recommendations for fruit and vegetable intake (i.e., 2 serves of fruit and 5 serves of vegetables per day), 18% meeting the guidelines for physical activity (i.e., at least 30 minutes of moderate intensity activity on most, preferably all, days of the week) and 25% exceeding the guidelines for alcohol consumption (i.e., no more than 2 standard drinks on a single

occasion) [1,11]. It is clear that successful health promotion interventions are needed to delay or prevent the onset of lifestyle-related chronic diseases and increase healthy life years.

1.1.3 Nutrition for healthy ageing

Ageing is a multifaceted process of several biological mechanisms, including molecular, cellular, and physiological changes, leading to functional impairments and increased disease vulnerability. There is evidence to suggest that age-related disease and disability are likely caused by the molecular changes that occur during the ageing process [12]. In particular, one of the key mechanisms of ageing is the presence of chronic, low-grade inflammation – a phenomenon known as “inflammageing” [13]. With an evolutionary purpose, inflammation is a physiological process that serves to protect the body from injury or infection [14]. Acute inflammatory responses are triggered in response to infections, physical injury, or environmental toxins, and are a necessary response in the body. However, inflammageing is characterised by persistent low-grade inflammation that occurs in the absence of overt infection and is a significant risk factor of morbidity and mortality in older adults [13]. This pro-inflammatory state is also linked to the pathogenesis of several age-related chronic conditions, including atherosclerosis, CVD, type 2 diabetes and neurodegenerative diseases [15]. While the traditional conceptualisation of inflammageing focussed solely on an increase in the presence of circulating pro-inflammatory markers, such as C-reactive protein (CRP), interleukin-6 (IL-6), interleukin-8 (IL-8), and tumour necrosis factor α (TNF-α), recent evidence suggests that it is likely a rise in overall activation of the inflammatory system, with simultaneous increases in both pro- and anti-inflammatory markers [16]. Although the mechanisms that connect inflammageing and chronic disease pathology are not yet well understood, it appears that strategies to modulate this inflammatory response and balance the activation of pro- and anti-inflammatory markers (i.e., upregulate anti-inflammatory markers and downregulate pro-inflammatory markers) may be beneficial for promoting healthy ageing.

At the individual level, the process of ageing is ‘plastic’. Although inflammation is not the only feature of ageing or the sole driver of chronic disease development and progression, it is strongly influenced by lifestyle factors such as poor diet [17]. Animal models have demonstrated how early molecular changes of ageing can be slowed or reversed through dietary modifications, thereby promoting healthy ageing [18]. Moreover, available data suggest that inflammageing is reversible and can be counteracted or slowed through appropriate diet and nutrition [19]. Indeed, it has been shown that consuming a high-quality diet can lead to improved immune function, reduced risk of chronic diseases, maintenance of muscle mass and strength, and improved cognitive function [20-22].

Historically, research on the connection between dietary intake and inflammation has primarily focussed on individual vitamins and nutrients. For example, omega-3 polyunsaturated fatty acids (including eicosapentaenoic and docosahexaenoic acid), fibres and prebiotics, antioxidants, and polyphenols are considered to have varying anti-inflammatory properties, whereas saturated and trans fatty acids contribute to the augmentation of pro-inflammatory processes [23]. While assessing individual vitamins and nutrients is important for building the body of evidence linking diet to inflammation, it is important to recognise that we do not consume vitamins and nutrients in isolation. Rather, we eat foods that contain complex combinations of nutrients and bioactive components. Evidence has demonstrated that different nutrients and components of foods work synergistically to promote healthy ageing and influence chronic disease risk [24]. As such, research in the nutrition field has moved toward investigating the patterns in which foods are consumed within a whole-diet context, rather than single nutrient or single food effects [25]. Moreover, the dietary behaviours observed in free-living individuals are better represented by overall patterns and therefore offer more valuable epidemiological insights [24]. As a result, the potential for acceptability, palatability and compliance is greater when recommended in behavioural dietary counselling.

There has been a growing interest in the notion of reducing chronic disease risk and inflammation in the body by consuming an overall diet that is anti-inflammatory in nature. While there is no universal definition of “anti-inflammatory diet”, there are numerous dietary patterns that have been identified as having anti-inflammatory properties, including the Mediterranean diet, the Nordic diet and the Washoku diet [26]. Although informed by the populations of their different locations, the emphasis in each of these patterns is on consuming whole and nutrient-dense foods that are rich in antioxidants and other anti-inflammatory compounds. This includes foods such as fruits and vegetables, nuts and seeds, extra virgin olive oil, wholegrains, fish, poultry and legumes, and the use of spices and herbs for flavour The Mediterranean diet is the most commonly researched and referenced type of anti-inflammatory diet and will be used as the exemplar in this thesis. There is a growing body of evidence from observational and intervention studies that supports the anti-inflammatory effects of the Mediterranean diet. A recent systematic review of 69 observational studies (60 cross-sectional and 9 longitudinal) reported that higher adherence to the Mediterranean diet was associated with lower levels of inflammation, including a reduction in CRP and IL-6 [27]. A meta-analysis of 22 randomised controlled trials published in 2022 found that a Mediterranean dietary pattern leads to the most pronounced effects on reducing inflammatory markers, across multiple populations, including healthy older adults, and adults with various chronic conditions such as CVD and type 2 diabetes [28]. Pooled effects showed that the Mediterranean dietary pattern was associated with a significant reduction in IL-6 (n = 524,

mean difference = -1.07, 95% CI: -1.94, -0.20) and interleukin-1β (n = 178, mean difference = -0.46, 95% CI: -0.66, -0.25). Although not statistically significant, there was a tendency for CRP (n = 1805, mean difference = -1.00, 95% CI: -2.02, 0.01), IL-8 (n = 229, mean difference = -1.34, 95% CI: -2.96, 0.14) and TNF-α (n = 335, mean difference = -1.69, 95% CI: -3.40, 0.02) to decrease after a Mediterranean diet. Interestingly, the analysis found that other dietary patterns, including the Dietary Approaches to Stop Hypertension (DASH) and vegetarian diets, exerted no substantial effects on inflammatory markers [28], suggesting that the Mediterranean diet may be the most promising dietary pattern for reducing inflammation and chronic disease risk.

1.2 The Mediterranean diet

1.2.1 What is the Mediterranean diet?

The Mediterranean diet reflects food and eating patterns typical of the olive growing areas of the Mediterranean region throughout the 1950s and 60s, including Crete, Greece, and parts of southern Italy, where life expectancy was high and the prevalence of diet-related chronic diseases were among the lowest [29,30]. Due to the wide span of geographical and cultural regions where the Mediterranean diet is found, there are multiple definitions and interpretations of what constitutes the Mediterranean diet. The most common interpretation within the scientific literature is the 'traditional' Mediterranean diet, a plant-based diet that is defined as being high in unprocessed plant foods including vegetables, fruits, whole grains, nuts, seeds, and extra virgin olive oil; moderate in fish and shellfish, and red wine; and low in meat, dairy, eggs, animal fats, and discretionary foods [29,31]. The Mediterranean diet pyramid was designed to illustrate the general proportions and frequency of food servings and food groups that form the overall dietary pattern (see Figure 1.2). As an indicator of general healthy food choices, it was designed as a dietary guide for the general population to promote good health, rather than specific dietary prescriptions for serving sizes and proportions of energy obtained from different food groups [30].

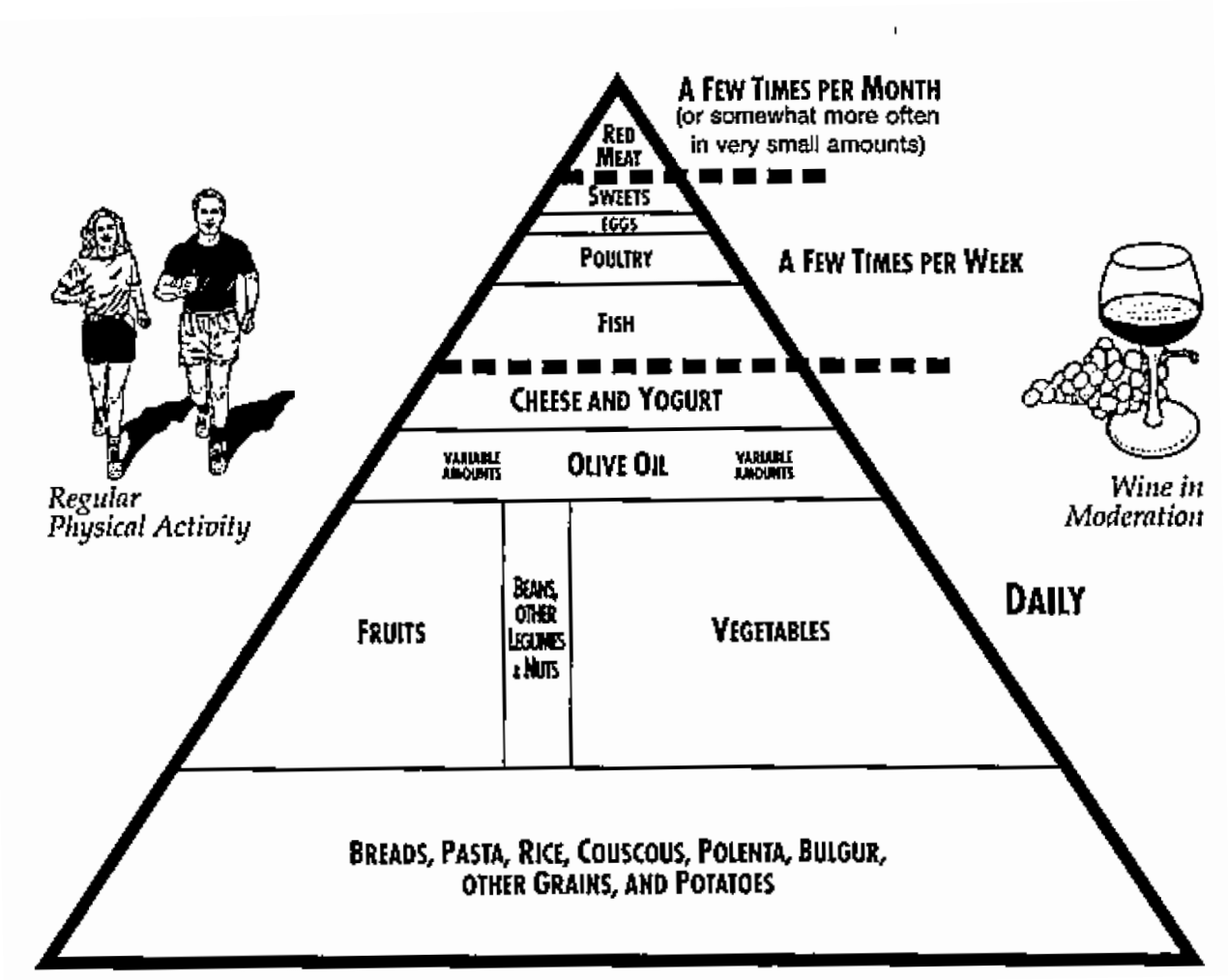

Figure 1.2. The original Mediterranean diet pyramid [30]

With accumulating epidemiological evidence on the benefits of the Mediterranean diet for health and wellbeing, this pyramid has been modified many times. The most recent adaptation was published in 2011 (see Figure 1.3) and provides specific quantitative recommendations on the proportions and frequency of consumption of the different food groups, alongside brief guidelines on the types of foods to be consumed and how often [32]. This adaptation also highlights a range of lifestyle and psycho-social elements beyond just food and nutrient intake; including preparing home-cooked meals from scratch using produce that is local and in-season, eating meals with others, getting adequate rest, and engaging in regular physical activity [32].

Figure 1.3. The Mediterranean diet pyramid today [32]

1.2.2 Mediterranean diet for chronic disease management

Although it was not widely recognised until the 1990s [33], there is a growing body of evidence supporting the notion that following a Mediterranean dietary pattern can lead to a variety of benefits pertaining to reducing risk factors and managing chronic conditions, ultimately promoting healthy ageing. An umbrella review of 29 meta-analyses of observational studies (n = 13) and randomised trials (n = 16) found robust evidence for an association between greater Mediterranean diet adherence and reduced risk of overall mortality, cardiovascular diseases (including coronary heart disease and myocardial infarction), overall cancer incidence, neurodegenerative diseases, and diabetes [34]. Evidence from RCTs also showed that participants who consumed a Mediterranean diet, compared to a control diet, demonstrated improved metabolic, anthropometrical, and inflammatory risk markers [34]. The Mediterranean diet includes foods rich in antioxidants (particularly vitamin C and carotenoids), phenolic compounds and unsaturated fatty acids, including long-chain omega-3 fatty acids and mono-unsaturated fatty acids. These nutrients and their food sources have been consistently shown to be associated with lower levels of inflammation [28,35]. Amongst other mechanisms, this anti-inflammatory capacity of the Mediterranean diet has been directly linked to reduced cardiovascular risk in older adults [36]. While most of this evidence demonstrating the link between Mediterranean diet adherence and reduced chronic disease risk is observational, the highest level of evidence exists for the primary and secondary prevention of CVD [37]. The Prevencione co Dieta Mediterranean (PREDIMED) study is the largest primary prevention trial to-date, including 7668 participants at high cardiovascular risk across

13 research centres. When compared to a lower-fat control diet, consuming a Mediterranean diet supplemented with extra virgin olive oil or mixed nuts led to significant improvements in cardiovascular-related outcomes, including blood pressure, inflammation, oxidative stress, and atherosclerosis over a period of 5 years. These improvements were associated with a 30% lower risk of major cardiovascular events [38]. Similarly, findings from the Lyon Diet Heart Study suggested that consuming a Mediterranean diet after a myocardial infarction was associated with a noticeably reduced rate of recurrence, additional cardiac events, and overall mortality, compared to the standard low-fat diet recommended for cardiovascular patients [39].

Beyond CVD, the Mediterranean diet has been linked to the prevention and management of a number of conditions relevant to older adults, including bone health and fracture risk [40-42], cancer [43,44], cognitive function and decline including mild cognitive impairment and dementia [45,46], depression [47-49], macular degeneration [50-52], non-alcoholic fatty liver disease [53,54], overweight, obesity and metabolic syndrome [55-57], sarcopenia and musculoskeletal health [58,59], and type 2 diabetes [60,61]. The positive health benefits of the Mediterranean diet are thought to be due to various metabolic and molecular mechanisms, including lipid-lowering effects, reduced oxidative stress, reduced inflammation, and reduced platelet aggregation. These mechanisms are likely triggered by specific micro- and macronutrients from core foods, as well as the synergistic effect of the entire dietary pattern. It is also important to highlight that the Mediterranean diet is associated with nutritional adequacy in adult populations, with research showing that a high degree of adherence to this dietary pattern is associated with a reduced risk of inadequate nutrient intake [62]. Consequently, the Mediterranean diet stands out as an appealing dietary pattern for meeting nutrient requirements while simultaneously addressing chronic disease risk factors, managing pre-existing conditions, and supporting overall healthy ageing.

1.2.3 Habitual dietary intake of older adults

Despite the evidence surrounding the importance of diet for healthy ageing and the health benefits associated with the Mediterranean diet, the overall diet quality of older adults in Australia is poor. The general dietary pattern of Australians is characterised by high consumption of meat and low consumption of vegetables, a pattern that has remained relatively consistent over time [63,64]. In 2020, more than 90% of Australian adults aged 65 years and older were not meeting the current dietary guidelines for fruit and vegetable intake [65]. This is a persistent trend, with comparable figures recorded in 2018 [66] and 2011 [67]. Although discretionary food intake has decreased over time, it is still above recommended limits, with an estimated 33% of total daily energy intake coming from discretionary food choices [67,68]. The Australian data aligns with that of the United States, where a recent report

from the National Health and Nutrition Examination Survey showed that between 2001 and 2008, consumption of fruits, vegetables, nuts, seeds and legumes decreased, while the consumption of fish and shellfish, processed meats, and saturated fat increased [69]. This approach to eating, generally referred to as a Western-style dietary pattern, directly contradicts the core principles of the Mediterranean diet. This trend of poor diet quality is consistent across other Western nations and has become more prominent over time [70-72].

Although intervention studies in Australian populations have demonstrated that adherence to a Mediterranean-style dietary pattern is possible and is associated with significant improvements in cardiovascular health [73,74], these interventions are short-term and intensive. They involve regular contact with study dietitians and the provision of specific food items like extra virgin olive oil, canned tuna, legumes, and nuts. However, long-term adherence to a Mediterranean-style dietary pattern has been shown to diminish in non-Mediterranean populations post-intervention. In a follow-up of the MedLey study in community-dwelling older adults in Australia, Murphy and colleagues [75] reported that while overall Mediterranean diet adherence remained significantly greater at 18-months compared to baseline, adherence had decreased between the end of the intervention to the 18-month follow-up, with a reduction in the consumption of legumes, vegetables, and nuts, and an increase in the consumption of discretionary foods and alcohol [75]. These findings illustrate how individuals can revert to their prior lifestyle and diet habits after a specified intervention period, which is particularly significant given that most chronic conditions require long-term therapy and permanent lifestyle behaviour change for effective management. Based on the available evidence, it is evident that general diet quality is poor, and adherence to the Mediterranean diet among the general population is low to moderate at best [76]. Considering the potential health benefits associated with anti-inflammatory dietary patterns such as the Mediterranean diet, promoting adherence to this dietary pattern could prove to be an effective strategy for improving the health of older Australians.

1.3 Using education and knowledge for behaviour change

1.3.1 The power of knowledge

There are many factors that determine the way an individual eats. The food environment (i.e., food availability, accessibility, and affordability), cultural beliefs, values and traditional practices, health literacy and knowledge, and our social environment all influence how we eat [77]. Because of these many dynamic and overlapping factors, changing people's eating behaviours is a challenging and complex task. There are many theoretical models that have been developed to describe how the process of behaviour change occurs. Many of these models, including the health belief model, social cognitive theory, the transtheoretical model

and the theory of planned behaviour, recognise the need for knowledge as a critical component for producing action [78]. The Behaviour Change Wheel (BCW) (Figure 1.4), which is based on these behaviour change theories, provides a structured approach to understanding behaviour change and for developing interventions that effectively target and promote behaviour change [79].

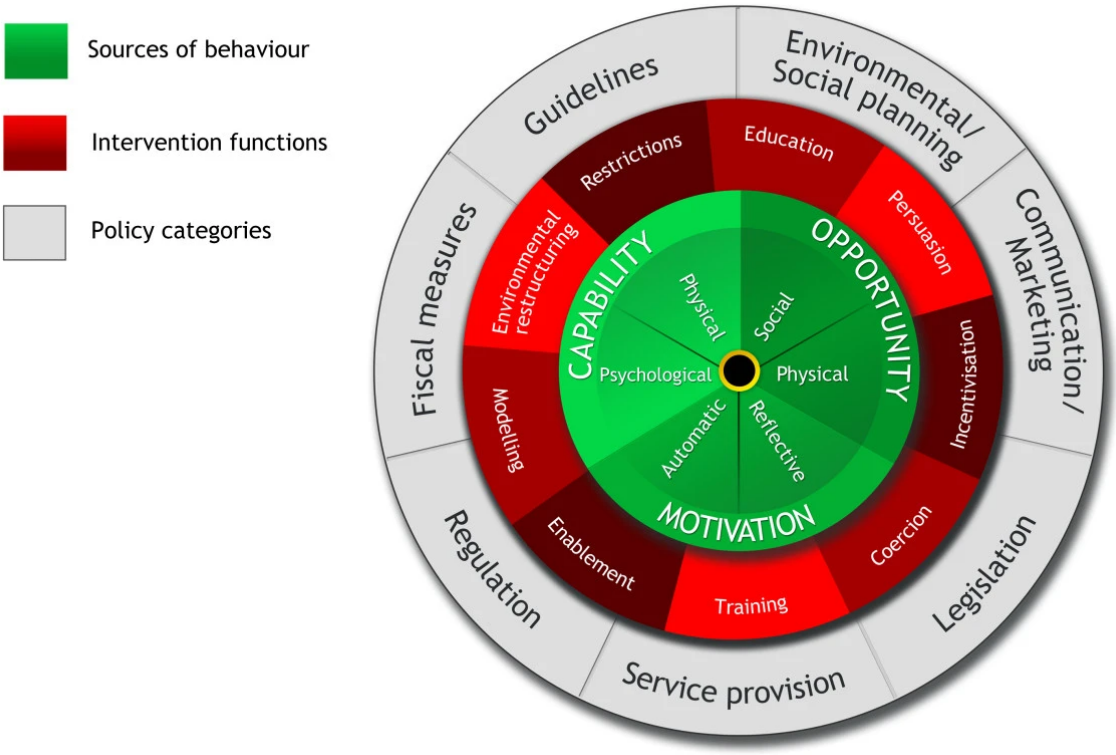

Figure 1.4. The Behaviour Change Wheel [79]

At its core, the Capability-Opportunity-Motivation-Behaviour (COM-B) system (Figure 1.5) explains how one's capability, opportunity and motivation interact to produce behaviour change [79]. This system acknowledges that performance of a particular behaviour relies on several prerequisites: having the physical (i.e., technical skills such as cooking and food preparation) and psychological (i.e., fundamental knowledge of what to do) capability to be able to perform the behaviour, physical (i.e., have the necessary access to required equipment) and social opportunities (i.e., environment that facilitates and promotes) to perform the behaviour, and a strong intention or motivation to perform the behaviour. Within this system, improving one's capability to eat a healthy diet (i.e., by increasing nutrition knowledge and improving skills) is essential for increasing understanding to initiate positive behaviour change.

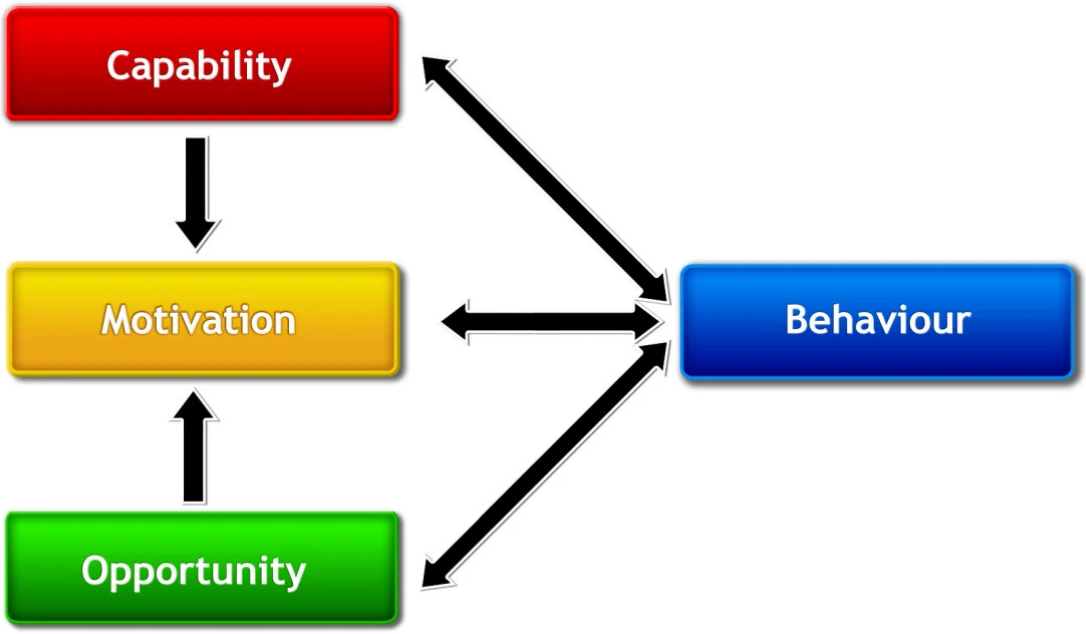

Figure 1.5. The COM-B system [79]

Knowledge can be defined in three ways: general knowledge of information, knowledge that increases personal awareness, and knowledge that increases skills [80]. Nutrition knowledge covers a range of topics including understanding of food sources of nutrients and daily recommendations for food groups and nutrients, as well as the benefits of consuming a balanced diet, the risks associated with consuming unhealthy diets, and the role of specific foods and nutrients for health [81,82]. It is a significant contributor in shaping food choices and eating behaviours, with research showing that knowledge gaps account for 16-22% of the barriers to achieving food literacy (i.e., the ability to acquire, understand, and apply knowledge about food and nutrition to make informed decisions that contribute to improved health) [83,84]. In a study of 1040 adults in the United Kingdom, participants who had greater nutrition knowledge were 25 times more likely to consume adequate amounts of fruit and vegetables every day [83]. Research has shown that those who have higher nutrition knowledge tend to consume diets that are less-energy dense, are lower in saturated fat, and contain fewer sugar sweetened beverages [85]. Other findings have demonstrated that having greater knowledge of the nutritional and health benefits of a food product was linked to greater acceptance and consumption, even if they didn't enjoy the taste of the food compared to other alternatives [86]. Greater nutrition knowledge is also associated with positive nutrition-related behaviours, such as reading the nutrition information panels on packaged food products to make more informed decisions about food choices [87,88].

This relationship between knowledge and food consumption is also present when looking at specific dietary patterns, such as the Mediterranean diet. Research has shown that greater knowledge of the Mediterranean diet is associated with higher levels of diet adherence. In Australia, a study of 373 adults demonstrated that greater knowledge of the Mediterranean diet, defined as understanding and awareness of the general Mediterranean dietary guidelines, food choices and health benefits, was significantly associated with higher Mediterranean diet adherence [89]. This relationship is consistent across other non-Mediterranean regions [90]. Compared to Mediterranean countries, knowledge of the Mediterranean diet is generally limited in non-Mediterranean regions [89], which may be contributing to the low levels of adherence in Australia and elsewhere. Given that increasing capability is essential for promoting behaviour change, improving knowledge of the Mediterranean dietary pattern is a potential first line strategy for supporting healthy eating habits and improving population health.

1.3.2 Education as a means to improve knowledge

Having identified a target behaviour for change, the next step is to plan how to do this. The BCW outlines nine intervention functions as the general methods through which an intervention can bring about behaviour change. Education is used as an intervention function with the desired outcome of increased knowledge through information. It can target all aspects of the COM-B system to strengthen capability (e.g., increase knowledge and skills related to a behaviour), opportunity (e.g., remove barriers to a behaviour) and motivation (e.g., change beliefs or attitudes about the behaviour) for behaviour change [79].Michie and colleagues differentiate education from training, with the latter focussing on increasing knowledge of skills [79]. It goes beyond the mere provision of information and tends to involve more practical and hands-on experiences to develop and refine the skills needed to perform a behaviour (e.g., food preparation and cooking). Education is a common strategy used in nutrition interventions designed to promote healthy eating and has been shown to be effective for increasing knowledge and improving dietary intake. In a study of older adults in the United States, MacNab and colleagues [91] developed an educational program targeting wholegrain consumption, which was demonstrated to be effective for improving wholegrain knowledge and increasing the frequency of wholegrain consumption post-intervention. Participants also reported that they liked the taste of wholegrain foods better, and they knew how to look at the food packaging to select products with wholegrains after participating in the intervention [91]. In a program targeting community-dwelling older adults, 4-weeks of dementia specific nutrition education was shown to increase nutrition knowledge by 43% immediately post-intervention, which was maintained three months later. This increase in knowledge was accompanied by an increase in the variety of vegetables eaten and a reduction in the use of added salt [92].

Interventions that also include aspects of training, such as cooking workshops, have been shown to increase skills and confidence in the kitchen, which is associated with improved diet quality [93]. In other populations, knowledge of the Mediterranean diet, food sources of macro- and micronutrients, and understanding of food labels has been improved through specific and targeted Mediterranean diet educational interventions, and this was associated with improvements in adherence to the Mediterranean diet [94].

1.3.3 Limitations of nutrition education interventions to date

Despite the positive effects on knowledge and, in turn, behaviour that these programs have shown, there are several limitations in the design of nutrition education programs to date, particularly those that have been provided to older adults. Many of these programs have been designed to be delivered in a traditional lecture format, often in an in-person group setting. For example, the educational program developed by MacNab and colleagues was delivered as lectures in three 1-hour, in-person group sessions [91]. Similarly, Wallace and colleagues constructed their program to be delivered in a group format over four, 3-hour sessions [92]. Despite being a commonly used approach for education delivery, this format comes with considerable barriers to participation. Many older adults may not be able to attend in-person sessions due to physical limitations or transportation barriers, which excludes them participating. Additionally, many of these programs are delivered in metropolitan areas, ignoring a significant proportion of the older adult population that resides in rural or remote regions. This is particularly concerning in Australia, where nutrition interventions are rare in rural areas despite the higher rates of poor dietary habits, diet-related chronic diseases, and preventable disease burden compared to urban areas [95-97]. The major drawback of these programs is the inability to reach a large audience, limiting the potential for meaningful public health impact. Other programs have provided participants with educational information in the form of a basic printed newsletter [98]. Whilst this format can be useful for reaching a wider audience compared to programs that require in-person attendance, they may become outdated quickly and can be limited in their ability to provide up-to-date information in a timely and cost-effective way. Taken together, it is clear that there is a need for nutrition education that is widely available and accessible to maximise the potential impact on public health outcomes.

1.3.4 Acknowledging the limitations of nutrition knowledge and education for behaviour change

While building knowledge through education is essential for equipping individuals with information and resources to make informed decisions around food choices, it is generally not sufficient for sustaining dietary behaviour change [82]. The quality of the evidence on the link

between nutrition knowledge and dietary behaviours is mixed [77]. Nutrition knowledge is more complex that just knowing what to eat. While declarative knowledge (i.e., the *what*) can form the basis for understanding the core components and cuisine elements of the Mediterranean diet, a level of procedural knowledge (i.e., the *how*) is needed to be able to apply this knowledge in daily practice to make appropriate meal choices and selections. Other aspects of nutrition knowledge, such as being able to read food labels to choose healthier packaged foods, is also complex and relies on having general literacy and numeracy skills alongside an understanding of what ingredients or nutrients are desirable (e.g., dietary fibre, wholegrains) or undesirable (e.g., trans and saturated fat, high salt) [99]. Individuals also need the capacity to actively participate and engage with educational information, which again relies on adequate literacy and numeracy skills to facilitate a meaningful and impactful learning experience. This is an important consideration when designing educational programs, with critical thought and planning needed to develop programs that can cater to those with reduced literacy skills and varying learning styles (e.g., visual versus verbal learners) [100].

Potential for dietary behaviour change can also be restricted by a range of external factors, even in the face of accurate nutrition knowledge; including the availability and accessibility of nutritious food options, pervasive food marketing, busy lifestyles that prioritise convenience over nutritional quality, longstanding habits, and emotional ties to food [101]. Although it is possible to make small but meaningful dietary changes as a result of improved knowledge through nutrition education [91,92], changing deeply ingrained dietary habits is a complex process and the impact of nutrition education alone is likely to be limited long-term without addressing the broader environmental, economic, and psychological factors that influence food choices. Psychological factors play a crucial role in determining what we eat, and it is important to acknowledge that individuals may need specialised support to address potential barriers. The use of evidence-based behaviour change techniques in diet behaviour change interventions, including problem-solving, goal setting, feedback and social support, can have greater impacts on driving meaningful behaviour change in older adults [102]. Other approaches such as motivational interviewing (MI) can be utilised to help overcome ambivalence to behaviour change through identification of intrinsic motivations for adopting healthier dietary patterns, fostering a sense of autonomy and self-efficacy [103]. Cognitive behavioural therapy (CBT) can help individuals to identify and reframe negative thought patterns associated with unhealthy eating to promote more positive and adaptive behaviours [104]. The integration of MI combined with CBT (MI-CBT) is a highly effective holistic approach to behaviour change [105]. This comprehensive method tackles key aspects of behaviour change such as readiness to change, motivation, and cognitive restructuring (i.e., identifying and challenging unhelpful thoughts and behaviours), and aids in developing behavioural

strategies to help develop practical skills needed to implement sustained dietary changes. The use of MI-CBT and other behavioural approaches empowers individuals to apply educational information and integrate their knowledge into practical strategies to foster meaningful dietary behaviour change.

1.4 Digital health as the solution for nutrition education

1.4.1 Access to digital health technologies

Digital health, which refers to the use of information and communication technology to facilitate and/or deliver healthcare, is inherently well placed as a potential delivery method for nutrition education. The rapid evolution of technology, fuelled by consumer demand, is leading to increased development and adoption of digital health technologies that are accessible and easier to use. Triggered by the COVID-19 pandemic, ongoing funding from the Australian government has legitimised digital health services to operate on a much larger scale than ever before, and interest, acceptance and uptake of digital health has increased dramatically [106,107]. They provide an opportunity to access health information and receive health care from home, and can empower, engage, and educate older adults [108]. Importantly, digital health is becoming increasingly available and acceptable to older adults. As of 2018, 61.6% of Australians aged 65 years and over had reported using the internet in the previous 3 months [109]. In 2020, 93% of older adults had access to the internet at home, and there has been a noticeable increase in ownership and usage of devices such as smartphones, tablets, laptops, and desktop computers among this demographic [110]. In response to low digital literacy being a prominent barrier to adoption of digital health technologies, an Australian government initiative has been introduced to enhance digital literacy and online safety of older adult users [111,112]. As such, it appears that having access and the skills to use the internet or a smartphone is not a significant obstacle to providing nutrition education via digital health platforms.

1.4.2 Use of digital health technologies

One of the main reasons older adults use the internet is to seek out health-related information and services [113]. Medlock and colleagues reported that older adults considered the internet to be a reliable source of health-related information, particularly when it comes to gaining knowledge about the prognosis, symptoms and treatments for their own health concerns [114]. Although there is little integration of digital health in routine medical practice, the market for mobile applications for self-management of health has boomed in recent years, with more than 300,000 health care apps available for users [115]. Alongside this, there has been a surge in research investigating the efficacy of digital health solutions for addressing various health conditions and risk factors, including diabetes, obesity, physical activity, and diet [116-

119]. When compared to traditional in-person care, digital interventions can have comparable effects on health outcomes, while reducing multiple barriers to participant engagement [120]. Moreover, there is evidence to suggest that delivering dietary education via digital health approaches can improve dietary habits in adults, and specifically increase adherence to the Mediterranean diet [121].

Importantly, technologies are able to be designed to include features and functions that draw on behaviour change techniques known to effectively support behaviour change, such as prompts and reminders, ability to self-monitor and track behaviour, learn problem solving skills, set goals, and receive feedback and social support [102]. For example, Paola (a virtual health coach) was designed to send weekly notifications to participants to remind them to complete a weekly check-in to monitor progress and set new goals [122]. Other technologies have provided a source of social support to users by connecting them with nutrition professionals for access to diet and behaviour change counselling, or by creating a virtual community with other users to share insights, receive encouragement, and collectively navigate the challenges and complexities of adopting and maintaining positive dietary habits [117].

Importantly, older adults have a high level of interest and motivation to use digital health technologies for healthy ageing [123], and they recognise that digital health can assist them to remain independent, active, and healthy [124]. Leveraging digital tools and technologies provides an exciting opportunity for healthcare professionals and researchers to make meaningful impact by increasing access to nutrition education and removing barriers that have limited the reach of previous efforts. Although there is a large range of technologies available for the purposes of preventing and managing ill-health, very few of these technologies have been designed specifically with older adults in mind. As such, these technologies may not be appropriate for older adult populations, and this is an important consideration when evaluating barriers to engagement and subsequent impacts on behaviour change.

1.4.3 Importance of consumer-led, participatory design research

While technology is becoming increasingly ubiquitous to deliver health information and interventions, it is typically not created with or designed for the older adult population. It is essential to provide accessible health services that cater to the needs of older adults, and any interventions developed for them should consider the challenges associated with ageing. Indeed, consideration of the unique needs of older adults in the design of digital health technologies is one of the most significant factors that contributes to uptake and ongoing use [125]. Enhancing community and consumer participation strategies have become a national

priority in the health, medical and research sectors [126]. To ensure the quality, usability, and acceptability of digital health technologies for older adults, it is widely recognised that utilising co-design methodologies such as participatory design and user testing are essential. Participatory design is a collaborative approach that involves end-users in the design process to create solutions that meet their needs and preferences. Research has shown that active participation of consumers through participatory design can produce an end-product that meets the needs of its intended users, improves usability, and increases engagement [127,128]. Moreover, ease of use is the main predictor of whether an older adult will use a technology and when technologies are deemed too difficult, engagement will be diminished [124]. Engagement with digital health is important for empowering individuals to be in control of their health and improve their wellbeing and strategies to support engagement in older adults are needed.

1.5 Rationale

The ageing population is continuing to grow, as is the burden of chronic lifestyle-related conditions. Chronic, low-grade inflammation is a hallmark feature of the ageing process, and is also implicated in the pathogenesis of several age-related chronic diseases, including CVD. At the individual level, the ageing process can be 'plastic' and there is data to suggest that the inflammation associated with ageing can be counteracted or slowed through lifestyle changes, including appropriate diet and nutrition. Given that older adults tend to have poor dietary habits, characterised by consumption of a Western-style dietary pattern directly linked to inflammation and increased chronic disease risk, there is a need for health promotion interventions that are targeted at improving diet quality.

Evidence has demonstrated that following low- or anti-inflammatory dietary patterns, such as the Mediterranean diet, can reduce chronic disease risk factors and ultimately support healthy ageing. Principles of a Mediterranean-style dietary pattern, particularly its characterisation as a predominately plant-based diet, are promoted globally for health and longevity [129,130]. It has also been shown to be a sustainable way of eating [131], which is becoming increasingly important in the context of continued population growth. While there are many determinants of eating behaviours, knowledge is a crucial first step for initiating positive behaviour change, by increasing awareness and motivating individuals to act. Education-based interventions have demonstrated their effectiveness in boosting adherence to the Mediterranean diet and improving overall dietary habits. However, the vast majority of these interventions have been delivered in urban areas through in-person formats and overlook potential barriers to engagement for older adults, including physical limitations, transportation difficulties, or those living in rural and remote regions. Digital health technologies are inherently well-placed as an

accessible, low-cost, and easily scalable solution to providing nutrition education. Although there has been a surge in the development and use of digital technologies for self-management of health conditions, there is a lack of technologies that have been specifically developed with the needs and preferences of older adults in mind. This is critical for ensuring the quality, usability, and acceptability of digital health technologies for older adults, and maximising their engagement with alternative forms of healthcare. The current thesis aims to fill these gaps.

1.6 Thesis aims and structure

This thesis is presented in six chapters. These include the Introduction and Discussion chapters (Chapters 1 and 6), as well as a series of papers published or submitted for publication in peer-reviewed journals (Chapters 2 – 5). Chapters 2 – 5 can be read independently as they include their own introduction, methods, results, discussion and reference sections.

The overall aim of this thesis was to identify and address important gaps in effective strategies for improving dietary knowledge and healthy eating among older adults. Specifically, this thesis aimed to:

1. Review and synthesise the available evidence on the use of educational strategies and other behaviour change techniques in Mediterranean diet interventions for older adults (Chapter 2);
2. Investigate the Mediterranean diet knowledge and nutrition-related attitudes and behaviours of community-dwelling older adults in Australia (Chapter 3);
3. Qualitatively explore user needs and preferences for an online nutrition education resource (Chapter 4); and
4. Assess the usability and acceptability of an existing web-based anti-inflammatory diet education resource and its effects on nutrition knowledge and dietary intake (Chapter 5).

The objective of the final chapter (Chapter 6) was to summarise and synthesise the findings of the thesis chapters and discuss their implications in the context of remaining research gaps.

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CHAPTER TWO

A SYSTEMATIC SCOPING REVIEW OF BEHAVIOUR CHANGE TECHNIQUES USED IN MEDITERRANEAN DIET INTERVENTIONS

Preface

Adherence to the Mediterranean diet in the general population in Australia is low. While there is some evidence from intervention studies that older adults can adhere to a Mediterranean diet over a short period, the capacity of these interventions to promote and maintain long-term behaviour change is unknown. Understanding the "active" ingredients of interventions is a crucial step in understanding what works for behaviour change with the aim of translating evidence-based interventions into practice. However, the ability to do so is contingent on the body of available evidence.

The aim of this chapter was to understand how education strategies and other behaviour change techniques have been used within Mediterranean diet interventions for older adults. To this end, a scoping review was selected as the preferred methodology, as the purpose was to scope a body of literature and identify knowledge gaps.

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Review

Behaviour Change Techniques Used in Mediterranean Diet Interventions for Older Adults: A Systematic Scoping Review

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Abstract: Mediterranean diet interventions have demonstrated positive effects in the prevention and management of several chronic conditions in older adults. Understanding the effective components of behavioural interventions is essential for long-term health behaviour change and translating evidence-based interventions into practice. The aim of this scoping review is to provide an overview of the current Mediterranean diet interventions for older adults (≥55 years) and describe the behaviour change techniques used as part of the interventions. A scoping review systematically searched Medline, Embase, CINAHL, Web of Science, Scopus, and PsycINFO from inception until August 2022. Eligible studies were randomized and non-randomized experimental studies involving a Mediterranean or anti-inflammatory diet intervention in older adults (average age > 55 years). Screening was conducted independently by two authors, with discrepancies being resolved by the senior author. Behaviour change techniques were assessed using the Behaviour Change Technique Taxonomy (version 1), which details 93 hierarchical techniques grouped into 16 categories. From 2385 articles, 31 studies were included in the final synthesis. Ten behaviour change taxonomy groupings and 19 techniques were reported across the 31 interventions. The mean number of techniques used was 5, with a range from 2 to 9. Common techniques included instruction on how to perform the behaviour (n = 31), social support (n = 24), providing information from a credible source (n = 16), information about health consequences (n = 15), and adding objects to the environment (n = 12). Although behaviour change techniques are commonly reported across interventions, the use of the Behaviour Change Technique Taxonomy for intervention development is rare, and more than 80% of the available techniques are not being utilised. Integrating behaviour change techniques in the development and reporting of nutrition interventions for older adults is essential for effectively targeting behaviours in both research and practice.

Keywords: Mediterranean diet; interventions; behaviour change techniques; older adults; scoping review

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1. Introduction

Older people make up a significant portion of Australia's population, with one in six people being 65 years or older [1]. The number and proportion of older adults in the population is projected to continue to rise over the next 40 years, due to increasing life expectancy and declining fertility rates [1,2]. While a portion of this population will be in good health, completely independent, and active in their communities, many may experience more marked effects associated with ageing, including decreasing quality of life, illness, and disease [3]. However, evidence suggests poor health in later life is not inevitable, with recent research showing that many ill-health characteristics associated with ageing can be attributed to modifiable lifestyle factors, such as hypertension, hypercholesterolemia, diabetes, obesity, and low levels of physical exercise [4].

Diet is a key lifestyle behaviour that is fundamental to overall health and quality of life. Indeed, adequate nutrition plays a role in the prevention and management of many chronic illnesses that affect older adults [5]. Despite the growing evidence demonstrating the role of diet in chronic disease management and healthy ageing, epidemiological and population evidence suggests that dietary quality tends to be poor among the older population, characterized by low intakes of fruits, vegetables, and wholegrains, alongside increased consumption of refined grains, sugars, and red and processed meats [6–9]. Dietary patterns such as the Mediterranean diet protect against age-related chronic conditions, including cardiovascular disease (CVD), type 2 diabetes, metabolic syndrome, risk of cancer, and reduced cognitive functioning [10]. While a Mediterranean-style diet is often endorsed in practice, adherence is generally low to moderate at best among older adults [11], which is unsurprising given the reports regarding diet quality in this group and the complexities associated with changing health behaviours [12]. While there is evidence from intervention programs that older adults can adhere to a Mediterranean diet over a short period [13,14], the long-term effectiveness, and therefore their capacity to change behaviour, of such programs is not well established. Thus, there is a need to identify and understand the effective components of behavioural interventions that contribute to increased dietary adherence and promote sustained health behaviour change in the long term.

Behaviour change theories provide a foundation to explain why people adopt a behaviour. Interventions that are theory-informed, particularly those that are underpinned by theories such as the social cognitive theory, theory of planned behaviour, and the transtheoretical model, have the potential to be more effective at promoting behaviour change and improving health outcomes than those developed in the absence of a guiding theory [15]. However, theory alone offers little explanation on the specific elements that contribute to the initiation and maintenance of behaviours [16]. Indeed, behavioural interventions are often complex and contain many interrelated components, which makes them difficult to replicate in research, adopt in real-world settings, and synthesize in systematic literature reviews [17,18]. Recent advancements in behaviour change science have led to the development of the Behaviour Change Technique Taxonomy, which provides a standardized classification system for behaviour change techniques to help develop new interventions, as well as to facilitate the replication of existing interventions [17]. Understanding the "active" ingredients of interventions is a crucial step in translating evidence-based interventions into practice. However, the ability to do this is contingent on the body of available evidence [17].

This review identifies and summarizes Mediterranean diet intervention studies in older adults. Specifically, we summarize the outcome measures related to diet components used in these studies (e.g., diet adherence, food and nutrient intake, nutrient biomarkers) and describe the delivery format and behaviour change strategies used in the intervention. Describing the behaviour change strategies used in diet interventions is an essential first step for identifying and understanding the "active" ingredients that produce the desired behavioural changes. The purpose of this review is to identify and describe behaviour change techniques used in Mediterranean diet interventions for older adults. To our knowledge, no scoping reviews have been conducted on Mediterranean diet interventions and behaviour change in older adults.

2. Methods

This review followed a systematic approach, with a protocol prospectively registered at Open Science Framework Registries (https://osf.io/28evm/, accessed on 3 June 2022). Search strategies, study selection, and result reporting were described according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) checklist (see Table S1 for PRISMA-ScR checklist) [19].

2.1. Search Strategy

The search strategy aimed to locate published studies. The databases searched included Medline, Embase, CINAHL Web of Science, Scopus, and PsycINFO. The search was not limited by date, beginning from inception and extending to August 2022. The search strategy was adapted for each database (see Table 1 for the search strategy for the Ovid MEDLINE database). The MeSH Keywords used across searches were 'Diet, Mediterranean', 'Aged', 'Clinical Trials as Topic', and 'Randomized Controlled Trials as Topic'. Linked papers to the included studies (i.e., protocol papers and those presenting the results of other outcomes) were also collected. Reference lists of included studies were examined to identify additional eligible records.

Table 1. Search strategy for the scoping review of Mediterranean diet interventions among older adults: database—Ovid MEDLINE.

Ovid MEDLINE(R) ALL <1946 to 16 August 2022>	
1	Diet, Mediterranean/ 4816
2	Mediterranean diet*.mp. 7055
3	Mediterranean dietary pattern*.mp. 541
4	Cretan diet*.mp. 12
5	Anti-inflammatory diet*.mp. 350
6	MedDiet*.mp. 537
7	MeDi.mp. 1985
8	MeDiet.mp. 45
9	Greek diet.mp. 31
10	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 10,121
11	older adult*.mp. 109,936
12	senior*.mp. 49,175
13	Elderly.mp. or Aged/ 3,451,491
14	11 or 12 or 13 3,509,706
15	10 and 14 2468
16	Clinical Trials as Topic/ or Randomized Controlled Trials as Topic/ 354,379
17	intervention.mp. 786,076
18	diet intervention.mp. 1084
19	quasi-experimental*.mp. 17,988
20	16 or 17 or 18 or 19 1,099,171
21	10 and 14 and 20 552

Note: * indicates truncation to return variations on spelling.

2.2. Eligibility Criteria

Table 2 includes the detailed inclusion and exclusion criteria for selected articles. Briefly, articles were included if they reported on active Mediterranean or anti-inflammatory diet interventions in adults with an average age of 55 years and older. This age range was chosen due to the increasing prevalence and, in turn, burden of diet-related chronic diseases beginning from the age of 55 years. In cases with multiple publications arising from the same study, the paper with the most comprehensive description of the methodology, intervention, and results on dietary outcomes was used.

Table 2. Inclusion and exclusion criteria of selected studies.

Parameter	**Inclusion Criteria**	**Exclusion Criteria**
Population	Community-dwelling older adults with an average age $\geq$ 55 years	Average age < 55 years Unspecified age group
Morbidities	With or without morbidities	N/A

Table 2. *Cont.*

Parameter	Inclusion Criteria	Exclusion Criteria
Study design	Parallel randomized controlled trial Quasi-experimental/pre post	Crossover intervention (not designed to assess behaviour change) Observational (e.g., cross-sectional) Systematic review or meta-analyses
Intervention	Diet only or combined lifestyle (e.g., diet and physical activity) Mediterranean or anti-inflammatory diet Length $\geq$ 4 weeks Examining: - Adherence to Mediterranean or anti-inflammatory diet - Impact of Mediterranean or anti-inflammatory diet on nutritional behaviours - Impact of Mediterranean or anti-inflammatory diet on nutrition-related health outcomes	Other dietary intervention (e.g., paleo, vegetarian) Non-food-based studies of dietary supplements Laboratory feeding trials
Outcomes	Diet adherence (index score, food, or nutrient intake) Anthropometric outcomes (e.g., blood pressure, weight) Biochemical outcomes (e.g., blood lipids, serum nutrient status)	N/A
Language	English	All other languages

2.3. Study Selection and Data Extraction

Following the search, all identified articles were collated into EndNote X9 and imported into the Covidence systematic review software [20] for duplicate removal and review. The review process consisted of two phases of screening: (1) title and abstract review and (2) full-text review. In the first phase of screening, title, and abstracts for retrieved articles were assessed against inclusion criteria by two independent reviewers (AT and HL). In the second phase, full-text articles were scanned in detail again by two independent reviewers (AT and HL), and studies that did not meet inclusion criteria were excluded. Any disagreements that arose between the reviewers during either phase of the review process were resolved through discussion with a senior reviewer (VF), who approved the final list of included studies. The data extraction was conducted by one reviewer (AT) and then discussed among the research team to reach a consensus. This was completed using a data extraction tool developed in Microsoft Excel and included (1) study design, (2) sample characteristics and setting, (3) study objective, (4) description of the dietary intervention, (5) delivery methods and format of the intervention, (6) dietary outcome measures, and (7) study results.

2.4. Coding of Behaviour Change Techniques

The Behaviour Change Technique Taxonomy (version 1; BCTTv1) was used to assess the inclusion of behaviour change techniques in intervention content. The BCTTv1 describes 93 behaviour change techniques organized into 16 hierarchies and provides a standardized method for reporting techniques used in behaviour change interventions. Behaviour change techniques were coded by one reviewer (AT) after completing an online training course

(http://www.bct-taxonomy.com/, accessed on 3 June 2022). The full text of included articles, additional secondary publications of the same intervention, and Supplementary Materials or protocols were analysed and coded. In studies where multiple behaviours were targeted (e.g., diet and physical activity), only the behaviour change techniques specific to the diet component were coded.

Two assumptions were made when coding. Where interventions mentioned "education", we coded 4.1 instruction on performing the behaviour and 5.1 information on health consequences. When "training" was mentioned, it was coded as 4.1. This approach was used to acknowledge a minimum of the educational strategies used in the interventions [21].

3. Results

3.1. Search Strategy Results

The flow of study identification and selection is outlined in Figure 1. The search strategy identified 2384 articles for screening, and 1 additional article was identified through a manual search/searching the reference lists of included articles. Following title and abstract screening, 256 papers were identified for full-text review, from which 225 did not meet inclusion/exclusion criteria and were excluded. A total of 31 articles were included in the current review.

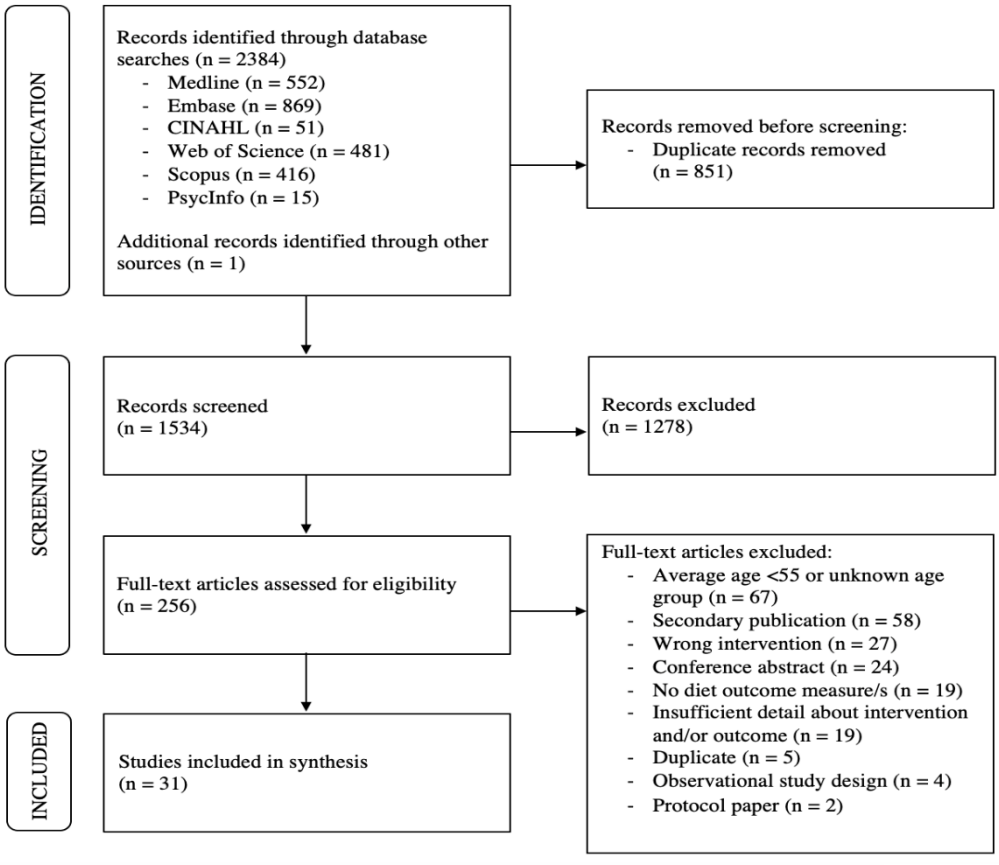

Figure 1. Preferred Reporting Items for Systematic Review and Meta-Analyses Extension for Scoping Review (PRISMA-ScR) of included articles [19].

3.2. Study Characteristics

The characteristics of the included studies are presented in Table S2. The papers included in the review were published between 2005 and 2022. Studies and the associated levels of evidence [22] included randomized controlled trials (Level I) (n = 25) and non-randomized (Level II) (n = 6) study designs. Sample sizes ranged from n = 15 to n = 7447. Five studies included females only, and one study included males only.

The 31 studies were conducted in the USA (n = 8), Spain (n = 7), Australia (n = 6), United Kingdom (n = 1), Ireland (n = 1), Greece (n = 1), Italy (n = 1), Sweden (n = 1), Luxembourg (n = 1), Germany (n = 1), Taiwan (n = 1), and Iran (n = 1). There was one multi-country study conducted in Europe, which spanned across Italy, Poland, France, the Netherlands, and the United Kingdom.

Intervention length ranged from 4 weeks to 2 years. Only six studies included a longitudinal follow-up component after the initial intervention (19.4%), ranging from 6 weeks to 12 months post-intervention.

Nineteen interventions were single component, targeting diet only (61.3%). The remaining 12 were combined lifestyle interventions, targeting physical activity and diet (38.7%).

Most studies included participants with comorbidities common among older adults, including diagnosed CVD and high cardiovascular risk (n = 9), metabolic syndrome (n = 2), type 2 diabetes (n = 2), cognitive impairment (n = 2), hypertension (n = 1), rheumatoid arthritis (n = 1), knee osteoarthritis (n = 1), breast cancer (n = 1), prostate cancer (n = 1), Parkinson's disease (n = 1), and heart or lung transplant patients (n = 1). Nine studies were conducted in reportedly healthy participants.

Comparison groups included usual or standard care (n = 12) that included the provision of typical information about dietary guidelines and general healthy eating (n = 6) or reducing dietary fat (n = 1). Two studies provided control participants with basic written instructions about the Mediterranean diet. Three interventions utilized the same structure for the control group as those in the treatment group but applied low-fat dietary principles. In six studies, participants were instructed to maintain their habitual diet (i.e., no dietary changes implemented). Three studies were combined lifestyle interventions, where the control participants engaged in the same Mediterranean diet intervention as the treatment participants (intervention differed in the provision of physical activity). Five studies were pre/post and did not include a control group.

3.3. Intervention Delivery Methods

Interventions were predominately delivered individually (n = 16, 51.6%), with four delivered in a group format (12.9%) and 10 delivered in a mixed individual and group format (32.3%). One study gave participants the option of completing the intervention in a group or individually.

The majority of interventions were delivered in-person (n = 15, 48.4%), with 12 delivered in a hybrid in-person and telehealth format (38.7%). Three interventions were delivered entirely via telehealth, and one study gave participants the option of completing the intervention in-person or via telehealth. Of those that delivered the intervention in a hybrid format, the most common telehealth method used was telephone calls (n = 11, 91.7%), and one utilized a smartphone app.

The interventions were most commonly administered by nutrition-qualified professionals, including dietitians (n = 19, 61.3%) and nutritionists (n = 5, 16.1%). Four interventions were administered by non-nutrition-trained researchers, and two studies did not report who administered the intervention. One intervention was delivered entirely online via an app developed by dietitians and did not require intervention administration staff.

3.4. Behaviour Change Theories and Techniques

Ten Behaviour Change Technique Taxonomy categories and nineteen techniques were reported across the thirty-one interventions (Table 3). The mean number of techniques was 5.1 and ranged from 2 to 9. Definitions of the identified behaviour change techniques are included in Table S3. The most common Behaviour Change Technique Taxonomy categories were '4.0 Shaping knowledge' (n = 31), '3.0 Social support' (n = 24), '9.0 Comparison of outcomes' (n = 16), '5.0 Natural consequences' (n = 15), '12.0 Antecedents' (n = 12), and '1.0 Goals and planning' (n = 11).

Table 3. Reported behaviour change theories and behaviour change techniques according to the Behaviour Change Technique Taxonomy (version 1) [16] in the included interventions.

	Alonso-Dominiguez et al. [23]	Baguley et al. [24]	Berendsen et al. [25]	Bihuniak et al. [26]	Choi et al. [27]	Chou et al. [28]	Cooper et al. [29]	Davis et al. [13]	Droste et al. [30]	Entwistle et al. [31]	Estruch et al. [32]	Grimaldi et al. [33]	Hagfors et al. [34]	Hardman et al. [35]	Katsarou et al. [36]	Keyserling et al. [37]	Landaeta-Diaz et al. [38]	Maher et al. [39]	Marcos-Forniol et al. [40]	Martinez-Rodriguez et al. [41]	Masumi et al. [42]	Mayr et al. [14]	McGrattan et al. [43]	Michalsen et al. [44]	Quintana-Navarro et al. [45]	Rusch et al. [46]	Salas-Salvado et al. [47]	Schwartz et al. [48]	Toobert et al. [49]	Tuttle et al. [50]	Zuniga et al. [51]
Behaviour change theory																															
Social cognitive theory																													•		
Cognitive learning theory						•																									
Behaviour change technique																															
1. Goals and planning																															
1.1 Goal setting (behaviour)			•								•					•		•					•		•	•		•			•
1.2 Problem solving							•				•					•		•					•				•				•
1.3 Goal setting (outcome)																											•				
1.5 Review behaviour goal(s)			•								•					•		•					•		•	•		•			•
1.6 Discrepancy between current behaviour and goal			•																						•						
1.7 Review outcome goal(s)																											•				
1.8 Behaviour contract											•																				
2. Feedback and monitoring																															
2.2 Feedback on behaviour	•				•		•											•													
2.3 Self-monitoring of behaviour	•				•			•								•		•					•						•		
2.4 Self-monitoring of outcome(s) of behaviour					•																										
3.0 Social support																															
3.1 Social support (unspecified)	•	•	•	•	•	•	•		•	•	•			•	•	•	•		•				•	•	•	•	•	•	•	•	•
4.0 Shaping knowledge																															
4.1 Instruction on how to perform the behaviour	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•

Table 3. *Cont.*

	Alonso-Dominiguez et al. [23]	Baguley et al. [24]	Berendsen et al. [25]	Bihuniak et al. [26]	Choi et al. [27]	Chou et al. [28]	Cooper et al. [29]	Davis et al. [13]	Droste et al. [30]	Entwistle et al. [31]	Estruch et al. [32]	Grimaldi et al. [33]	Hagfors et al. [34]	Hardman et al. [35]	Katsarou et al. [36]	Keyserling et al. [37]	Landaeta-Diaz et al. [38]	Maher et al. [39]	Marcos-Forniol et al. [40]	Martinez-Rodriguez et al. [41]	Masumi et al. [42]	Mayr et al. [14]	McGrattan et al. [43]	Michalsen et al. [44]	Quintana-Navarro et al. [45]	Rusch et al. [46]	Salas-Salvado et al. [47]	Schwartz et al. [48]	Toobert et al. [49]	Tuttle et al. [50]	Zuniga et al. [51]
5.0 Natural consequences																															
5.1 Information about health consequences					•	•	•	•		•		•			•					•	•		•	•		•	•	•			•
6.0 Comparison of behaviour																															
6.1 Demonstration of the behaviour				•						•		•	•											•							•
8.0 Repetition and substitution																															
8.1 Behavioural practice/rehearsal					•							•	•								•			•					•		
9.0 Comparison of outcomes																															
9.1 Credible source		•	•	•	•		•	•			•	•	•						•			•	•		•	•	•		•		
10.0 Reward and threat																															
10.1 Material incentive (behaviour)																													•		
10.3 Non-specific reward																					•										
12.0 Antecedents																															
12.5 Adding objects to the environment			•	•			•	•			•		•	•		•						•	•	•		•					

Note: • = Present in intervention.

The most common techniques were '4.1 Instruction on how to perform the behaviour' (n = 31), '3.1 Social support (unspecified)' (n = 24), '9.1 Credible source' (n = 16), '5.1 Information about health consequences' (n = 15), '12.5 Adding objects to the environment' (n = 12), and '1.1 Goal setting (behaviour)' (n = 9). Only one study directly referenced the BCTTv1 in regard to intervention development.

Of the 31 interventions, the majority did not report using any behaviour change theories in the development of the intervention (n = 29 interventions, 93.5%, Table 3). The two interventions that reported the use of theory utilized the social cognitive theory and cognitive learning theory. Four interventions were based on motivational interviewing (12.9%).

4. Discussion

Behaviour change theory provides a foundation to explain how and why individuals adopt a behaviour. The findings of this review demonstrate that behaviour change techniques are commonly reported in Mediterranean diet interventions for older adults, with instructions on how to perform the behaviour, social support, and providing information from a credible source being the most common techniques used. Despite the use of behaviour change techniques within interventions, only one study directly referred to using the BCTTv1 when developing the intervention. Indeed, behaviour change theory was rarely described, with the use of theory limited to two studies, one describing the social cognitive theory and one describing the cognitive learning theory.

This review highlights a lack of theoretical underpinning within Mediterranean diet interventions in older adults. The use of theory provides a systematic approach to the design and development of a complex intervention, providing a range of ways to target behaviour change through behaviour change techniques [52]. Only 19 techniques were reported across the included interventions, suggesting that 80% of the available behaviour change techniques are not being utilized, which is considerably less than the techniques that have been used in behaviour change research in other health behaviour interventions [53]. The application of behaviour change techniques has the potential to accelerate behaviour change science but is yet to be realized in this field. This finding underscores the need for clinicians and researchers to utilize an established behaviour change technique taxonomy—such as the BCTTv1—when designing, developing, and reporting on interventions. This will allow for an understanding of the exact nature and content of the intervention, thereby enabling future replication in research, translation into public health practice, and evidence synthesis [54].

The most common component of the included interventions is the use of education and training to increase knowledge and/or understanding of the Mediterranean diet and impart necessary skills to facilitate dietary behaviour change. Studies have shown that the use of education and training in interventions is effective for facilitating change in various lifestyle behaviours, including smoking cessation [55], physical activity [56], and nutrition [57,58]. Knowledge and understanding are key components of behaviour and, importantly, are directly linked to better diet [59]. In Australia, a lack of knowledge about the Mediterranean diet is recognized as a barrier to adoption and adherence, and it has been suggested that having more knowledge would make acceptance of the diet easier [60]. A recent study of Australian adults demonstrated that knowledge of core Mediterranean diet foods, meals, and cooking methods is lacking [61]. However, the evidence for whether education and, in turn, improved knowledge are sufficient for meaningful and sustained behaviour change is mixed [38,41]. The 'COM-B system' of behaviour details how an individual's capability, motivation, and opportunity interact to produce behaviour change [62]. Capability is defined as both the physical and psychological capacities to engage in a behaviour, which include having the required knowledge and skills [60]. The model acknowledges that knowledge alone is not enough to change behaviour, but that change is not possible without it. Indeed, improving knowledge is not inherently linked to changing behaviour [63]. Considering this model, it is likely that differences in diet adherence post-education intervention are due to

other behavioural aspects, such as motivations (e.g., addressing a specific diagnosed health disorder, reducing a future risk of illness) and opportunity (e.g., accessibility, affordability).

The findings of the review show that most interventions to date have been delivered in a direct, in-person format. While several studies utilized hybrid in-person and telehealth formats, only three studies included delivering the intervention solely using digital means. The COVID-19 pandemic forced the healthcare system to adapt and illustrated how health services can successfully be provided without the need for in-person contact [64]. Digital health technologies allow for the efficient dissemination of health programs and interventions to individuals in rural and remote regions, without access to transportation, and with limited mobility. They have been utilized in the management and treatment of a range of health conditions, including diabetes [65], obesity [66], sleep problems [67], and depression and anxiety [68]. There is also an increasing interest in the use of digital technologies for self-management and prevention, particularly where time is a significant barrier for clinicians implementing preventative healthcare [69]. Importantly, there is growing evidence to suggest that web-based nutrition education interventions can be effective for increasing awareness, improving knowledge, and improving adherence to the Mediterranean diet [70]. Not only are digital health technologies becoming more accessible—with 93% of Australian older adults having internet access in their homes in 2020—they are also highly sought after by older adults [71,72], although few have been designed specifically for this population. Those that have been applied in the older adult population have been shown to be effective at increasing physical activity [73] and promoting healthy eating behaviours [74].

Importantly, this review identified a large gap in the availability of self-directed, online interventions targeting nutrition—specifically the Mediterranean diet—for older adults. An app-based virtual health coach intervention was successful in increasing Mediterranean diet adherence and was shown to be efficacious and feasible in a sample of older adults, suggesting the utility of digital health technologies for providing education and promoting adherence to the Mediterranean diet [39]. Another study found that dietary counselling provided by a dietitian through a smartphone app led to increased adherence to the Mediterranean diet, comparable to traditional in-person counselling [27]. The Maintain Your Brain trial is a web-based multidomain intervention targeting modifiable risk factors for dementia [75]. The fully online nutrition module promotes the adoption of the Mediterranean diet and is administered to participants who report dietary intakes that do not align with the Mediterranean diet or those who have chronic disease risk factors and may benefit from dietary change. The findings from this trial are expected to be available in 2023 and are expected to provide further evidence regarding the value of digital health technologies for delivering dietary interventions and facilitating behaviour change in older adults [75].

Much of the research in the health and lifestyle space consists of developing strategies and interventions and evaluating their efficacy on clinical markers and hard endpoints. Despite the investment put into designing, developing, and testing the efficacy and internal validity of interventions, there continues to be little or no consideration of the translation of research interventions and their implementation into the general population. Participant characteristics, resource availability, competing time demands, and level of skill of those implementing the intervention are significantly different in the traditional efficacy research environment, compared to real-world settings [76]. This is significant, given that approximately 80% of older adults are living with a chronic condition, most of which require long-term therapy and permanent lifestyle behaviour change [1]. Whilst the Australian Dietary Guidelines provide evidence-based advice on eating habits to promote overall health and reduce the risk of diet-related disease, it is obvious that they are yet to be effective on a population level, given that CVD continues to be a leading cause of death in the country [77]. Current patterns of diet consumption in Australia are marked by high intakes of red meat and low intakes of fruits and vegetables, fish, and legumes, all of which are hallmark components of the Mediterranean diet [11]. Although high Mediterranean diet adherence is possible in Australia, long-term maintenance has been shown to be difficult [78]. During interventions, adherence is achieved using a range of intensive

intervention strategies, including one-on-one counselling, supply of food, written resources, and cooking classes [79]. However, this level of interaction and involvement is unlikely to be feasible for the general population, given the lack of specialist nutrition services available, particularly in rural, remote, and disadvantaged areas [80]. The RE-AIM (reach, effectiveness, adoption, implementation, maintenance) framework provides a practical means to enhance the effects of health promotion interventions by evaluating the aspects considered to be the most relevant to real-world implementation [81]. Whilst it has been applied in some settings to evaluate various health behaviour interventions [82,83], it is not routinely utilized, and only one of the studies included in this review reported the use of this framework [49]. If the goal of health promotion is to achieve equity in health, health promotion research should draw on frameworks such as RE-AIM, in conjunction with behaviour change theories and techniques, to ensure that the positive health effects of interventions can be realized by all individuals and not just those who have the resources and opportunities to engage in research [81].

This scoping review has limitations worth noting. The authors cannot exclusively say that Mediterranean diet interventions for older adults were not informed by one or more behaviour change theories; rather, publications did not report the use of the theories for intervention development. The coding of behaviour change techniques depended on reported content. In some instances, descriptions of the interventions were limited and lacked precision. It is possible that the absence of a behavioural strategy could reflect a reporting omission rather than an absence within the intervention. Every effort was made to obtain the study protocol and any additional publications arising from the study to ensure the complete collection of information. Additionally, our assumption that the reporting of education as a behaviour change strategy would involve (at minimum) information about health consequences and instructions on how to perform the behaviour may have resulted in these techniques being over-reported. The alternative, which we felt would have been unhelpful, was to miss participant education in some instances. Only one study that was included reported using the BCTTv1 when developing the intervention; therefore, all behaviour change techniques were subjectively coded. To enhance accuracy and reliability, the coder completed the online BCTTv1 training prior to coding the interventions.

5. Conclusions

This scoping review highlights that behaviour change theory is not consistently reported in Mediterranean diet interventions for older adults. Similarly, whilst some behaviour change techniques are used to facilitate behaviour change within interventions, almost 80% of the available techniques are not being utilized. Integrating behaviour change theories and techniques in the development and reporting of nutrition interventions for older adults is essential for effectively targeting behaviours and allowing future replication, translation, and synthesis.

Supplementary Materials: The following supporting information can be downloaded at https://www.mdpi.com/article/10.3390/nu15051189/s1, Table S1: PRISMA-ScR Checklist; Table S2: Characteristics of included studies; Table S3: Definitions of identified behaviour change techniques from the Behaviour Change Technique Taxonomy (version 1).

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SUPPLEMENTARY MATERIAL

Supplementary Material 2.1. PRISMA-ScR checklist

Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
TITLE			
Title	1	Identify the report as a scoping review.	1
ABSTRACT			
Structured summary	2	Provide a structured summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach.	4-5
Objectives	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives.	5-6
METHODS			
Protocol and registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.	6
Eligibility criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale.	6
Information sources*	7	Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed.	6
Search	8	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.	28
Selection of sources of evidence†	9	State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review.	6-7
Data charting process‡	10	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.	7
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.	7
Critical appraisal of individual sources of evidence§	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe the methods used and how this information was used in any data synthesis (if appropriate).	N/A

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
Synthesis of results	13	Describe the methods of handling and summarizing the data that were charted.	6
RESULTS			
Selection of sources of evidence	14	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	8, 33
Characteristics of sources of evidence	15	For each source of evidence, present characteristics for which data were charted and provide the citations.	8-11
Critical appraisal within sources of evidence	16	If done, present data on critical appraisal of included sources of evidence (see item 12).	N/A
Results of individual sources of evidence	17	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.	8-11
Synthesis of results	18	Summarize and/or present the charting results as they relate to the review questions and objectives.	8-11
DISCUSSION			
Summary of evidence	19	Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups.	11-15
Limitations	20	Discuss the limitations of the scoping review process.	15-16
Conclusions	21	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps.	16
FUNDING			
Funding	22	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.	N/A

JBI = Joanna Briggs Institute; PRISMA-ScR = Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews.

* Where *sources of evidence* (see second footnote) are compiled from, such as bibliographic databases, social media platforms, and Web sites.

† A more inclusive/heterogeneous term used to account for the different types of evidence or data sources (e.g., quantitative and/or qualitative research, expert opinion, and policy documents) that may be eligible in a scoping review as opposed to only studies. This is not to be confused with *information sources* (see first footnote).

‡ The frameworks by Arksey and O'Malley (6) and Levac and colleagues (7) and the JBI guidance (4, 5) refer to the process of data extraction in a scoping review as data charting.

§ The process of systematically examining research evidence to assess its validity, results, and relevance before using it to inform a decision. This term is used for items 12 and 19 instead of "risk of bias" (which is more applicable to systematic reviews of interventions) to include and acknowledge the various sources of evidence that may be used in a scoping review (e.g., quantitative and/or qualitative research, expert opinion, and policy document).

From: Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA Extension for Scoping Reviews (PRISMAScR): Checklist and Explanation. Ann Intern Med. 2018;169:467–473. doi: 10.7326/M18-0850.

Supplementary Material 2.2. Characteristics of included studies

Author, (year), country	Study design	Target group/sample/health condition	Study aim	Intervention duration	Longitudinal follow-up duration[a]	Sample size, retention at longest follow-up; age: mean ± SD or mean/median [range]; sex: n (%); BMI: mean ± SD or mean/median [range]	Outcome(s) and measure(s)	Intervention effect compared to baseline
Alonso-Dominiguez et al. (2019), Spain	RCT, parallel	T2D	To assess the effectiveness of a multifactorial intervention for improving adherence to the MD and diet quality among adults with T2D	3 months	9 months (12 months since baseline)	Sample size: n = 204 (Intervention n = 102, Control n = 102). Retention: Intervention 92.2%, Control 89.2%. Age: Intervention 60.8 ± 7.8, Control 60.4 ± 8.4. Sex: Intervention 52F (51.1%), Control 41F (40.2%). BMI: Intervention 29.5 ± 4.2, Control 30.3 ± 5.6.	MEDAS, weight, waist circumference, BMI, TC, LDL-c, HDL-c	Post intervention: ↑ MEDAS (p<0.001) ↑ EVOO ≥4tbsp/day (p<0.001) ↑ vegetables ≥2s/d (p<0.001) ↑ fruits ≥3s/d (p=0.004) ↑ fish/seafood ≥3s/w (p=0.018) ↑ nuts ≥3s/w (p<0.001) ↑ white meat more than red meat (p<0.001) ↑ sofrito sauce ≥2s/w (p<0.001) ↓ commercial bakery products ≤s/w (p=0.003) ↓ waist circumference (p<0.001) Follow-up: ↑ MEDAS (p<0.001)

								↑ EVOO ≥4tbsp/day (p<0.001) ↑ nuts ≥3s/w (p<0.001) ↑ white meat more than red meat (p=0.004) ↑ sofrito sauce ≥2s/w (p=0.004)
Baguley et al. (2021), Australia	RCT, parallel	Men with prostate cancer	To determine the effects of the MD on cancer-related fatigue and quality of life in men with androgen deprivation therapy treated prostate cancer	3 months	N/A	Sample size: n = 23 (Intervention n = 12, Control n = 11). Retention: Intervention 91.6%, Control 90.9%. Age: Intervention 66.6 ± 7.6, Control 65.1 ± 7.9. BMI: Intervention 27.4 ± 3.4, Control 30.6 ± 2.9.	MEDAS, dietary intake (WDI), IL-6/8, weight, body fat percentage	↑ MEDAS ↑ vegetables (p<0.001) ↑ PUFA (p=0.043) ↑ omega-3 fats (p=0.033) ↑ fibre (p<0.001) ↓ energy intake (p=0.032) ↓ processed meat s/d (p<0.001) ↓ dairy s/d (p=0.033) ↓ SFA (p<0.001) ↓ weight (p<0.001) ↓ fat mass (p=0.032) ≠ IL-6/8

Berendsen et al. (2018), multi-country (Italy, Poland, France, Netherlands, UK)	RCT, parallel	Healthy older adults	To evaluate if a personally tailored Mediterranean-like dietary pattern is effective for shifting dietary intake	12 months	N/A	Sample size: n = 1294 (Intervention n = 644, Control n = 650). Retention: 80.4% (Intervention 88.7%, Control 87.7%). Age: Intervention 70.7 ± 4.0, Control 71.1 ± 3.9. Sex: Intervention 248M (43%), Control 26M (46%). BMI: Intervention 26.7 ± 4.1, Control 26.7 ± 3.7.	Dietary intake (7DFR and NU-AGE Index)	↑ NU-AGE Index (p<0.01) ↑ wholegrains (g/day) (p<0.01) ↑ fruits (g/day) (p=0.02) ↑ vegetables (g/day) (p<0.01) ↑ legumes (g/day) (p<0.01) ↑ low-fat dairy (g/day) (p<0.01) ↑ fish (g/day) (p<0.01) ↑ nuts (g/day) (p<0.01) ↑ olive oil (g/day) (p<0.01) ↓ alcohol (g/day) (p=0.02) ↓ sodium (mg/day) (p=<0.01) ↓ sweets (g/day) (p<0.01)
Bihuniak et al. (2016), USA	Pre/post	Postmenopausal women	To assess the efficacy of a MD intervention in a group of postmenopausal women in the USA and examine the influence of a MD on cardiovascular risk factors	6 months	N/A	Sample size: n = 22. Retention: 72.7%. Age: 77 ± 6.8. BMI: 25.4 ± 2.9.	MDS, dietary intake (3DFR), TC, LDL-c, HDL-c, fatty acids	↑ MDS (p<0.001) ↑ fat (g and %E) (p<0.05) ↑ omega-3 fatty acids (g and %E) (p<0.01) ↑ omega-6 fatty acids (g and %E) (p<0.01) ↑ HDL-c (p<0.05) ↑ EPA (p<0.01) ↑ DHA (p<0.001)

								↓ %E CHO (p<0.05) ↓ sugar (g) (p<0.05) ↓ TG (p<0.001) ≠ SFA (%E and g), fibre, TC, LDL-c
Choi et al. (2019), USA	RCT, parallel	CVD	To evaluate the effectiveness of dietary counselling provided through a custom smartphone app for the implementation and compliance to a MD	3 months	3 months (6 months since baseline)	Sample size: n = 100 (Intervention n = 51, Control n = 49). Retention: 89% (Intervention 88.2%, Control 88.8%). Age: Intervention 57.2 ± 1.8, Control 56.6 ± 1.7. Sex: Intervention 22F (43.1%), Control 17F (34.7%). BMI: Intervention 29.5 ± 0.6, Control 30.8 ± 0.6.	MDS, hs-CRP, weight, BP, TC, TG, LDL-c, HDL-c	Post-intervention: ↑ MDS (p>0.05)[c] ↓ weight (p<0.05) ≠ MDS, hs-CRP, BP, TC, TG, LDL-c, HDL-c (all p>0.05) Follow-up: ↑ MDS (p<0.001)[c] ↓ weight (p=0.04) ≠ MDS, hs-CRP, BP, TC, TG, LDL-c, HDL-c (all p>0.05)
Chou et al. (2022), Taiwan	RCT, parallel	Healthy older adults	To investigate the effect of a mini-flipped, game-based MD learning program on dietary behaviour and cognitive function	8 weeks	N/A	Sample size: n = 84 (Intervention n = 43, Control n = 41). Retention: 95.2% (Intervention 95.3%, Control 95.1%). Sex: Intervention 38F (92.7%), Control 29F (74.4%). BMI: Intervention 24.35 ± 3.56, Control 23.99 ± 3.80.	MDS[h]	↑ MDS (p<0.001)

Cooper et al. (2022), Australia	Pre/post	Adults with knee osteoarthritis	To determine the feasibility of an anti-inflammatory diet intervention delivered via telehealth for patients with knee osteoarthritis	9 weeks	N/A	Sample size: n = 28. Retention: 78.6%. Age: 66 ± 8. Sex: 22F (82%). BMI: 30.6 ± 4.6.	Dietary intake(24hr recall and 3DFR)	↑ total fat (%E and g) (p<0.05) ↑ PUFA (g) (p=0.019) ↑ MUFA (g) (p=0.003) ↓ CHO (%E and g) (p<0.05) ≠ SFA, fibre, vegetables, fruit, wholegrains
Davis et al. (2017); Murphy et al. (2022), Australia	RCT, parallel	Healthy older adults	To determine how well healthy older adults in Australia can adopt the MD	6 months	12 months (18 months since baseline)	Sample size: n = 166 (Intervention n = 85, Control n = 81). Retention: Age: Intervention 71.0 ± 4.9, Control 70.9 ± 4.9. Sex: Intervention 57.5%F, Control 55.1%F. BMI: Intervention 26.7 ± 3.7, Control 27.1 ± 4.1.	MDS[d], dietary intake (3DFR), erythrocyte fatty acids	Post-intervention: ↑ MDS (p<0.01) ↑ EVOO (p<0.001) ↑ vegetables (p<0.001) ↑ fruit (p<0.001) ↑ nuts (p<0.001) ↑ legumes (p<0.001) ↑ dairy (p<0.001) ↑ fish/seafood (p<0.001) ↑ %E fat (p<0.01) ↑ %E MUFA (p<0.001) ↑ MUFA:SFA ratio (p<0.001) ↑ fibre (p<0.001) ↑ omega-3 fatty acids (p<0.001) ↑ erythrocyte MUFA (p<0.001) ↑ DHA (p=0.01) ↓ meats (p=0.03) ↓ miscellaneous (p<0.001)

								↓ %E SFA (p<0.001) ↓ %E CHO (p<0.001) ↓ sugars (p<0.01) ↓ sodium (p<0.001) ↓ erythrocyte SFA (p<0.001) Follow-up:[e] ↓ MEDAS (p<.001) ↓ legumes (p<.001) ↓ vegetables (p=0.03) ↓ breads (p<.001) ↑ alcohol (p=0.03) ↑ discretionary foods (p<.001) ↑ SFA (g/MJ/day) (p<.001)
Droste et al. (2013a); (2013b), Luxembourg	RCT, parallel	Arteriosclerosis	To assess the effect of lifestyle counselling on lipid profile in patients with arteriosclerosis	4 weeks	16 weeks (20 weeks since baseline)	Sample size: n = 122 (Intervention n = 60, Control n = 62). Retention: Intervention 88.3%, Control 88.7%. Age: Intervention 63.7 ± 8.1, Control 63.4 ± 10.6. Sex: Intervention 64%M, Control, 69%M. BMI: Intervention 27.3 ± 4.5, Control 27.8 ± 4.2.	Dietary intake (3DFR), BMI, TC, TG, LDL-c, HDL-c	Post-intervention: ↑ PUFA (g) (p<0.001) ↑ fibre (g) (p<0.001) ↑ nuts (g) (p<0.001) ↑ vegetables (g) (p<0.001) ↑ tomatoes (p<0.001)

								↓ energy intake (kcal) (p=0.026) ↓ CHO (g) (p=0.047) ↓ SFA (g) (p=0.019) ↓ BMI (p=0.025) Follow-up: ↑ PUFA (g) (p<0.001) ↑ fibre (g) (p<0.001) ↑ nuts (g) (p<0.001) ↑ vegetables (g) (p<0.001) ↑ tomatoes (p<0.001) ↓ energy intake (kcal) (p=0.049) ↓ CHO (g) (p=0.037) ↓ TC (p=0.023) ↓ LDL-c (p=0.029) ↓ LDL:HDL ratio (p=0.024) ↓ TG (p=0.036)
Entwistle et al. (2018), UK	RCT, parallel	Thoracic transplant recipients	To assess adherence in thoracic transplant recipients to a dietary intervention known to	12 months	6 weeks	Sample size: n = 41 (Intervention n = 21, Control n = 20). Retention: Intervention 95.2%, Control 95%. Age: Intervention 58 [33-65], Control 59 [27-65]. Sex: Intervention 15M (71%), Control	MDS, MDS Index[i], weight, BMI, TG	Post-intervention: ↑ MDS (p<0.001) ↑ MDS Index (p<0.05) ↓ weight (p<0.05) ↓ BMI (p<0.05) ↓ TG (p<0.05) Follow-up:

			reduce CVD risk factors			14M (70%). BMI: Intervention 29 ± 4, Control 29 ± 5.		↑ MDS (p<0.001) ↑ MDS Index (p<0.05)
Estruch et al. (2018), Spain	RCT, parallel	Adults at high cardiovascular risk	To assess the efficacy of two MDs (one supplemented with EVOO and one supplemented with nuts) on primary cardiovascular prevention	5 years	N/A	Sample size: n = 7447 (Med diet + EVOO n = 2543, Med diet + nuts n = 2454, Control n = 2450). Age: Med diet + EVOO 67.0 ± 6.2, Med diet + nuts 66.7 ± 6.1, Control 67.3 ± 6.3. Sex: Med diet + EVOO 1493F (58.7%), Med diet + nuts 1326F (54.0%), Control 1463F (59.7%). BMI: Med diet + EVOO 29.9 ± 3.7, Med diet + nuts 29.7 ± 3.8, Control 30.2 ± 4.0.	MEDAS, dietary intake (FFQ)	MD + EVOO: ↑ MEDAS (p<0.001) ↑ EVOO (p<0.001) ↑ nuts (p<0.001) ↑ legumes (p<0.001) ↑ fish/seafood (p=0.01) ↑ %E fat (p<0.001) ↑ %E SFA (p=0.004). ↑ %E MUFA (p<0.001) ↑ %E PUFA (p<0.001) ↓ energy intake (p<0.001) MD + Nuts: ↑ MEDAS (p<0.001) ↑ EVOO (p<0.001) ↑ nuts (p<0.001) ↑ legumes (p<0.001) ↑ fish/seafood (p=0.001) ↑ fibre (p<0.001) ↑ %E fat (p<0.001)

								↑ %E MUFA (p<0.001) ↑ %E PUFA (p<0.001) ↓ energy intake (p<0.001)
Grimaldi et al. (2018), Italy	Non-randomised intervention	Adults at high cardiovascular risk	To investigate the efficacy and durability of a 3-month intensive dietary intervention on body weight and metabolic risk factors	3 months	9 months	Sample size: n = 116 (Intervention n = 71, Control n = 45). Retention: Intervention 88.7%, Control 64.4%. Age: Intervention 59 ± 10, Control 56 ± 11. BMI: Intervention 32.3 ± 4.2, Control 32.6 ± 3.9.	Dietary intake (7DFR), weight, BMI, TC, HDL-c, LDL-c, TG	Post-intervention: ↑ fibre (p<0.001) ↓ SFA (g) (p<0.001) ↓ weight (p<0.001) ↓ HbA1c (p<0.001) ↓ triglycerides (p<0.01) ↓ BP (p<0.01) Follow-up: ↑ fibre (p<0.001) ↓ energy (kcal) (p<0.01) ↓ total fat (%E and g) (p<0.05) ↓ SFA (%E and g) (p<0.001) ↓ weight (p<0.001) ↓ HbA1c (p<0.001) ↓ BP (p<0.001)
Hagfors et al. (2005), Sweden	RCT, parallel	Rheumatoid arthritis	To investigate the efficacy of a MD vs ordinary Western diet for suppression of disease activity and patients	3 months	N/A	Sample size: n = 56 (Intervention n = 29, Control n = 27). Retention: Intervention 89.7%, Control 92.6%. Age: Intervention 58 [33-73], Control 59	Dietary intake (self-report diet questionnaire and diet history interview)	↑ fish/seafood (p<0.001) ↑ poultry (p<0.001) ↑ low-fat cheese (p=0.005)

			with rheumatoid arthritis			[39.75]. Sex: Intervention 5M/21F, Control 5M/20F. BMI: Intervention 28.4 [21.5-38.7], Control 25.6 [16.4-31.4].		↑ seeds (p=0.016) ↑ total serum n-3 fatty acids (p=0.001) ↓ red and processed meat (p<0.001) ↓ full fat dairy (p<0.001) ↓ sweets (p<0.001) ↓ total serum n-6 fatty acids (p=0.008) ↓ serum n-6:n-3 ratio (p=0.002)
Hardman et al. (2005), Australia	RCT, parallel	Healthy older adults	To investigate the effect of a change of diet to a MD and/or increase in walking-based exercise on cognition over 6-months	6 months	N/A	Sample size: n = 102 (Diet only n = 25, Diet and exercise n = 24, Control n = 27). Retention: Intervention 72%, Diet and exercise 75%, Control 92.6%. Age: Diet only 77.68 ± 7.38, Diet and exercise 76.54 ± 7.37, Control 78.22 ± 5.81. Sex; Diet only 20F, Diet and exercise 17F, Control 18F. BMI: Diet only 28.26 ± 5.37, Diet and exercise 26.64 ± 3.39, Control 29.01 ± 4.90.	MDS[j], dietary intake (FFQ), TC, hs-CRP, BP, HbA1c	Diet only: ≠ MDS, BP, TC, hs-CRP, HbA1c Diet + exercise: ≠ MDS, BP, TC, hs-CRP, HbA1c
Katsarou et al. (2014), Greece	RCT, parallel	Hypertension	To examine the effect and feasibility of a combined	2 months	N/A	Sample size: n = 45 (Intervention n = 21, Control = 24). Retention: Intervention	MDS[k], BP, BMI	≠ MDS, BP, BMI (all p>0.05)

			intervention of dietary education and stress management on the control of hypertension			76.2%, Control 83.3%. Age: Intervention 61.1 ± 10.9, Control 68.9 ± 10.7. Sex: Intervention 43.8%M, Control 35%M. BMI: Intervention 29.08 ± 4.30, Control 29.48 ± 4.41.		
Keyserling et al. (2016), USA	Pre/post	Healthy older adults	To develop and evaluate a dietary, physical activity and weight loss intervention for residents of south-eastern USA	6 months	N/A	Sample size: n = 339. Retention: 74%. Age: 56 ± 0.6. Sex: 260F (77%). BMI: 36 ± 0.5.	Dietary intake (DRA[l], FVS[m], DFQA[n]), weight, BP	↑ DRA (p<0.001) ↑ FV screener (p<0.01) ↑ DFQA (p<0.001) ↓ weight (p<0.01) ↓ BP (p<0.001)
Landaetea-Diaz et al. (2012), Spain	RCT, parallel	Adults with MetS	To investigate how the different dimensions of health-related quality of life evolved in metabolic syndrome patients after following a hypocaloric MD	3 months	N/A	Sample size: n = 45 (Diet only n = 24, Diet and exercise n = 21). Retention: Intervention 83.3%, Control 95.2%. Age: Diet only 57.2 ± 0.98, Diet and exercise 59.05 ± 1.22. Sex: Diet only 15F (62.5%), Diet and exercise 13F (61.9%). BMI: Diet only 38.44 ± 1.46, Diet and exercise 37.05 ± 0.72.	MEDAS, dietary intake (3DFR)	Diet only: ↑ MEDAS (p<0.05) ↑ MUFA (%E) (p<0.05) ↓ energy (kcal) (p<0.05) ↓ total fat (%E) (p<0.05) ↓ SFA (%E) (p<0.05) ↓ weight (p<0.05) ↓ BP (p<0.05) ↓ total cholesterol (p<0.05) Diet + exercise: ↑ MEDAS (p<0.05)

								↑ MUFA (%E) (p<0.05) ↓ energy (kcal) (p<0.05) ↓ total fat (%E) (p<0.05) ↓ SFA (%E) (p<0.05) ↓ BP (p<0.05) ↓ total cholesterol (p<0.05)
Maher et al. (2020), Australia	Pre/post	Healthy older adults	To assess the preliminary effect of a virtual health coach for improving physical activity, MD adherence and health risk factors	3 months	N/A	Sample size: n = 31. Retention: 90.3%. Age: 56.2 ± 8.0. Sex: 18F (64.3%).	MEDAS, weight, BP	↑ MEDAS (p<0.001) ↓ weight (p=0.01) ↓ waist circumference (p=0.003) ≠ BP
Marcos-Forniol et al. (2018), Spain	RCT, parallel	ACS	To evaluate the efficacy of a secondary CHD prevention programme on risk factor control, adherence to a MD, quality of life, physical function, readmission and mortality in elderly patients with a recent coronary event	12 months	N/A	Sample size: n = 127 (Intervention n = 64, Control n = 63). Retention: Intervention 84.4%, Control 82.5%. Age: Intervention 76 [74.1-79.2], Control 75.4 [73.7-78.9]. Sex Intervention 17F (31.5%), Control 25F (48.1%).	MDS[j], dietary intake (FFQ), BMI, BP, LDL-c, HbA1c	↑ MDS (p=0.013) ↓ BP (p<0.05) ↓ LDL-c (p<0.05) ↓ HbA1c (p<0.05) ≠ BMI (p>0.05)

Martinez-Rodriguez et al. (2021), Spain	RCT, parallel	Healthy older women	To evaluate the effect of the addition of aquatic resistance interval training to a nutritional intervention on body composition, body image perception and adherence to the MD	14 weeks	N/A	Sample size: n = 40 (Intervention n = 20, Control n = 20). Retention: 85%. Age: Intervention 69.6 ± 5.0, Control 67.7 ± 3.6. BMI: Intervention 28.8 ± 4.7, Control 28.2 ± 4.2.	MEDAS	≠ MEDAS (p>0.05)
Masumi et al. (2022), Iran	RCT, parallel	Healthy older adults	To examine the effectiveness of small group education on nutritional knowledge and attitudes towards the MD	4 weeks	N/A	Sample size: n = 100 (Intervention n = 50, Control n = 50). Retention: 91% (Intervention 92%, Control 90%). Age: Intervention 63.1 ± 3.7, Control 62.3 ± 3.9.	MEDAS[g], BMI and BP	↑ MEDAS (p<0.001) ≠ BMI, BP
Mayr et al. (2019), Australia	RCT, parallel	CHD	To evaluate the efficacy of a 6-month MD intervention in reducing the incidence of secondary CVD events compared with patients on a low-fat diet	6 months	6 months (12 months since baseline)	Sample size: n = 73 (Intervention n = 37, Control n = 36). Retention: Intervention 73.0%, Control 80.6%. Age: Intervention 61.8 ± 9.2, Control 61.8 ± 9.5. Sex: Intervention 27M (79.4%), Control 27M (87.1%). BMI: Intervention 30.7 ± 5, Control 29.1 ± 5.3.	MEDAS, dietary intake (7DFR)	Post-intervention: ↑ MEDAS (p<0.001) ↑ vegetable, tomato (p<0.05)) ↑ yoghurt (p<0.05)) ↑ nuts (p<0.05) ↑ legumes (p<0.05) ↑ seafood (p<0.05) ↑ unsaturated oils (p<0.05) ↑ olive oil (p<0.05)

								↑ MUFA (%E) (p<0.05) ↑ PUFA (%E) (p<0.05) ↑ n-3 (g) (p<0.05) ↓ processed meat (p<0.05) ↓ CHO (%E) (p<0.05) Follow-up:[e] ↓ MEDAS (p=0.01)
McGrattan et al. (2021) Ireland	RCT, parallel	MCI	To evaluate the feasibility, acceptability and implementation of the THINK-MED intervention among older adults with cognitive impairment	6 months	6 months (12 months since baseline)	Sample size: n = 15 (THINK-MED baseline n = 5, THINK-MED staged n = 4, Control n = 6). Retention (post-intervention): 60% (THINK-MED baseline 60%, THINK-MED staged 75%, Control 50%); (12-month follow-up): 40% (THINK-MED baseline 60%, THINK-MED staged 25%, Control 33%). Age: THINK-MED staged 73.7 ± 12.1, THINK-MED baseline 79.2 ± 5.0, Control 75.7 ± 6.0. Sex: THINK-MED staged 3M (20.0%), THINK-MED baseline 4M (26.7%), Control	MDS	THINK-MED staged:[c,f] ↑ MDS THINK-MED baseline:[c,f] ↑ MDS

						2M (13.3%). BMI: THINK-MED staged 28.6 ± 4.8, THINK-MED baseline 26.0 ± 3.2, Control 29.1 ± 4.1.		
Michaelsen et al. (2006), Germany	RCT, parallel	CAD	To investigate the effect of a MD on markers of inflammation and metabolic risk factors in patients with treated CAD	12 months	N/A	Sample size: n = 105 (Intervention n = 51, Control n = 54. Retention: Intervention 94.1%, Control 98.1%. Age: Intervention 59.0 ± 8.7, Control 59.8 ± 8.6. Sex: Intervention 79.2%M, Control 75.5%M. BMI: Intervention 26.1 ± 3.2, Control 27 ± 2.8.	Dietary intake (7DFR), plasma fatty acids, hs-CRP, TC, LDL-c, HDL-c, TG, fasting insulin, BMI	↑ fruits (p=0.038) ↑ low-fat dairy products (p<0.010) ↑ wholegrain bread/pasta (p<0.010) ↑ fish (p<0.010) ↑ walnuts (p<0.010) ↑ EPA (p=0.026) ↑ DHA (p=0.022) ↓ meat/sausages (p<0.010) ↓ %E CHO (p=0.034) ↓ %E total fat (p=0.011) ↓ %E SFA (p<0.001) ↓ %E MUFA (p=0.024) ≠ vegetables (p=0.067) ≠ cakes/sweets (p=0.646) ≠ fibre (p=0.399) ≠ BMI, hs-CRP, TC, LDL-c, HDL-c, TG, fasting insulin (all p>0.05)

Quintana-Navarro et al. (2020), Spain	RCT, parallel	CAD	To investigate the dietary changes and assess both the level of adherence and long-term maintenance following a MD versus a low-fat diet	5 years	N/A	Sample size: n = 1002 (Intervention n = 502, Control n = 500. Retention: Intervention 89%, Control 81.2%. Age: Intervention 59.7 ± 0.4, Control 59.5 ± 0.4. Sex: Intervention 414M (82.5%), Control 413M (82.6%). BMI: Intervention 31.0 ± 0.1, Control 31.2 ± 0.2.	MEDAS, dietary intake (FFQ)	↑ MEDAS ($p<0.001$) ↑ %E EVOO ($p<0.05$) ↑ %E fish/seafood ($p<0.05$) ↑ %E nuts ($p<0.05$) ↓ %E red/processed meat ($p<0.05$) ↓ %E cereals ($p<0.05$) ↓ %E commercial bakery products ($p<0.05$) ↓ %E dairy products ($p<0.05$) ↓ %E seed oils ($p<0.05$) ≠ %E vegetables, fruits, legumes, sweet/carbonated drinks (all $p>0.05$)
Rusch et al. (2021), USA	Pre/post	Parkinson's disease	To determine whether adhering to the MD is feasible and induces beneficial changes in gastrointestinal function, intestinal permeability	5 weeks	N/A	Sample size: n = 8. Retention: 100%. Age: 71.4 ± 2.6. Sex: 5M (63%). BMI: 26.7 ± 1.4.	MEDAS, dietary intake (24hr recall)	↑ MEDAS ($p<0.001$) ↑ fibre ($p=0.027$) ↑ fat (g and %E) ($p<0.05$) ↑ MUFA (g and %E) ($p<0.05$) ↑ PUFA (%E) ($p=0.009$) ↓ CHO (%E) ($p=0.036$)

			and faecal microbial communities in individuals with Parkinson's disease					
Salas-Salvado et al. (2019), Spain	RCT, parallel	Overweight/obese adults with MetS	To evaluate the effect of an intensive weight loss intervention based on an energy-restricted MD, physical activity and behaviour support on hard cardiovascular events compared to usual care	12 months	N/A	Sample size: n = 698 (Intervention n = 361, Control n = 337). Retention: Intervention 88.1%, Control 86.6%. Age: Intervention 66 ± 5, Control 65 ± 5. Sex: Intervention 148M (45%), Control 141M (47%). BMI: Intervention 32.3 ± 3.4, Control 32.6 ± 3.6.	Dietary intake (MD questionnaire and FFQ)	↑ MD questionnaire ($p<0.001$) ↑ MUFA (%E) ($p<0.001$) ↑ nuts (g/day) ($p=0.05$) ↑ wholegrain cereals ($p=0.01$) ↓ refined cereals ($p<0.001$)
Schwartz et al. (2019), USA	RCT, parallel	Cognitive decline (mild dementia, MCI, SCD)	To investigate the efficacy of a behaviour health coaching intervention to increase adherence to behaviours associated with brain health and improve quality of life in patients at risk for cognitive decline	6 months	N/A	Sample size: n = 40 (Intervention n = 21, Control n = 19). Retention: 92.5%. Age: Intervention 74.7 ± 10.4, Control 74.3 ± 8.0. Sex: Intervention 10M/9F, Control 6M/12F. BMI: Not described.	MedScore (calculated from FFQ)	↑ MedScore ($p=0.016$)
Toobert et al. (2005), USA	RCT, parallel	Postmenopausal women with T2D	To evaluate the effects of a Mediterranean	6 months	N/A	Sample size: n = 279 (Intervention n = 163, Control n = 116).	Dietary intake	↑ fruit ($p<0.001$) ↑ vegetables ($p<0.001$)

			lifestyle program versus usual care on behaviour risk factors for CHD in women with T2D			Retention: 88%. Age: Intervention 61.1 ± 8.0, Control 60.7 ± 7.8. BMI: Intervention 35.1 ± 7.7, Control 35.6 ± 8.8.	(FFQ), weight	↓ total fat (p<0.001) ↓ SFA (p<0.001) ↓ weight (p=0.004)
Tuttle et al. (2008), USA	RCT, parallel	MI	To compare a low-fat versus MD on cardiovascular events and survival after first MI	2 years	N/A	Sample size: n = 101 (Intervention n = 51, Control n = 50). Retention: Intervention 72.5%, Control 72%.Age: Intervention 58 ± 10, Control 57 ± 10. Sex: Intervention 41M (80%), Control 75M (74%). BMI: Intervention 30 ± 5, Control 29 ± 6.	Dietary intake (3DFR), hs-CRP, weight, BMI, BP, TG, LDL-c, HDL-c, glucose, insulin	↑ omega-3 fats (p<0.001).
Zuniga et al. (2019), USA	RCT, parallel	Breast cancer survivors	To improve adherence to an anti-inflammatory dietary pattern in breast cancer survivors	6 months	N/A	Sample size: n = 153 (Intervention n = 76, Control n = 77). Retention: Intervention 78.9%, Control 84.4%). Age: Intervention 55.3 ± 10.3, Control 58.4 ± 8.2. BMI: Intervention 31.2 ± 4.1, Control 32.7 ± 5.2.	MEDAS, dietary intake (3DFR)	↑ MEDAS (p<0.001) ↓ energy intake (p=0.045) ≠ %E fat, %E SFA, fibre, fruit, vegetables

[a]Time since end of intervention. [b] If no control group, compared to baseline. [c] Compared to baseline. [d] Dietary outcomes are assessed at 4 months. [e] Compared to post-intervention. [f] Study was under-powered and did not test for significance. [g] MEDAS (question on wine intake removed, scores ranging from 0-13). [h] MDS (Chinese version, scores ranging from 0-17). [i] MDS Index (scores from the MDS were rescaled to range from 0-100 to reflect percentage of score achieved). [j] MDS (scores ranging from 0-9). [k] MDS (scores ranging from 0-55). [l] DRA (scores ranging from 0-52, higher scores indicate higher diet quality). [m] FVS (scores rangings from 0-35, higher scores indicate greater intake from fruit/vegetables). [n] DFQA (scores ranging from 0-24, higher scores indicate greater healthful fat intake).

↑ or ↓ indicates the intervention significantly improved outcomes compared to control and ≠ indicates no significant difference between intervention and control groups.

Abbreviations: %E, percentage of energy; 3DFR, 3-day food record; 7DFR, 7-day food record; ACS, acute coronary syndrome; BMI, body mass index; BP, blood pressure; CAD, coronary artery disease; CHD, coronary heart disease; CHO, carbohydrates; CRF, chronic renal failure; DFQA, dietary fat quality assessment; DHA, docosahexaenoic acid; DRA, dietary risk assessment; EPA, eicosapentaenoic acid; EVOO, extra virgin olive oil; FFQ, food frequency questionnaire; FVS, fruit and vegetable screener; HDL-c, high-density lipoprotein cholesterol; hs-CRP, high sensitivity c-reactive protein; IL, interleukin; LDL-c, low-density lipoprotein cholesterol; MCI, mild cognitive impairment; MD, Mediterranean diet; MDS, Mediterranean Diet Score; MEDAS, MEditerranean Diet Adherence Screener; MetS, metabolic syndrome; MI, myocardial infarction; MUFA, monounsaturated fat; PUFA, polyunsaturated fat; RCT, randomised controlled trial; s/d, servings per day; s/w, servings per week; SCD, subjective cognitive decline; SFA, saturated fat; T2D, type 2 diabetes; TC, total cholesterol; TG, triglycerides; UK, United Kingdom; USA, United States of America; WDI, Wollongong Dietary Inventory.

Supplementary Material 2.3. Definitions of identified behaviour change techniques from the Behaviour Change Technique Taxonomy (version 1) *

Label	Definition
1. Goals and planning	
1.1 Goal setting (behaviour)	Set or agree on a goal defined in terms of the behaviour to be achieved
1.2 Problem solving	Analyse or prompt the person to analyse, factors influencing the behaviour and generate or select strategies that include overcoming barriers and/or increasing facilitators
1.3 Goal setting (outcome)	Set or agree on a goal defined in terms of a positive outcome of wanted behaviour
1.5 Review behaviour goal(s)	Review behaviour goal(s) jointly with the person and consider modifying goal(s) or behaviour change strategy in light of achievement. This may lead to re-setting the same goal, a small change in that goal or setting a new goal instead of (or in addition to) the first, or no change
1.6 Discrepancy between current behaviour and goal	Draw attention to discrepancies between a person's current behaviour (in terms of the form, frequency, duration, or intensity of that behaviour) and the person's previously set outcome goals, behavioural goals or action plans (goes beyond self-monitoring of behaviour)
1.7 Review outcome goal(s)	Review outcome goal(s) jointly with the person and consider modifying goal(s) in light of achievement. This may lead to resetting the same goal, a small change in that goal or setting a new goal instead of, or in addition to the first
1.8 Behavioural contract	Create a written specification of the behaviour to be performed, agreed on by the person, and witnessed by another
2. Feedback and monitoring	

2.2 Feedback on behaviour	Monitor and provide informative or evaluative feedback on performance of the behaviour
2.3 Self-monitoring of behaviour	Establish a method for the person to monitor and record their behaviour(s) as part of a behaviour change strategy
2.4 Self-monitoring of outcome(s) of behaviour	Establish a method for the person to monitor and record the outcome(s) of their behaviour as part of a behaviour change strategy
3. Social support	
3.1 Social support (unspecified)	Advise on, arrange or provide social support (e.g. from friends, relatives, colleagues,' buddies' or staff) or noncontingent praise or reward for performance of the behaviour. It includes encouragement and counselling, but only when it is directed at the behaviour
4. Shaping knowledge	
4.1 Instruction on how to perform the behaviour	Advise or agree on how to perform the behaviour
5. Natural consequences	
5.1 Information about health consequences	Provide information (e.g. written, verbal, visual) about health consequences of performing the behaviour
6. Comparison of behaviour	
6.1 Demonstration of the behaviour	Provide an observable sample of the performance of the behaviour, directly in person or indirectly e.g. via film, pictures, for the person to aspire to or imitate
8. Repetition and substitution	

8.1 Behavioural practice/rehearsal	Prompt practice or rehearsal of the performance of the behaviour one or more times in a context or at a time when the performance may not be necessary, in order to increase habit and skill
9. Comparison of outcomes	
9.1 Credible source	Present verbal or visual communication from a credible source in favour of or against the behaviour
10. Reward and threat	
10.1 Material incentive (behaviour)	Inform that money, vouchers or other valued objects will be delivered if and only if there has been effort and/or progress in performing the behaviour
10.3 Non-specific reward	Arrange delivery of a reward if and only if there has been effort and/or progress in performing the behaviour
12. Antecedents	
12.5 Adding objects to the environment	Add objects to the environment in order to facilitate performance of the behaviour

***** For the full Behaviour change technique taxonomy refer to the publication *"The Behavior Change Technique Taxonomy (v1) of 93 Hierarchically Clustered Techniques: Building an International Consensus for the Reporting of Behavior Change Interventions"* by Michie et al (2013).

CHAPTER THREE

INVESTIGATING THE MEDITERRANEAN DIET KNOWLEDGE OF OLDER ADULTS IN AUSTRALIA

Preface

While there are many determinants of dietary intake, the knowledge-attitude-behaviour model explains how health behaviours follow a process of three stages: acquiring knowledge, developing attitudes or beliefs, and forming behaviours. Although knowledge is not the only predictor of behaviour change, it is a critical first step in building capacity for change. As such, understanding the level of nutrition knowledge specific to the Mediterranean diet is essential for developing targeted education programs aimed at improving knowledge and supporting healthy eating habits among older adults.

The aim of this study was to investigate Mediterranean diet knowledge, attitudes and behaviours of community-dwelling older adults in Australia.

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ORIGINAL PAPER

Knowledge, Attitudes, and Behaviours Concerning the Mediterranean Diet Among Older Adults in Australia

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Abstract
Despite the growing body of evidence demonstrating the positive health effects of the Mediterranean diet, it is not routinely recommended in practice and adherence is low in the general population in Australia. The knowledge-attitude-behaviour model explains how health behaviours are supported through a process of acquiring knowledge, developing attitudes, and forming behaviours. Evidence has suggested that having a high level of nutrition-related knowledge is associated with more positive attitudes, which is directly linked to positive dietary behaviours. However, reports of knowledge and attitudes towards the Mediterranean diet, and how these directly relate to behaviours in older adults, are lacking. This study explored Mediterranean diet-related knowledge, attitudes, and behaviours among community-dwelling older adults in Australia. Participants were adults aged 55 years and older who completed an online survey that contained three parts: (a) knowledge – Mediterranean Diet Nutrition Knowledge Questionnaire (Med-NKQ); (b) nutrition-related attitudes and behaviours, and barriers and enablers to dietary change; (c) demographics. The sample included 61 adults who ranged in age from 55 to 89 years. The overall knowledge score was 30.5 out of a possible 40 points, with 60.7% classified as having a high level of knowledge. Knowledge was lowest for nutrient content and label reading. Attitudes and behaviours were generally positive and were not associated with level of knowledge. The most common barriers to dietary change were perceived cost and lack of knowledge, and motivational factors. There are a number of key gaps in knowledge that should be addressed through targeted educational programs. Strategies and tools to overcome perceived barriers and improve self-efficacy are needed to facilitate positive dietary behaviours.

Keywords Mediterranean diet · Knowledge · Attitudes · Behaviours · Older adults

Introduction

As the global population continues to grow, supporting the health and well-being of older adults is critical to ensure that they can continue to actively participate in society. Although there have been clear improvements in overall health along with increasing life expectancy, non-communicable chronic conditions continue to be the leading cause of disease burden and disability in older adults worldwide [1]. Poor diet quality is a major modifiable risk factor for many of these

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conditions, including cardiovascular disease (CVD) and type 2 diabetes [2], and contributes to approximately 5% of the total disease burden in Australia [3]. Specifically, diets low in legumes, wholegrains, fruits, and vegetables, and high in sodium, added sugar, alcohol, and red and processed meats, are responsible for much of this burden. Poor diet quality is common in older adults, with less than 8% meeting daily recommendations for fruit and vegetable intake [4]. Discretionary food intake is also high, accounting for approximately 33% of daily energy intake, with alcoholic beverages forming the largest source of energy from discretionary foods (approximately 7%) [5].

The Mediterranean diet is a dietary pattern that is rich in plant foods (e.g., wholegrains and cereals, fruits, vegetables, legumes, nuts, and seeds) with extra virgin olive oil as the primary source of fat, along with moderate intake of fish and seafood, poultry, eggs, dairy, and alcohol in the form of red wine; and low intake of red meat and processed foods high in saturated fat and sugar [6]. This pattern of eating is high in nutrients and dietary fibre, rich in antioxidant compounds and bioactive elements with anti-inflammatory properties, and is associated with nutritional adequacy in adult populations [7]. Because of these factors, there is extensive evidence to suggest a role for the Mediterranean diet in general healthy ageing, as well as in reducing CVD-related events, type 2 diabetes incidence, and overall mortality [2]. It has also been linked to benefits in cognition and dementia risk, and improvements in overall mood and symptoms of depression [8, 9]. Despite this growing body of evidence, the Mediterranean diet is not routinely used in practice for chronic disease management [10]. While adherence has been shown to be feasible and acceptable for adults in non-Mediterranean countries [11], adoption of the Mediterranean diet in the general population is low [12].

Behavioural change is complex, and a thorough understanding of the personal factors that underpin an individual's dietary habits is vital when attempting to adopt a new dietary pattern. The knowledge-attitude-behaviour model explains how individual health behaviours follow a process of three stages: acquiring knowledge, developing attitudes or beliefs, and forming behaviours [13]. Alongside other influences of food choice, such as the broader social environment, food availability and affordability, taste preferences, and traditional cultural practices [14], knowledge and understanding can directly shape attitudes or beliefs, and together they influence behaviour. Indeed, studies have shown that knowledge of health-related behaviours is directly related to attitudes and practices in health management [15]. Nutrition knowledge covers a range of topics, including identifying food sources for particular nutrients, daily recommendations for food groups and nutrients, and understanding how diet is implicated in the maintenance of health and chronic diseases [16]. Overall, general nutrition knowledge tends to be poor among older adults, particularly compared to young and middle-aged adults [17, 18]. Having a high level of nutrition-related knowledge and more positive attitudes towards healthy eating is directly linked to positive dietary behaviours, including liking fruits and vegetables and proactively looking for nutrition information [19]. Although knowledge alone is not enough to produce behavioural change, it is critical for building the capability to change [20]. Assessing and analysing people's nutrition-related knowledge, attitudes, and behaviours is a valuable method for gaining insight into the personal determinants of dietary intake and is an essential step for informing effective behaviour change interventions and evaluating nutrition education programs. Considering the role of diet, specifically the Mediterranean diet, in healthy ageing and chronic disease management, an in-depth understanding of older adults' knowledge, attitudes, and behaviours in relation to the Mediterranean diet is needed. However, reports of knowledge and attitudes towards the Mediterranean diet and how these are directly related to behaviours are lacking. Thus, this study explored Mediterranean diet-related knowledge, attitudes, and behaviours among community-dwelling older adults in Australia.

Methods

Participants

A cross-sectional survey was conducted with 61 Australian adults aged ≥ 55 years. Participants were recruited via Twitter and the JoinUs Research Register, from October 2021 to June 2022, requesting voluntary participation. Qualtrics^{XM} survey software was used to construct and host the surveys. A link to the survey was disseminated via the recruitment methods described above, and included study requirements and possible risks for potential participants. Exclusion criteria included individuals < 55 years of age, non-residents of Australia, or those unable to complete the survey in English.

Data Collection

Mediterranean diet knowledge, attitudes, and behaviours were assessed using a 41-item self-administered online questionnaire designed to be completed in approximately 15 minutes. No time restrictions were applied to complete the questionnaire, and the participants were required to answer every question in each part of the survey before proceeding to subsequent questions. The online questionnaire was divided into three parts:

Part A consisted of the knowledge component of the questionnaire, which was assessed using the Mediterranean Diet Nutrition Knowledge Questionnaire (Med-NKQ) [21]. The Med-NKQ is a 20-item tool that has been validated to assess knowledge of the Mediterranean diet in an Australian population [21]. The questionnaire assessed three major domains: (a) dietary patterns, foods, and nutrients to reduce cardiac risk factors (four questions); (b) nutrient content of foods, quantification, and food label reading (seven questions); and (c) core Mediterranean diet foods, dietary patterns, and meal selection (nine questions). Scores were calculated for overall knowledge and for each of the three domains, with higher scores indicating greater knowledge (see Table 1 for a summary of scoring). The Med-NKQ is shown in Supplementary Material 1.

Part B assessed participants' attitudes and behaviours towards the Mediterranean diet, as well as barriers and facilitators to changing their habitual diet. Attitudes were assessed via three statements related to everyday diet and food choices and scored on a 7-point Likert scale (response options ranging from 'strongly disagree' to 'strongly agree') [22]. These questions have been previously used to measure nutrition-related attitudes in older adults [22]. The three statements were as follows: (1) The healthiness of food has little impact on my food choices; (2) It is important for me that my daily diet contains a lot of vitamins and minerals; and (3) I eat what I like and do not worry much about the healthiness of food. Two of the three statements had an inverse response scale and were recoded accordingly. The total attitude score was calculated by summing the three items (ranging from to 3–21 with higher scores indicating a more positive attitude towards healthy foods and diet). Behaviours were assessed using four questions. The questions were developed and adapted from previous surveys [19, 23, 24]. Part B of the survey is provided in Supplementary Material 2.

Part C consisted of open- and closed-ended questions related to the participants' demographic characteristics, including age, sex, level of education, country of birth, language spoken at home, diagnosed health conditions, height, and weight.

Data Analysis

Data were analysed using Statistical Package for the Social Sciences (SPSS, Version 28). Descriptive data are expressed as means ± standard deviations for continuous data and as frequencies and percentages for categorical data. Total and individual domain knowledge scores were dichotomised as high knowledge and low knowledge, and the total attitude score was dichotomised as positive and negative using the median split method [25]. This choice was made because of the (1) asymmetrical distribution of the raw scores and (2) infrequent occurrence of extremely low values. Behaviours were dichotomised as positive or negative. Associations between nutritional knowledge, attitudes, and sociodemographic variables were examined using non-parametric and Fisher's exact tests. A p-value of < 0.05 was used to determine significance (two-tailed).

Results

Participant Characteristics

Of the 92 participants who agreed to complete the online survey, 31 either did not answer all the questions or did not complete the survey to the end. Therefore, 61 participants provided valid responses and were included in the analysis. The median time to complete the survey was 12 minutes (interquartile range [IQR]: 8.7–15.5).

A summary of participants' demographic characteristics is presented in Table 2. Participants ranged in age from to 55–89 years (63.7 ± 8.1). Among the participants, 73.8% ($n = 45$) were female, 70.5% ($n = 43$) had completed some form of tertiary-level education, 67.2% ($n = 47$) were born in Australia, and 75.4% ($n = 46$) lived in metropolitan areas.

Mediterranean Diet Knowledge

As shown in Table 1, out of a possible 40 points on the Med-NKQ, the mean ± standard deviation (SD) and median score (IQR) for the whole sample was 30.5 ± 5.0 and 31 (IQR: 28–34), respectively. The total scores ranged from 17 to 40. More than half of the participants had high total knowledge ($n = 37$, 60.7%), whereas almost 40% had low overall knowledge ($n = 24$, 39.3%). Sex, level of education (tertiary

Table 1 Summary of the Med-NKQ Scores (n = 61)

Domains	Related questions	Score range	Mean score	SD	Median	IQR
CVD risk factors	1, 2, 4, 5	0–10	8.4	1.6	9	8–9
Nutrient content of foods, quantification, and label reading	3, 6, 7, 8, 9, 19, 20	0–15	10.0	2.8	10	9–12
Core MD foods, patterns, and meal selection	10, 11, 12, 13, 14, 15, 16, 17, 18	0–15	12.2	2.4	13	10.5–14
Total		0–40	30.5	5.0	31	28–34

Abbreviations: CVD, cardiovascular disease; MD, Mediterranean diet; SD, standard deviation; IQR, interquartile range

Table 2 *Demographic Characteristics of Study Participants (n = 61)*

Continuous variables	Mean	SD
Age, years	63.7	8.1
Body mass index, kg/m^2	25.4	5.0
Categorical variables	n	%
Sex		
- Male	16	26.2
- Female	45	73.8
Education level		
- Postgraduate	31	50.8
- Bachelors	12	19.7
- Advanced certificate/diploma	15	24.6
- Secondary (Year 7–12)	3	4.9
Country of birth		
- Australia	41	67.2
- United Kingdom	12	19.7
- New Zealand	1	1.6
- Other*	7	11.5
Language spoken at home		
- English only	57	93.4
- Other†	4	6.6
State		
- New South Wales	39	63.9
- Queensland	10	16.4
- Victoria	4	6.6
- South Australia	4	6.6
- Western Australia	3	4.9
Diagnosed health condition, % yes	41	67.2
- Cancer	6	9.8
- Diabetes	3	4.9
- Heart disease	8	13.1
- Hypertension	4	6.6
- Kidney disease	1	1.6
- Lung condition	2	3.3
- Mental health condition	11	18.0
- Stroke	2	3.3
- Other‡	19	31.1
Main grocery shopper		
- Yes	34	55.7
- No	4	6.6
- I share the responsibility	23	37.7

Abbreviations: SD, standard deviation

* Includes India, the USA, Hong Kong, Papua New Guinea, and Nigeria. † Includes Cantonese, French, Danish, and Estonian. ‡ Includes hypercholesterolemia, osteoarthritis, Hashimoto's disease, diverticulitis, fibromyalgia, and osteoporosis

vs. non-tertiary), and area classification (metropolitan vs. rural) did not differ between the two groups (all $p > 0.05$). There was also no difference between the groups in terms of age ($U = 429.50$, $p = 0.830$) or body mass index (BMI) ($U = 335.00$, $p = 0.190$).

Domain 1 – Dietary Patterns, Foods, and Nutrients for Reducing Cardiac Risk Factors

Of the possible 10 points, the mean ± SD and median (IQR) scores were 8.4 ± 1.6 and 9 (IQR: 8–9), respectively. Scores ranged from 1 to 10. Thirty-six participants were classified as having high knowledge (59.0%) and 25 were classified as having low knowledge (41.0%). There were no differences between the groups in terms of sex, level of education, area classification, age, or BMI (all $p > 0.05$).

Thirteen participants (21.3%) scored full points in this domain. There were two questions within this domain where 75% or more of the participants scored full points (questions 4 and 5). These questions covered general nutritional facts and foods that increase blood cholesterol levels. On a question asking for correct statements about foods for lowering blood cholesterol, less than 50% of respondents scored full points (question 1), with 21 participants (34.4%) incorrectly identifying reducing salt consumption as a strategy to reduce cholesterol.

Domain 2 – Nutrient Content of Foods, Quantification, and Food Label Reading

Out of a possible 15 points, the mean ± SD and median (IQR) scores were 10.0 ± 2.8 and 10 (IQR: 9–12), respectively. Scores ranged from 2 to 15. Thirty-nine participants (63.9%) had higher knowledge than 22 (36.1%) with low knowledge. Those who had a high level of knowledge in this domain were more likely to be younger (*mean age* = 62.05, *SD* = 7.59) than those classified as having low knowledge (*mean age* = 66.68, *SD* = 8.33, $U = 277.50$, $p = 0.023$). There were no differences between the groups in terms of sex, level of education, area classification, or BMI (all $p > 0.05$).

Only two participants (3.3%) scored full points in this domain. There were two questions within this domain where 75% or more of the respondents scored full points (Questions 7 and 19). These questions covered foods with good sources of fibre and the ability to accurately read nutrition information panels to identify the product with the highest amount of salt. There were two questions in which less than 50% of the sample scored full points (questions 8 and 9), both of which were pictorial. Question 8 asked participants to correctly identify foods that were high in salt. Although 59 respondents (96.7%) correctly identified deli ham as being high in salt, more than half (n = 32, 54.2%) were unable to correctly identify smoked salmon as being high in salt, resulting in a loss of points. Question 9 asked participants to select the alcoholic beverage with the lowest number of standard drinks (200mL red wine vs. 375mL full-strength beer vs. 60mL dark spirit); more than half of the participants (57.4%) were unable to do so. Regarding the

questions related to label reading of packaged foods, 85.2% of participants were able to correctly identify the product with the highest amount of salt. However, only 54.1% of the participants were able to correctly identify the product that was better for heart health based on the nutrition information panel.

Domain 3 – Core Mediterranean Diet Foods, Dietary Patterns, and Meal Selection

Of the possible 15 points, the mean ± standard deviation and median (IQR) scores were 12.2 ± 2.4 and 13 (IQR: 10.5–14), respectively. The scores ranged from 4 to 15. Thirty-one participants were classified as having high knowledge (50.8%) and 30 as having low knowledge (49.2%). Those classified as having high knowledge in this domain were more likely to have a significantly lower BMI (*mean BMI* = 23.33, *SD* = 5.43) than those with a low level of knowledge (*mean BMI* = 27.33, SD = 3.55, $U = 238.00$, $p = 0.003$). The groups did not differ in terms of sex, education level, area classification, or age (all $p > 0.05$).

Ten participants (16.4%) scored full points in this domain. There were three questions within this domain where 75% or more of the participants scored full points (questions 10, 13, and 18). These questions covered meal options that aligned with the Mediterranean diet and foods used to add flavor to meals. Less than 50% of participants were able to correctly identify cooking methods typical of the Mediterranean diet. Although 56 participants (91.8%) identified moist cooking methods, such as stewing, as the most typical method, more than half (n = 29, 51.8%) of those lost points due to incorrect identification of additional cooking methods.

Attitudes and Behaviours

When asked about their current diet, 38 respondents (62.3%) rated their quality as excellent or very good and were classified as having a high-quality diet, and 23 participants (37.7%) rated their diet of average or poor quality and were classified as having a low-quality diet. Notably, the probability of subjectively rating diet as high quality was higher among those with a low level of overall knowledge than among those with a high level of knowledge ($p = 0.034$).

Fig. 1 shows the attitudes of older adults towards nutrition. Just over half of the sample ($n = 34$, 55.7%) were classified as having an overall positive attitude towards food choices and healthy eating. There were no differences in age, BMI, sex, level of education, or area classification between those with an overall positive attitude and those with a negative attitude (all $p > 0.05$). There was also no difference in attitudes between those with a high level of knowledge and those with a low level of knowledge (all $p > 0.05$). However, those with an overall positive attitude towards food choices and healthy eating were more likely to subjectively rate their diet quality as high, whereas those with a positive attitude were four times more likely to rate their diet as good quality compared to those with a negative attitude (*OR* = 4.06, 95%CI [1.3559 to 12.1722], $p = 0.01$).

Nutrition-related behaviours were overwhelmingly positive, with 53 participants (86.9%) stating that they proactively sought out nutrition information and 59 (96.7%)

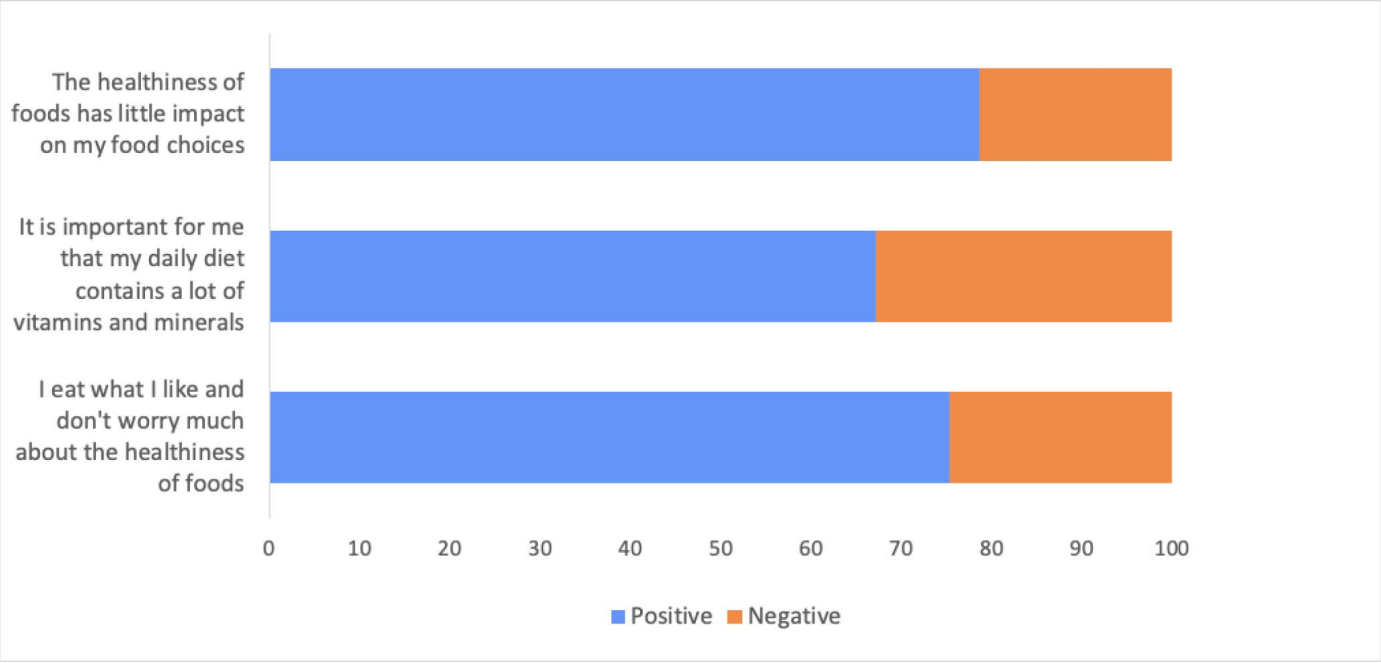

Fig. 1 Nutrition-Related Attitudes (n = 61)

stating that they read the nutrition information panel sometimes or most of the time. In terms of specific eating behaviours, 48 participants (78.7%) stated that they were interested in tasting new foods that they had not tasted before, and 50 (82.0%) preferred to eat home-cooked meals rather than eating out or ready-made meals.

Barriers and Enablers to Adopting a New Dietary Pattern

Barriers

The percentage of participants who endorsed a particular barrier is shown in Fig. 2. Almost one-third of the participants (27.9%) stated that the cost was a deterrent to trying a new diet. 20% of the sample stated that a lack of knowledge and time for cooking would make it more difficult to adopt a new dietary pattern, whereas a third of participants (34.4%) identified that taste preferences would make it harder. Other barriers (entered as free text by respondents) to changing habitual diets included living with others who have different food preferences and not wanting to cook more than one type of meal, food intolerance, and a lack of interest in cooking. There were no differences in the number or type of barriers identified between those with high and low levels of total and individual domain knowledge (all $p > 0.05$).

Enablers

The percentage of participants who endorsed a particular enabler is shown in Fig. 3. 50% of participants reported that educational information would help them with dietary changes. Approximately 40% of the participants stated that ongoing nutritional support and access to meal preparation resources, such as meal plans and recipes, would make them more willing to make changes to their current diet. Other enablers to adopting a new dietary pattern included clear evidence of effectiveness and more 'yumminess' factor.

Discussion

This study provides an overview of older Australian adults' Mediterranean diet knowledge and attitudes as well as perceived enablers and barriers to changing their habitual diet. This study aimed to understand how much older adults in a non-Mediterranean community know about the Mediterranean diet and how this relates to nutrition-related attitudes and behaviours. Most participants in our sample were female, with a high level of education, and English as their first language. The main findings of this study are as follows: (1) more than half of our sample had a high level of Mediterranean diet knowledge; (2) nutrition-related attitudes were

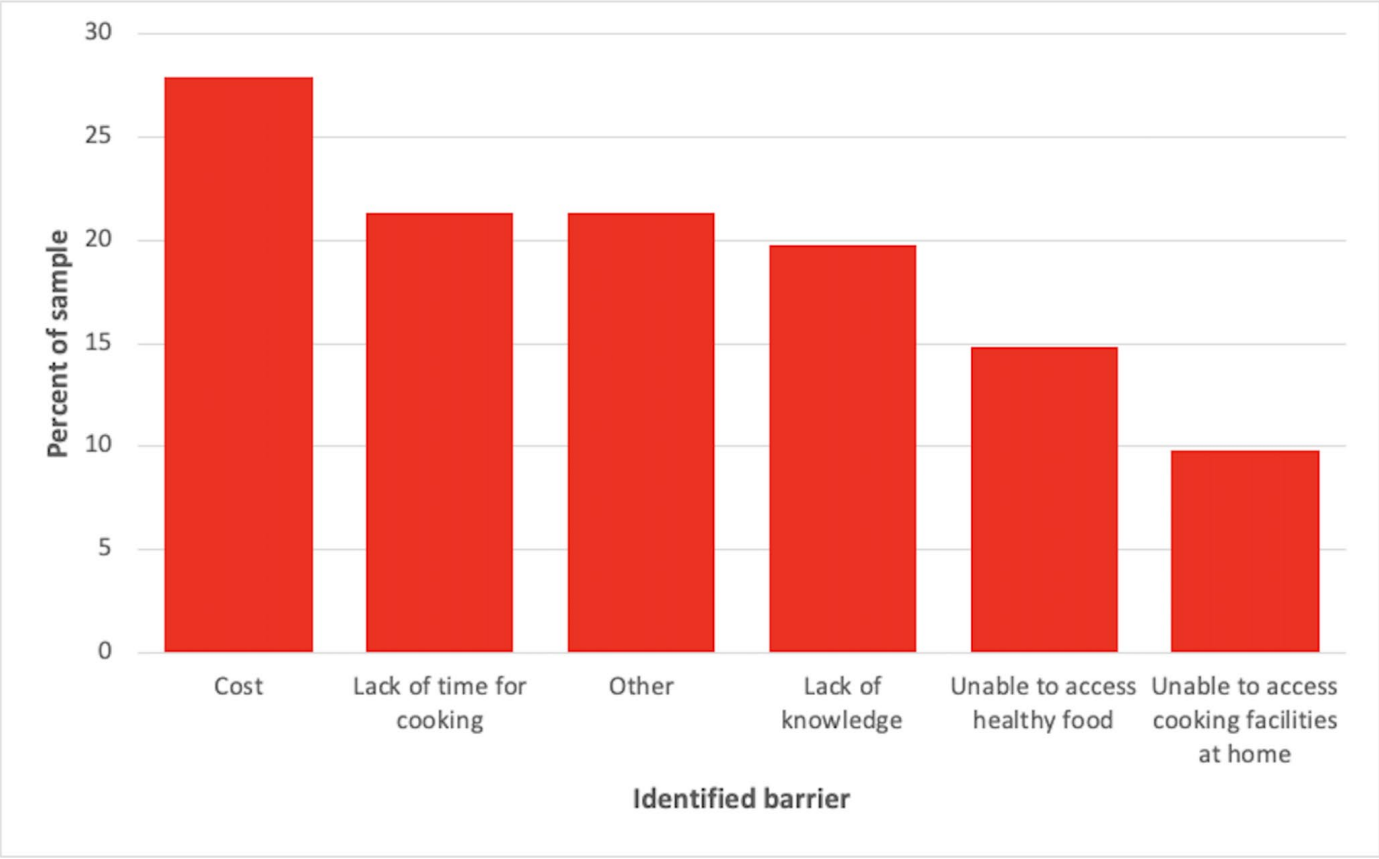

Fig. 2 Barriers to Adopting a New Dietary Pattern (n = 61)

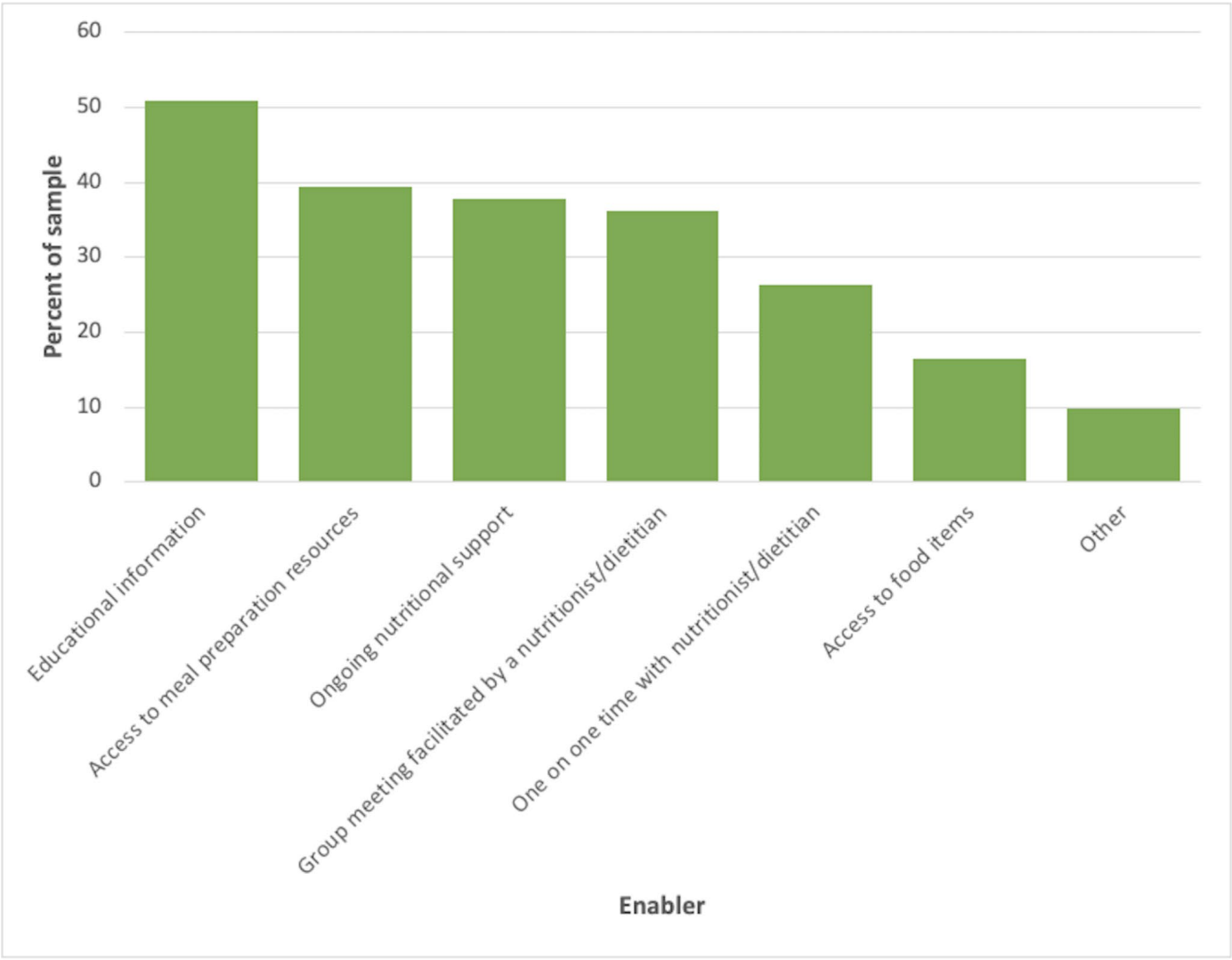

Fig. 3 Enablers to Adopting a New Dietary Pattern (n = 61)

generally positive, irrespective of knowledge level; and (3) there were several perceived barriers identified, including cost and family food preferences, that impede older adults ability to make changes to their habitual diet.

The findings from this study indicate that even in this highly educated and generally well-informed sample, there are still some key area gaps in knowledge, and any strategy to address these are likely to be beneficial for the entire population. These findings are consistent with those obtained from a sample of Australian cardiac patients [21]. Indeed, across multiple Australian populations, there is a lack of understanding about the nutrient content of foods that are not commonly consumed in the standard Australian diet (e.g., smoked salmon) [26], alcoholic content of beverages, and cooking methods typical of the Mediterranean diet. Conversely, knowledge of what foods provide a good source of fibre and foods that raise blood cholesterol, as well as the ability to identify certain nutrients from a nutrition information panel and meal options that align with the Mediterranean diet are generally strong [21]. This highlights that there are consistent strengths and weaknesses in Mediterranean diet knowledge across Australian populations, and provides a strong case for specific education programs that target the known gaps.

Interestingly, we found that overall knowledge did not seem to differ between males and females, or between those with varying levels of education. This contrasts with many previous studies that have demonstrated that females and those with higher levels of education tend to have greater nutritional knowledge [27]. The contrasting findings are likely related to the small and relatively homogenous sample size, and caution should be exercised when generalising beyond this sample. The results are still valuable in highlighting key knowledge deficits that are present across multiple Australian populations to which education programs can be targeted. Given the demographic bias of the sample, the real picture in Australia is likely to be worse than suggested by these results. Collecting nationally representative

data would be useful in developing national education programs tailored to the needs of a broader population.

CVD continues to be the leading cause of death in Australia, and poor diet contributes to approximately 50% of the disease burden [28]. In this sample, more than half of the participants reported having at least one chronic condition, and one-quarter of the sample reported having a condition for which dietary risk factors contribute to a significant proportion of the disease burden [3], highlighting the need to maintain and improve health through diet. Although overall knowledge of dietary patterns, foods, and nutrients for reducing cardiac risk is generally sound, there are a range of individual areas where knowledge is suboptimal and represents a target for improving knowledge, particularly in the context of cardiovascular health. For example, although participants were able to correctly identify packaged foods high in salt based on the nutrition information panel, less than 50% of the sample were able to correctly identify foods for lowering blood cholesterol and foods high in salt. Given the role of cholesterol and sodium in CVD and hypertension, both of which are common conditions associated with ageing [28], these knowledge gaps are significant. Additionally, much of the sample had a poor understanding of the alcoholic content of the beverages. This is in keeping with previous studies that have illustrated that older adults tend to have poor knowledge of safe drinking guidelines and the risks associated with their own alcohol consumption [29]. Heavy alcohol consumption is a well-known contributor to the CVD disease burden and a range of other serious health effects [30]. Alcohol consumption is high among older adults, and the proportion of those aged 50 years and older who drink at risky levels has increased substantially in Australia [31]. Recent modelling evidence has suggested that even a slight reduction in alcohol intake, equivalent to approximately three-quarters of a standard drink, would be beneficial for reducing overall energy intake and the contribution of discretionary foods to daily energy intake [32]. This finding has implications for public education campaigns and highlights the need for clear information and targeted approaches to address and improve population health.

There is evidence that the public is generally aware of dietary guidelines, which has increased over time [33]. Indeed, approximately 65% of the sample were able to correctly identify the daily recommended number of servings of vegetables, which is similar to findings from other Australian studies [33]. However, there is an obvious gap between relevant knowledge and actual eating behaviours, given that adherence to dietary guidelines in Australia is low across the population [34]. Awareness of dietary intake is also a key determinant of dietary quality. In this study, those who had a low level of overall knowledge were more likely to subjectively rate their current diet as high-quality compared to those with a high level of knowledge. However, those who are more knowledgeable are likely to be better equipped with an understanding of what constitutes a high-quality diet. Given the generally poor diet quality of older adults in Australia, it is possible that there is a disconnect between individual perceptions of diet quality and actual diet quality in this group. These findings are consistent with the Dunning-Kruger effect, a type of cognitive bias in which individuals overestimate their abilities, often because those with lower levels of knowledge have not developed the necessary understanding and skills to accurately evaluate their own health knowledge [35]. Data from the United States suggest that inaccurate identification of diet quality is common, with a large percentage of the population perceiving their diet to be of higher quality than indicated by objective measurements [36]. Older adults have also been shown to overestimate adherence to vegetable intake [37]. Overestimation of diet quality is problematic and highlights a group who may be at greater risk of chronic disease because those who misperceive their diet quality as high are unlikely to see a need to change their diet and therefore may not respond to health promotion messages. Thus, strategies are needed to address this cognitive bias and to overcome this barrier. Although we did not collect dietary intake data and we are unable to directly comment on whether misperceptions of diet quality versus actual diet intake were present in this sample, it is an important consideration in the context of health promotion and an area for future research.

Our results provide new insights into the factors that influence an individual's intention to change their diet. Although it has been shown that older adults in Australia can adhere to a Mediterranean diet in short-term intensive interventions [38], the reality of widespread dietary behaviour change at the population level, where differences in food habits, preferences, and cultural influences are extensive, is more complex. Participants acknowledged several economic and practical barriers that would impact their capacity for dietary change, including cost, knowledge, and time. Cost and affordability were the most common barriers, despite the sample being highly educated and likely from a higher-income bracket. This is similar to findings from other studies that have reported that increasing food costs and a lack of affordability are important barriers to general healthy eating [39] and adherence to the Mediterranean diet among adult populations in non-Mediterranean regions [40]. Evidence preceding the COVID-19 pandemic suggests that the Mediterranean diet may be more cost-effective than the typical diet of Australians [41]. With the increasing cost of living, the cost of eating a healthy diet – particularly one that includes fresh fruits, vegetables, and whole grains – has increased markedly due to supply chain disruptions and global inflation as a result of the COVID-19 pandemic.

However, the overall food costs associated with consuming a healthy diet continue to be lower than those of the standard habitual diet [42]. There is also evidence to suggest comparable nutrient content between fresh and frozen or canned fruits and vegetables, which are more accessible and tend to come at a cheaper price point [43]. Thus, cost may only be a perceived barrier, and education could potentially address this concern. The provision of educational information and meal preparation resources were the most cited enablers of changing the habitual diet in this sample. Findings from an Australian study suggest that acceptance of the Mediterranean diet can be improved by providing simple resources, including educational material, advice for recipe modification, clear recommendations for daily and weekly servings of core food groups, and templates for creating individual shopping lists and meal plans [40]. However, nutrition professionals have identified a lack of patient education resources specific to the Mediterranean diet, particularly those that provide practical advice that is simple and culturally appropriate [10]. It is clear that developing targeted educational information, including how to create a cost-effective and nutritionally balanced diet (for example, purchasing home-brand products, buying in-season or frozen fruits and vegetables, and swapping meat for legumes as an alternative protein source) is needed.

Motivation is also a key component of health behaviour change, directly impacting the intention to change behaviour [20]. In the present study, participants indicated that the individual food preferences of other household members and a lack of interest in cooking were key barriers that influenced their motivation to change their habitual diet. Consistent with this, family food preferences are a key barrier to healthy eating [44] and adapting to a Mediterranean diet in non-Mediterranean countries [45]. Social support is a key determinant of dietary adherence and can act as an intermediary to stressors that are often experienced when making lifestyle changes [44]. In addition, cooking and food preparation are key activities for maintaining independent living, and enjoyment of cooking is a key element of cooking skills, both of which play a direct role in adopting healthy eating patterns and meeting dietary guidelines [46]. Importantly, evidence suggests that dietary behaviour change is guided by willpower and willingness to change [47], highlighting the importance of improving self-efficacy. Self-efficacy is a key determinant of positive outcomes in lifestyle interventions and is integral for facilitating and improving adherence to a Mediterranean diet [48]. However, commentary on the self-efficacy of older adults in Australia to adapt their eating habits in the context of perceived barriers is scarce. Strategies to support and improve self-efficacy and intrinsic motivation are likely to be beneficial for providing older adults with tools to overcome perceived barriers and make positive dietary changes.

Our study had several limitations that should be considered. First, the population was a small, relatively homogenous convenience sample of older adults who were mostly aged 65 years or younger, well educated, and had English as their first language, which may not be representative of the general older Australian population. Given that more than 30% of the older adult population in Australia has a culturally and linguistically diverse (CALD) background [28], which has not been captured in this sample, future studies would benefit from investigating Mediterranean diet knowledge across different CALD subgroups to design inclusive and appropriate interventions for the general population. The use of social media platforms as part of our recruitment strategy may have resulted in selection bias given that approximately 65% of the cohort recruited were < 65 years old (i.e., those older than 65-years may be less likely to use social media platforms). An online survey was selected to increase the reach and response rate; however, we acknowledge that not offering a paper-based alternative to the online option may have produced biased results by excluding a subgroup of potential participants who lacked access to the Internet or digital literacy to complete an online survey [49]. Additionally, response rates to online surveys are lower than those for face-to-face or paper-based surveys, and participants are more likely to exit before completing the survey [50]. To overcome this, the survey was designed to take 15 minutes to complete, and we limited the use of the open-ended questions. Importantly, we did not collect dietary intake data; therefore, we cannot draw conclusions about the links between nutrition-related knowledge, attitudes, behaviours, and eating habits in this population. Finally, while the Med-NKQ has been tested for repeatability in a cardiac population of similar age demographics [21], it is yet to be implemented in an intervention study to measure and understand changes following education, and there is no indication of how much knowledge is needed to impact healthy eating. Future research would benefit from investigating the utility of the Med-NKQ to measure changes following dietary education and to identify if there is a critical cut-off point of knowledge to incite dietary behaviour change.

Conclusions

To our knowledge, this is the first Australian study to assess the knowledge, attitudes, and behaviours of older adults towards the Mediterranean diet. The findings indicate that even in this highly educated and generally well-informed sample, a few key knowledge deficits appear to be

consistent across multiple cohorts in Australia, highlighting the need for targeted education programs. The study also highlighted several potential strategies and tools to support dietary change by addressing perceived barriers, including the provision of simple and practical resources, detailing how to construct a cost-effective and nutritionally balanced diet. Despite the importance of motivation and self-efficacy, there has been little consideration of these factors in intervention design, and they are likely to be critical targets for future research in Australia. Finally, examining the association between Mediterranean diet knowledge and adherence in Australian older adults and how strategies to overcome perceived barriers and improve self-efficacy impact dietary change and health outcomes warrant further exploration.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s10900-023-01237-1.

Author Contributions AT: conceptualisation, methodology, data analysis and interpretation, writing – original draft preparation, project administration. HML: conceptualization, writing – review and editing, supervision. CM: writing – review and editing. FO: writing – review and editing. SLN: writing – review and editing. VMF: conceptualisation, writing – review and editing, supervision.

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Data Availability The data that support the findings of this study are available from the corresponding author upon request.

Declarations

Disclosure of interests AT, HL, CM, FO and SLN have no conflicts to disclose. VF is President-elect of the Nutrition Society of Australia, the Director of the Australian Rural Health Education Network, and an Editor for the journals Nutrition & Dietetics and Nutrients. These are voluntary roles, and no payment is received for the positions.

Ethical standards disclosure This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving research study participants were approved by the University of Sydney Human Research Ethics Committee. Written informed consent was obtained from all participants.

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SUPPLEMENTARY MATERIAL

Supplementary Material 3.1. Survey Part A – Med-NKQ

1. Which of the following statements is true if you want to lower your blood cholesterol? You may choose more than one.

☐ Eat more fruits and vegetables

☐ Eat more wholegrain foods

☐ Eat less fatty and processed meats

☐ Eat more dairy products

☐ Eat less salt on your food

2. Which of the following statements are true if you want to lower your blood pressure? You may choose more than one.

☐ If using packaged foods, choose products with less salt

☐ If you are overweight, try to lose some weight

☐ Drink more alcohol

☐ Eat more dark leafy greens

☐ Eat more white bread

3. What is the recommended number of servings of vegetables per day? 1 serve = ½ cup cooked vegetables **or** 1 cup raw vegetables/salad.

☐ 2 serves

☐ 3 serves

☐ 5 serves

☐ 7 serves

4. Which of the following statements are true? You may choose more than one.

☐ The only nutritional benefit of fruits and vegetables is vitamins and minerals

☐ Fat is always bad for your health; you should therefore avoid it as much as possible

☐ Dietary fibre is important for lowering your cholesterol

5. Which of the following foods are more likely to raise your blood cholesterol? You may circle more than one.

Wholemeal bread

Extra Virgin olive oil

Fried bacon

Butter

6. Circle the foods that are a source of healthy fats. You may circle more than one.

Unsalted nuts

Dark chocolate

Salmon fillet

Butter

7. Which of the following foods are a good source of fibre? You may circle more than one.

Rolled oats

Corn flakes

Rice crackers

Legumes

8. Which of the following foods are high in salt? You may circle more than one.

Smoked salmon

Boiled egg

Canned tuna in spring water

Deli ham

9. Which alcoholic beverage below contains the lowest number of standard drinks?

200mL red wine

375mL full strength beer

60mL of dark spirit

10. Which pasta meal better reflects the Mediterranean diet principles for heart health? Circle the correct response.

Pasta with tomato sauce

Pasta with mushroom and cream sauce

11. Which of the following foods are considered core components of the Mediterranean diet? You may circle more than one.

White rice

Legumes

Chicken breast

Extra Virgin olive oil

12. Which of the following foods are considered core components of the Mediterranean diet? You may circle more than one.

Leafy greens

Unsalted nuts

Salami

Blue cheese

13. Which of the below are used in the Mediterranean diet to add flavour to food? You may circle more than one.

Oregano

Lemon juice

Powdered stock cube

Garlic

14. Which of the following cooking methods is most typical of the Mediterranean diet? You may choose more than one answer.

☐ High heat stir-fry
☐ Use of moist cooking methods such as stewing
☐ Barbeque
☐ Only eating raw foods

15. Which of the following statements is true about the Mediterranean diet? You may choose more than one answer.

☐ Use of Extra Virgin Olive Oil as main oil
☐ Fruit juice consumed with all meals
☐ Eating red meat 3-4 times per week
☐ Mostly plant-based diet

16. Which of the following drinks is consumed the most as part of the Mediterranean diet?

☐ Water
☐ Fruit juice
☐ Wine
☐ Coffee

17. Which of the following meals would be considered the best choice if following the Mediterranean diet for heart health?

Vegetable and lentil soup with wholegrain bread and olive oil

Carbonara

Oven baked crumbed fish and potato

Grilled steak and garden salad with fat free dressing

18. If you were having breakfast in a café, which menu option would best fit the Mediterranean diet?

Eggs benedict with smoked salmon on toast

Beans cooked in tomato and onion on toast

19. Looking at products 1 and 2, which one has the most amount of salt?

Pack Size: 425g **Serving Size: 69g** **Servings per packet: 4**		
	Per Serve	Per 100g
Energy	327kJ	474kJ
Protein	17.7g	25.7g
Fat, total	0.7g	1.0g
- Saturated	0.3g	0.4g
Carbohydrate, total -Sugars	<1g	<1g
Sodium	311mg	450mg
< means less than		

Canned tuna 1

Pack Size: 185g **Serving Size: 60g** **Servings per packet: 2**		
	Per Serve	Per 100g
Energy	284kJ	474kJ
Protein	15.46g	25.7g
Fat, total	0.6g	1.0g
- Saturated	0.2g	0.4g
Carbohydrate, total -Sugars	<1g	<1g
Sodium	210mg	350mg
< means less than		

Canned tuna 2

20. Which of these two products is better for heart health? Circle the best choice.

Nutrition Information Serving Size: 83g Servings per pack: 8		
	Per Serving	Per 100g
Energy	773kJ	931kJ
Protein	9.0g	10.8g
Fat, total	4.0g	4.8g
-saturated	0.5g	0.6g
Carbohydrate	25.0g	30.1g
-sugars	1.6g	1.9g
Dietary Fibre	6.1g	7.3g
Sodium	268mg	323mg

Bread 1

Nutrition Information Serving Size: 60g Servings per pack: 11		
	Per Serving	Per 100g
Energy	612kJ	1020kJ
Protein	5.0g	8.4g
Fat, total	1.2 g	2.0g
-saturated	0.4g	0.6g
Carbohydrate	27.8g	46.31g
-sugars	1.4g	2.4g
Dietary Fibre	1.6g	2.7g
Sodium	240mg	400mg

Bread 2

Source: Moroney C, O'Leary F, Flood VM. The Med-NKQ: A reliable Mediterranean diet nutrition knowledge questionnaire for cardiovascular disease. *Nutrients*. 2021;13(9):2949. doi:10.3390/nu13092949

Supplementary Material 3.2. Survey Part B – Attitudes and behaviours

21. How would you rate the quality of your overall diet (High quality = high in fresh foods, low in processed foods)?

☐ Excellent
☐ Very good
☐ Good
☐ Average
☐ Poor

22. The healthiness of foods has little impact on my food choices.

☐ Strongly disagree
☐ Disagree
☐ Somewhat disagree
☐ Neither or agree or disagree
☐ Somewhat agree
☐ Agree
☐ Strongly agree

23. It is important for me that my daily diet contains a lot of vitamins and minerals.

☐ Strongly disagree
☐ Disagree
☐ Somewhat disagree
☐ Neither or agree or disagree
☐ Somewhat agree
☐ Agree
☐ Strongly agree

24. I eat what I like and do not worry much about the healthiness of foods.

☐ Strongly disagree
☐ Disagree
☐ Somewhat disagree
☐ Neither or agree or disagree
☐ Somewhat agree
☐ Agree
☐ Strongly agree

25. Do you proactively look for nutrition information?

☐ Yes
☐ No

26. How often do you read the nutrition facts label found on packaged foods?

☐ Most of the time
☐ Sometimes
☐ Rarely

☐ Never

27. I prefer to eat home cooked meals rather than eating out or ready-made meals.

☐ Strongly disagree
☐ Disagree
☐ Somewhat disagree
☐ Neither or agree or disagree
☐ Somewhat agree
☐ Agree
☐ Strongly agree

28. I am interested in tasting new food that I haven't tasted before.

☐ Strongly disagree
☐ Disagree
☐ Somewhat disagree
☐ Neither or agree or disagree
☐ Somewhat agree
☐ Agree
☐ Strongly agree

29. What factors or circumstances would make it difficult (harder) to try a new diet? Please select all that apply.

☐ Cost
☐ Unable to access healthy food
☐ Unable to access cooking facilities at home
☐ Lack of knowledge about diet/nutrition
☐ Lack of time for cooking
☐ Inconvenience
☐ Satisfied with current diet
☐ Food taste preferences
☐ Other (please specify): _____

30. What factors or circumstances would facilitate or promote your willingness to try a new diet? Please select all that apply.

☐ Educational information
☐ One on one time with nutritionist/dietitian
☐ Ongoing nutritional support
☐ Access to food items
☐ Access to meal preparation resources e.g. cooking classes, meal plan, recipes
☐ Group meeting (i.e. attended with other participants) facilitated by nutritionist/dietitian
☐ Other (please specify): _____

CHAPTER FOUR

PARTICIPATORY DESIGN OF AN ONLINE NUTRITION EDUCATION RESOURCE FOR OLDER ADULTS

Preface

Digital health technologies hold promise for providing nutrition education to older adults; however, it is crucial to understand and acknowledge their specific preferences with regards to technology features, functions, and content as well as the challenges they may encounter in engaging with technology. To ensure effective utilisation of technology among older adults, it is essential to develop and design solutions that cater to their unique needs and preferences. This involves considering factors such as usability, acceptability, and accessibility, as well as the appropriateness and relevance of digital solutions for an older adult target audience.

Using participatory design methods, the aim of this study was to explore the desired features, functions, and content for an online nutrition education resource specifically tailored for older adults.

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ORIGINAL ARTICLE

WILEY

Older adults' needs and preferences for a nutrition education digital health solution: A participatory design study

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Abstract

Background: The global population is ageing rapidly and there is a need for strategies to promote health and wellbeing among older adults. Nutrition knowledge is a key predictor of dietary intake; therefore, effective educational programmes are urgently required to rectify poor dietary patterns. Digital health technologies provide a viable option for delivering nutrition education that is cost-effective and widely accessible. However, few technologies have been developed to meet the unique needs and preferences of older adults.

Objective: The aim of this study was to explore technology use among older adults and qualitatively determine the content needs and design preferences for an online nutrition education resource tailored to older adult consumers in Australia.

Methods: Twenty adult participants aged 55 years and older (95% female) participated in one of four 2-h participatory design workshops. In each workshop, prompted discussion questions were used to explore participants' technology use and preferences and to explore content needs and design preferences for an online nutrition education resource specific to older adults.

Results: All participants were regularly using a range of different devices (e.g., smartphones, tablets and computers) and reported being comfortable doing so. Participants wanted a website that provided general nutrition information, practical advice and recipes. To enhance engagement, they sought a personalised resource that could be adjusted to suit their needs, included up-to-date information and allowed for easy sharing with others by exporting information as a PDF.

Conclusions: Participatory design methods generate new knowledge for designing and tailoring digital health technologies to be appropriate and useful for the target audience. Specifically, older adults seek an online resource that has large and simple fonts with clear categories, providing them with practical advice and general nutrition information that can be personalised to suit their own needs and health concerns, with the option to export and print information into a paper-based format.

Patient or Public Contribution: Older adults actively participated in the development and evaluation process to generate ideas about potential features, functionalities, uses and practicalities of an online nutrition education resource.

KEYWORDS
ageing, education, nutrition, participatory design, technology

1 | INTRODUCTION

The global population is ageing rapidly. In Australia, one in six adults is aged 65 years and older and it is predicted that older people will make up almost one-quarter of the population by 2066.[1] Approximately 80% of this demographic are living with at least one chronic disease.[1] This puts significant strain on public healthcare services, leading to increased social and economic pressure on the wider community.[2] Poor diet is a key contributor to chronic disease burden. Despite government health promotion campaigns, a large proportion of the population continues to underconsume healthful foods, with only 8% of adults over the age of 65 meeting the daily recommendations for fruit and vegetable intake.[3] Improved population health relies on changing behaviour, particularly dietary habits, which can be challenging to sustain. Consequently, there is a need for effective resources and interventions tailored to support dietary behaviour change among the ageing population.

Numerous factors influence behaviour and one's capacity for behaviour change. As a starting point, knowledge and understanding are fundamental prerequisites for changing health- and nutrition-related behaviour.[4] Alongside other determinants of dietary behaviour, including price, preference and access, several studies have highlighted the significance of increased nutritional knowledge in promoting behavioural changes.[5] Individuals with a better understanding of what constitutes a healthy diet are more likely to incorporate fruits and vegetables in their diets.[6] Thus, nutrition education programmes may serve as a crucial first step in supporting healthy eating habits, particularly in older adults who often exhibit lower levels of nutrition-related knowledge compared to their middle-aged counterparts.[7,8] Research has demonstrated the effectiveness of education programmes targeting older adults, leading to improved overall nutrition knowledge and dietary intake in this population.[9,10] However, these studies delivered information through traditional in-person lectures, which may not be appropriate for older adults facing challenges in attending in-person sessions due to physical limitations, transportation barriers, or for those residing in regional or remote areas where the availability of such interventions is limited.

Digital health technologies are inherently well placed as a viable option for delivering educational programmes in a nontraditional format, particularly in the increasingly digital age during and following the COVID-19 pandemic. Importantly, digital health technologies that provide health information and deliver health care are becoming increasingly accessible. In 2018, 61.6% of older Australians aged over 65 years reported using the internet in the previous 3 months, and in 2020, 93% of older adults had internet access in their homes.[11,12] There have also been clear increases in the number of older adults who own and use various devices, including smartphones, tablets, laptops and desktop computers.[12] Digital health technologies have proved to be invaluable in the health care sector for providing services that are relatively cheap, timely and efficient compared to traditional models of care, with similar impact.[13,14] A major advantage of digital health over traditional models of care includes the capacity to recruit and deliver services on a large scale, as well as remotely, thereby enabling more widespread involvement in major public health issues.

Digital health technologies are increasingly being utilised in the management and treatment of a range of health conditions, including diabetes,[15] healthy eating habits,[16] obesity,[17] sleep,[18] physical activity[19] and depression and anxiety.[20] However, few have been developed specifically for older adults, representing a largely untouched area for potential technologies to improve the health and wellbeing of older adults in Australia and globally. Importantly, there is a high level of interest and motivation to use digital health technologies to improve health and wellbeing, with a study reporting that almost 95% of participants in a study of older adults aged 50 years and older would find it beneficial to be able to access a website designed to support healthy ageing, including overall physical health and cognition, as well as self-management of existing conditions.[21] Despite the benefits of digital health technologies and reported motivation to engage, there are several challenges for use in older adults, particularly around a lack of confidence in their ability to use technology.[22,23] As such, it is essential that digital health technologies be designed and tailored with the interests of the older adult population in mind, considering their unique and varying needs.

The Medical Research Council's Framework for Complex Interventions outlines four phases of intervention research that follow an iterative approach: development, feasibility, testing and implementation.[24] The initial development phase emphasises engagement of relevant stakeholders and target end-users to determine the potential outcomes from the development and implementation in a real-world setting. The use of participatory design methodologies within the development phase positions potential end-users as empowered participants to independently explore their needs to shape development outcomes.[25] As such, the aim of this study was to explore technology use among older adults and qualitatively determine the content needs and design preferences for

an online nutrition education resource tailored to older adult consumers in Australia.

2 | METHODS

This study was part of a larger project to determine needs and preferences for an online nutrition education resource and evaluate the acceptability and feasibility of a digital health resource for delivering nutrition education to older adults. This study employed an exploratory qualitative study design using participatory design methods and adhered to the Consolidated Criteria for Reporting Qualitative Research guidelines[26] (see Supporting Information S1: File 1). The study protocol was approved by the University of Sydney Human Research Ethics Committee (2022/423) and participants gave informed electronic consent before participation.

2.1 | Participants

Participants were eligible if they were aged 55 years and older, proficient in English, lived in Australia and had completed the required informed consent process. A total of 20 people (95% female) aged 55 years and older participated in this study. Aligning with our previous work, we defined older adults as aged ≥55 years as this represents the age range when addressing risk factors (e.g., cardiovascular disease, diabetes, obesity) is typically recommended[27] due to the increasing prevalence and, in turn, burden of diet-related chronic disease beginning from the age of 55 years. Participants were not reimbursed for their participation.

2.2 | Recruitment strategies

The study was digitally advertised through Facebook and the JoinUs national research register. Advertisements on both platforms were targeted to potential participants who met the inclusion criteria (i.e., were aged 55 years or older and lived in Australia). Additional targeting was used for Facebook advertisements to identify potential participants with interests in human nutrition and healthy lifestyles. Interested participants were directed to a study-specific webpage using REDCap (Research Electronic Data Capture) hosted at the University of Sydney,[28,29] where they were able to read detailed study information and provide informed consent. Potential participants were advised that participation was entirely voluntary and that if they agreed to participate, they could withdraw their consent at any time without being required to provide any reasons.

2.3 | Data collection

Participatory design workshops are collaborative and inclusive sessions that involve various keyholders, including target end-users, in discussions around the design and development of digital health technologies. The primary goal of participatory design is to ensure that the outcome meets the needs, preferences and expectations of the people who will use and interact with it.[25] As a part of the initial development phase (per the Framework for Complex Interventions), participatory design workshops allow for user input to be considered in the process of designing new technologies before significant investments are made in formal development.[24]

A series of four group-based participatory design workshops of approximately 2-h duration, each with up to 10 participants, were conducted in September 2022 with older adult consumers. The aim of each workshop was to actively engage the older adult community in discussions about how technology may be used to deliver nutrition education specific to the Mediterranean diet. The research team developed a semistructured discussion guide that prompted extensive discussion around the potential utility of an online nutrition education resource for older adults, what kind of information it would need to include and how it might look or function. The discussion guide was designed to enable the sessions to follow an iterative process so that initially generated ideas could be further developed by participants in subsequent workshops (see Supporting Information S2: File 2). Two researchers with experience in qualitative research (A. T., H. M. L.) conducted the workshops via videoconferencing (Zoom Video Communications Inc.). Three workshops were recorded and transcribed verbatim into Microsoft Word by A. T. The fourth group was not recorded due to facilitator error, but both facilitators took detailed field notes to capture participant comments.

Under the same ethics protocol, participants were invited to engage in a user-testing study of an existing nutrition education resource. Those who consented to participate in both aspects of the protocol (i.e., participatory design workshops and user testing) provided basic demographic information via an online survey hosted on REDCap, including age, sex, level of education and country of birth.

2.4 | Data analysis

Descriptive demographic data are expressed as mean ± standard deviation (SD) for continuous data, and frequencies and percentages for categorical data. Established deductive thematic analysis techniques were used to analyse the transcriptions and notes from the workshops.[30] A coding framework outlining all key concepts was developed to analyse qualitative data by A. T and H. M. L. Data were coded in NVivo software[31] using this framework. Coding followed an established iterative process of reading, coding and exploring the pattern and content of coded data, followed by reflection and discussion. A. T. and H. M. L. developed coding labels and coded 25% of the data collectively, with any differences of opinion being resolved through discussion to reach a consensus. The remaining data was coded independently by A. T., with discussion with H. M. L. as needed. Aligning with the topics explored in the participatory design workshops, five themes were identified: (1) technology use among older adults, (2) flexible access, (3) information needs, (4)

TABLE 1 Demographic characteristics of participants.

Continuous variables	Mean	SD
Age (years)[a]	63.3	5.8
Categorical variables	***n***	**%**
Sex[b]		
Male	2	11.1
Female	16	88.9
Education level[a]		
Postgraduate	9	56.3
Bachelors	3	18.8
Advanced certificate/diploma	3	18.8
Secondary (Years 7–12)	1	6.3
Country of birth[a]		
Australia	12	75.0
United Kingdom	2	12.5
Other[c]	2	12.5

[a]Data missing for $n = 4$.
[b]Data missing for $n = 2$.
[c]Includes El Salvador and Canada.

personalised experience and (5) content from a trusted source. All themes were checked against each other and back to the original data to ensure that all relevant references had been gathered. This process resulted in a coherent and consistent thematic framework.

3 | RESULTS

3.1 | Participant characteristics

A summary of participants' demographic characteristics is presented in Table 1. Participants were well-educated, mostly female and ranged in age from 56 to 74 (63.3 ± 5.8) years.

3.2 | Findings

The main findings are organised into the five themes identified via the data analysis process. Table 2 provides an overview of the themes, corresponding subthemes, codes and illustrative quotes.

3.2.1 | Theme 1: Technology use among older adults

Subtheme: *Perceived competence*. Participants reported being generally confident and comfortable using technology. Statements included, 'I'm pretty comfortable with technology' (Workshop 1) and 'I have no trouble with it' (Workshop 3). Another participant remarked that 'I think the fact that we're all here [via Zoom] shows that we are reasonably competent with this' (Workshop 3).

Subtheme: *Preferred devices, websites and apps*. When asked 'what kinds of devices are you using to access the internet', participants reported a broad range of devices, including desktop and laptop computers, smartphones and tablets; computers were the most frequently referenced device. Computers were used most often because participants had 'a preference for a larger device' (Workshop 3), particularly when they wanted to 'go on a site and look in more detail' (Workshop 1) because 'it's a bigger screen' (Workshop 1). Smartphones were the most frequently criticised device because 'a mobile phone is really annoying if you're trying to read an article because it's too small' (Workshop 1). However, others preferred to use a smartphone because 'your phones [always] with you' (Workshop 3) and 'you can use it on a bus, or when you're waiting for a haircut' (Workshop 3).

Participants were using a broad range of different apps and websites across their different devices. The most common types of apps being used fell into the 'Health' category, which included general health (e.g., 'booking appointments on the my doc app'), fitness and nutrition. Social media apps were also common, including Facebook, Messenger, Twitter and Instagram. Websites were the most common source for health information, including international health organisations, such as the 'World Health Organisation' and government-based websites, such as the '[Australian] Department of Health'. Other participants utilised search engines, most typically Google, to look for general information on health conditions including 'pain management, sleep apnoea, arthritis and diabetes'. Participants were also searching for specific nutrition information and recipes using a range of websites, including 'Noom', 'real food dietitians', 'dietdoctor.com', 'well nourished', 'quirky cooking' and 'CSIRO'.

Subtheme: *Barriers to technology use*. The most common barrier to adoption and ongoing engagement with technology, including websites and apps, was poor user experience. This included issues such as 'things that are in a very small [and silly] font' (Workshop 3), 'bad spelling and grammar' (Workshop 1)), 'pale print on a white background' (Workshop 1) and 'poor quality images and videos' (Workshop 2).

A lack of digital literacy was also identified as a key barrier to using and engaging with technology, particularly for older adults. Participants emphasised that this would be an important consideration for the development of an online resource. Participants also noted that older adults may have differing levels of digital literacy, depending on the device being used and the context or situation for use. The general consensus was that older adults tend to be more comfortable and 'be able to sit at home with their computer' (Workshop 2), but they 'are not necessarily going to be tech savvy enough to be dealing with an app in the supermarket' (Workshop 2).

Other barriers to technology use included a preference for nondigital sources of information and a general unwillingness to engage with digital technology. To address these potential barriers

TABLE 2 Overview of qualitative data analysis process.

Theme	Subtheme	Illustrative quotes	Codes
Technology use among older adults	Perceived competence	'I think the fact that we're all here [via Zoom] shows that we are reasonably competent with this' (Workshop 3)	Comfort
	Preferred devices, websites and apps	'If I want to go on that site and look in more detail, I go on my computer because it's a bigger screen' (Workshop 1) 'I suppose, because you can use [a smartphone] on the bus, or when you're waiting for a haircut, or something like that' (Workshop 3)	Device preferences Types of websites/apps
	Barriers to technology use	'Most older people I know, they're still struggling to use the mobile phone. And they tell me they don't even know how to text people, let alone look something up' (Workshop 2) 'Whereas other people might not even do that, you might have to print it off yourself, put it in an envelope, put a stamp on and put it in the mail' (Workshop 1)	Poor user experience Lack of digital literacy Preference for nondigital Unwillingness to engage
	Facilitators of technology use	'I would say that, like I'm retired, and I have been for a while, and say of fifty people I can think of only one who isn't tech savvy' (Workshop 1)	Ease of use Digital literacy
Flexible access		'The more detailed information, you'd probably sit down at home when you've got time, and you know, you can read the website. But in terms of accessibility for the recipes and the ingredients, I think maybe on the phone would be … an app would be easier' (Workshop 2)	Mode of access Format (website vs. app) Mobile friendly
Information needs		'I certainly think the nutrition basics would be important' (Workshop 1) 'I mean, another suggestion could be is If you do have a recipe, then as an after you know, what you can do with the leftovers, so maybe you could convert it to this or to that' (Workshop 2)	General nutrition Practical advice Recipes Relationship between diet and health
Personalised experience		'One size does not fit all, but you know that's for sure. I get annoyed when people you know, they lost thirty kilos on a keto diet Therefore everyone else should be on it. And you know someone else gains thirty kilos type of thing' (Workshop 1)	Tailored to individual needs Recipe adjustment Substitutions Conversions Search engine capabilities
Content from a trusted source		'Where to go for more information. [I] would want to see peer-reviewed studies to demonstrate that it is evidence based, [there is] so much fad diet [and] misinformation out there' (Workshop 4)	Regular updates Evidence base Integration with established sources References

to technology use, participants commented that online resources should include an option to export information as a PDF, so they had the 'ability to be able to print information, if that's what you wanted to do' (Workshop 3). This would enable easy sharing of the information, giving users 'the ability to forward things easily to other people, or make suggestions to your friends that you know are on certain diets' (Workshop 3), particularly for those who 'find that it's easier to read a hard copy' (Workshop 3) or 'who don't access things online' (Workshop 3).

Subtheme: *Facilitators of technology use*. Ease of use was the most commonly identified facilitator of technology use, with participants reporting that they were more likely to continually engage with a website or app when they found it easy to use. In particular, this is related to digital tools that '[have] clear categories' (Workshop 2), 'open and download quickly' (Workshop 2) and are easy to navigate with 'everything on the same page' (Workshop 3). To facilitate ease of use for the older adult population, participants emphasised a number of key design features, including 'good font size' (Workshop 2), 'simple fonts that are easy to read' (Workshop 2), 'the right colours of fonts' (Workshop 2) with 'really good contrast' (Workshop 3), 'clear categories to make it easy to find stuff' (Workshop 2) and 'fewer clicks needed to get to where you want to be' (Workshop 1).

Digital literacy was also identified as a facilitator to using technology. Participants commented that they and most others that they knew were able to comfortably use technology, stating that 'of fifty people, I can think of only one who isn't tech savvy' (Workshop 1).

3.2.2 | Theme 2: Flexible access

Most participants stated that they would prefer a nutrition education platform to be hosted on a website, rather than an app. It was suggested that a website would be more likely to reach a larger audience because 'most people would go to a website, only a few people would go to an app (Workshop 3). For those who would prefer an app, they also saw the benefits of a website and suggested having the platform accessible from a website and an app, depending on the intended use—'you could have the website with more information, but if you wanted a quick meal, you could have an app'' (Workshop 2). For the more detailed educational information, participants wanted to 'go on my computer because it's a bigger screen' (Workshop 1) and 'sit down at home when you've got time, and you know, you can read the website' (Workshop 1). This was preferred to using a mobile phone because 'a mobile phone is really annoying if you're trying to read an article because it's too small' (Workshop 2). However, they commented that for 'accessibility for the recipes and the ingredients, I think maybe on the phone would be… an app would be easier' (Workshop 2), particularly when they are on the go at the supermarket. Therefore, to maximise usability, participants referenced the need for the platform to be accessible on a desktop computer as well as to be mobile friendly.

3.2.3 | Theme 3: Information needs

When discussing the specific content and type of information they would need from an online nutrition education platform, participants noted several things they would want to include: (1) *practical advice* (e.g., information on how to read food labels, meal planning guidance to aid with organisation, a list of seasonal produce, suggestions on what to do with leftovers from a meal, budget-friendly ingredients and recipes, suggestions for what to order when eating out and specific options for each meal of the day); (2) *general nutrition information* (e.g., food groups, nutrient sources, foods to combine to maximise nutrient absorption, nutrition information panels on recipes and evidence on the link between diet and diseases such as diabetes and Alzheimer's disease); and (3) *recipes*.

3.2.4 | Theme 4: Personalised experience

The primary preferred functionality was *personalisation* (i.e., a tool that is designed to meet the needs and requirements of the consumer according to data entered by the consumer) with participants commenting that they 'would like something tailored to the individual specific to their health concerns' (Workshop 4) because 'one size does not fit all' (Workshop 1). This included being able to enter relevant data to receive feedback and specific advice or recipes based on their current dietary intake, health conditions (e.g., Hashimoto's, gluten intolerance) and food preferences (e.g., low carbohydrates).

Another component of personalisation that participants wanted was the ability to adjust recipes based on the number of serves required, 'being able to adapt it for different sized families, so you know, if there's one or two of you … being able to moderate the recipe' (Workshop 3). Participants also noted that they wanted a list of substitutions to account for individual allergies and food preferences with each recipe, 'If you don't want dairy, try this. If you're allergic to nuts, try this instead. If you want to go low fructose, try this' (Workshop 1).

Participants also liked the idea of having a search engine that could be used to find specific information or recipes depending on what ingredients they have at home or what is on sale at the supermarket. This was particularly important for older adults who may be on a pension and needing to keep food costs and wastage down, 'when you're on a pension, that's the only way to go, and a lot of older people are on a pension. So you know, whatever is available, seasonal and well-priced is what I base my menu on' (Workshop 3).

3.2.5 | Theme 5: Content from a trusted source

Participants emphasised the need for a resource that included up-to-date information that was evidence-based and came from a trusted source. Participants noted that there is a lot of 'fad diet and misinformation out there" (Workshop 4) so the inclusion of references would be helpful. Participants liked the idea of articles that included external links for where to go for 'more in-depth information should people require it' (Workshop 1) and 'links to peer-reviewed publications' (Workshop 1). To ensure that users were aware of how up to date the information is, it was suggested that it would be useful if the resource included a 'this information is up to date at X' (Workshop 1) statement to maintain transparency.

4 | DISCUSSION

This participatory design study aimed to explore technology use among older adults and to qualitatively determine the content needs and design preferences for an online nutrition education resource tailored to older adults in Australia. Given the rise of diet-related disease burden among the ageing population, the provision of evidence-based nutrition education may be an essential first step in supporting healthy eating habits in older adults. Traditional approaches to nutrition education often do not account for the unique needs of older adults, and digital health approaches present a viable alternative. However, there are limited technologies that have been developed to cater to the needs of older adults, and this is essential to address perceived barriers to the acceptance and adoption of digital health solutions before implementation.

Our findings on the use of technology are largely in line with previous data highlighting that older adults regularly use technology and feel comfortable using a range of different devices, including smartphones, computers and tablets.[32] Consistent with the growth of

smartphone ownership in older adults, all participants stated that they owned and regularly used smartphones. For example, smartphone ownership in the United States increased by 48% between 2012 and 2021 in adults over the age of 65, and 78% of Australians aged 50 years and over used a smartphone to access the internet in 2020.[12,33] Although many participants noted that they generally preferred to use other devices (i.e., laptop, tablet) depending on what they were doing (e.g., searching for information), others preferred using a smartphone because it is convenient and portable. Most participants stated that they would prefer a nutrition education resource to be hosted on a website, rather than an app. This is consistent with previous findings that older adults prefer accessing online health-related information via a website as opposed to a smartphone app.[34] Overall, the most common type of information being sought by participants was related to health, indicating that older adults are accepting of technology to access health-related information. Furthermore, participants reported engaging with a range of nutrition-specific sources, highlighting the acceptability of online sources of nutrition information.

Although it was not a personal concern among our participants, a lack of familiarity with technology has frequently been cited as a barrier to adoption for older adults. Participants did note that when thinking about their older friends and family members, a lack of digital literacy was a potential barrier to technology use and meaningful engagement. This speaks to the notion of a digital divide. Data from the United States shows that there is a notable difference in the ownership and use of smartphones and tablets between adults aged 65–69 years and those aged 75–79 years, with ownership rates ranging from 59% and 41% and 31% and 28%, respectively.[35] Furthermore, individuals with higher education levels, specifically those with a bachelor's degree or higher, are significantly more likely to own a computer and/or smartphone.[21] Therefore, it is essential to recognise the existence of this digital divide when examining technology use among older adults as they may face obstacles in accessing online information and resources. These obstacles have the potential to impede their ability to participate in online activities, such as accessing vital health information. Being able to download and print online information into hard-copy formats is a common request from older adults,[36] and participants suggested that being able to export and print information to give to others who lack digital literacy skills may be a solution to address potential barriers to technology use. Although issues related to digital exclusion were not personally relevant to them, due consideration should be given to these issues when delivering digital health technologies to the wider population.

The ultimate goal of nutrition education is to provide individuals with the knowledge and skills to consume a healthy diet. Importantly, designing nutrition education programmes based on a prior needs assessment with the target population has been shown to support nutrition-related knowledge and behaviours among older adults.[37] The data from this study identified a range of specific informational and content requirements for crafting a nutrition education resource tailored to promote an anti-inflammatory dietary pattern. First, participants highlighted the need for general nutrition information, including details of what foods to prioritise, what foods to limit or avoid and the nutritional composition of foods (e.g., energy content). They also emphasised the need for practical advice, such as guidance on meal planning, using leftover ingredients, adapting recipes for smaller portion sizes, how to read nutrition panels on packaged foods and suggestions for what to order when eating out. This is a significant consideration, as practical nutrition knowledge and food skills—which encompass the wider components of meal preparation such as meal planning, grocery shopping and budgeting—are more closely linked to dietary behaviours than general nutrition knowledge.[38,39]

Given that preparing and cooking meals at home is associated with improved diet quality,[40] providing older adults with resources to facilitate this will not only allow them to actively apply their nutritional knowledge, but it will also promote the development of their cooking skills and boost their confidence in preparing healthy meals, which is likely to contribute to improving diet quality. Similar content requirements were identified in a sample of older adults in Germany using participatory design methods to design a nutrition chatbot, highlighting key similarities in the nutrition information needs of older adults across populations.[41] Collectively, these findings emphasise the multifaceted informational needs of older adults and provide a valuable foundation for shaping the content of nutrition education programmes aimed at improving diet quality in this demographic.

Although participants highlighted specific informational and content needs, more importantly, they desired the information to be personalised and tailored to the individual. This need for personalised health information has been consistently reported in the literature.[32] Furthermore, there is growing evidence to suggest that providing individuals with personalised feedback and advice is considerably more effective in prompting changes in dietary behaviours compared to generic, one size fits all information.[42] Older adults are also likely to be more trusting and confident in educational materials that are tailored and specifically relevant to them as an individual.[36] Personalised nutrition approaches offer individuals tailored dietary recommendations based on their unique characteristics, such as their current diet, health status (e.g., diagnosed conditions, blood glucose and cholesterol levels and food allergies) and personal preferences (such as taste preferences). In this context, digital health technologies are inherently well placed to deliver cost-effective personalised nutrition advice in real-time, and their feasibility and efficacy in improving dietary behaviours have already been demonstrated.[43] Further research is needed to investigate the feasibility and effectiveness of providing personalised nutrition education and advice, specifically based on an anti-inflammatory diet, to older adults via digital health technologies.

Written materials are a fundamental component of health-related education, including nutrition education. Among various methods of health education delivery (e.g., group classes), written health information (including online and hard copy) is favoured by older adults[36,44] and it allows them the flexibility to engage with the content in their own time and at their own pace. While ensuring

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appropriate readability levels of written materials is crucial, the layout and presentation of the information are equally vital aspects that contribute to overall suitability and usability of materials and are often overlooked.[45] Consistent with prior research,[36,46] participants noted several design and presentation principles to minimise issues with usability specific to the needs of older adults. This included the use of large and simple fonts, using dark type on a light background (i.e., black font on a white background) and incorporating clear categories to facilitate easy navigation. These suggestions represent just a fraction of the guidance available for developing effective written health education materials, drawing from the existing body of evidence.[47] The findings from this study, alongside the broader spectrum of evidence, emphasise the importance for researchers and health professionals to consider and consult these recommendations when creating and evaluating written health information for older adults. Moreover, there is a need for further research aimed at identifying the most critical design and presentation principles for enhancing the usability and uptake of online written health information and how these elements contribute to facilitating behaviour change.

This study is not without its limitations. Our recruitment strategy exclusively relied on online recruitment methods. While online strategies offer an innovative avenue to reach a wide audience of potential participants, they tend to attract individuals who are more affluent and possess higher levels of education.[48] This is consistent with the demographic profile of participants included in this study, where 94% of participants held postsecondary education qualifications (compared to approximately 31% of the general older adult population[1]). The sample is also relatively privileged in that most reported owning and using multiple different devices to access the internet. This constrained our study cohort to participants who regularly used and engaged with technology and reported being very comfortable using a range of different devices. Consequently, our study could not delve into the accessibility, engagement and appropriateness of technology for novice users or those without reliable access to technology. Future research should utilise a combination of online and offline recruitment channels in an effort to recruit diverse samples with differing levels of technology use and experience. Moreover, it is important to acknowledge that our sample is a self-selected group of individuals who are likely to be more health conscious, and therefore willing to engage with health-related research, than the general population. Therefore, it remains unclear to what extent these findings are applicable to the broader older adult demographic, and our capacity to generalise our findings is limited.

5 | CONCLUSION

The purpose of this study was to build an understanding of the content needs and design preferences for an online nutrition education resource. Specifically, older adults seek an online resource that has large and simple fonts with clear categories, providing them with practical advice and general nutrition information that can be personalised to suit their own needs and health concerns, with the option to export and print information into a paper-based format. Given the lack of online, self-directed and evidence-based nutrition education resources for older adults, the findings from this study can be used to design and develop digital health solutions that meet the needs and preferences of older adults. Although the proportion of older adults who use and engage with technology has increased over time, it is possible that the uptake of digital health solutions may be impacted by variations in digital literacy. Active co-design of digital health tools with the target population may assist with increasing adoption and acceptance; however, we must also consider the need for ongoing education and digital literacy training.

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CONFLICT OF INTEREST STATEMENT

Victoria M. Flood is the President-elect of the Nutrition Society of Australia, the Director of the Australian Rural Health Education Network and an Editor for the journals Nutrition & Dietetics and Nutrients. These are voluntary roles and no payment is received for the positions. The remaining authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ETHICS STATEMENT

This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving research study participants were approved by the University of Sydney Human Research Ethics Committee. Electronic informed consent was obtained from all participants.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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SUPPLEMENTARY MATERIAL

Supplementary Material 4.1. Participatory design workshop semi-structured prompted discussion guide

Domain 1: Research team and reflexivity	
Personal Characteristics	
Interviewer/facilitator: Which author/s conducted the interview or focus group?	HL – conducted 2 groups AT – took notes during the first 2 groups and conducted the second 2 groups
Credentials: What were the researcher's credentials? E.g. PhD, MD	AT holds a BPsych(Hons) and MBMSc
Occupation: What was their occupation at the time of the study?	AT is a PhD Candidate and Research Assistant
Gender: Was the researcher male or female?	AT is a female
Experience and training	
What experience or training did the researcher have?	AT has organised and conducted >10 individual semi-structured interviews with research participants. She was trained on conducting focus groups by HL
Relationship with participants	
Relationship established: Was a relationship established prior to study commencement?	AT had no prior relationships with any of the adults who took part
Participant knowledge of the interviewer: What did the participants know about the researcher? e.g. personal goals, reasons for doing the research	None of the participants knew the interviewer prior to the focus group
Interviewer characteristics: What characteristics were reported about the interviewer/facilitator? e.g. Bias, assumptions, reasons and interests in the research topic	No characteristics were reported
Domain 2: study design	
Theoretical framework	
Methodological orientation and Theory: What methodological orientation was stated to underpin the study? e.g. grounded theory, discourse analysis, ethnography, phenomenology, content analysis	Framework approach – thematic analysis
Participant selection	
Sampling: How were participants selected? e.g. purposive, convenience, consecutive, snowball	Convenience
Method of approach: How were participants approached? e.g. face-to-face, telephone, mail, email	Advertisements were posted on social media and volunteer research registers
Sample size: How many participants were in the study?	44 consented and invited 20 included in final analysis

Non-participation How many people refused to participate or dropped out? Reasons?	21 did not respond 3 agreed to take part but did not attend due to various reasons (e.g. sickness)
Setting	
Setting of data collection: Where was the data collected? e.g. home, clinic, workplace	Online using Zoom teleconference
Presence of non-participants: Was anyone else present besides the participants and researchers?	No
Description of sample What are the important characteristics of the sample? e.g. demographic data, date Data collection	N/A – demographic data was not collected
Interview guide: Were questions, prompts, guides provided by the authors? Was it pilot tested?	Questions were asked by the interviewer but were not provided to participants
Repeat interviews: Were repeat interviews carried out? If yes, how many?	4x focus groups were held until thematic saturation was reached
Audio/visual recording: Did the research use audio or visual recording to collect the data?	Audio recording was used to collect data via Zoom teleconference
Field notes: Were field notes made during and/or after the interview or focus group?	Yes, during and after
Duration: What was the duration of the interviews or focus group?	2 hours
Data saturation: Was data saturation discussed?	Yes
Transcripts returned: Were transcripts returned to participants for comment and/or correction?	No
Domain 3: analysis and findings	
Data analysis	
Number of data coders: How many data coders coded the data?	Two data coders for 25% of data (AT and HL), AT coded remaining independently
Description of the coding tree: Did authors provide a description of the coding tree?	Yes
Derivation of themes: Were themes identified in advance or derived from the data?	Derived from the data
Software: What software, if applicable, was used to manage the data?	Transcripts produced in Microsoft Word, thematic analysis in NVivo 12
Participant checking: Did participants provide feedback on the findings?	No
Reporting	
Quotations presented: Were participant quotations presented to illustrate the themes / findings? Was each quotation identified? e.g. participant number	Yes
Data and findings consistent: Was there consistency between the data presented and the findings?	Yes

Clarity of major themes: Were major themes clearly presented in the findings?	Yes
Clarity of minor themes: Is there a description of diverse cases or discussion of minor themes?	Yes

Supplementary Material 4.2. Participatory design workshop semi-structured prompted discussion guide

PARTICIPATORY DESIGN WORKSHOP
DRAFT AGENDA

Study Title: Participatory design to inform a subsequent online nutrition education program for older adults

Welcome and workshop overview (15 minutes)
- Introduction and housekeeping
- Overview of the workshop

DISCOVERY (45 minutes):
Exposure to the Mediterranean diet/nutrition education –
- Have you ever actively sought out nutrition information? Where do you go to find the information you want/need (e.g. dietitian/nutritionist, searching for info online, intervention study, etc)?
- Have you ever heard of the Mediterranean diet before?
- If yes, do you know anything about the diet (e.g. typical foods/meals to include/exclude, cooking methods)?

Technology use among older adults –
- How comfortable are you using technology and/or accessing the internet?
- If you use the internet, what sort of websites/services do you use?
- What kind of devices are you using to access the internet (e.g. computer, smartphone, iPad/tablet)? Use of apps versus websites?
- What turns you off when you look at a website (e.g. movement, colour, too much text, etc)? What brings you back to an app/website? What helps you to stay engaged (e.g. quality of info, games, necessity, etc)? Examples from participants of websites and/or apps that they use/like → provide examples of good/bad websites geared towards older adults for feedback on what's good vs bad (e.g. Lumosity).
- Do you use technology to access health and wellbeing services or information? Have you ever engaged in any online health-related programs (e.g. online IQ tests, cognitive brain training, exercise, etc)? Engagement in telehealth (e-Health) health services (e.g. GP, dietitian, etc)? If yes, via phone, Zoom, Skype etc.

BREAK (15 minutes)

PROTOTYPING (45 minutes):
- If there were no limitations, and any were possible, what would you want from a technology solution to provide nutrition education for healthy ageing?
- Consider: what kind of technology is it (e.g. app, website)? How do you want to access it (e.g. smartphone, computer)? What could it look like? Who is it for? When would they use it? What does it include? What kind of supports would be included (e.g. links to other resources/nutritionists/dietitians, recipes, cooking demos)?
- Would you want functionality to track food intake or general diet adherence, weight, other health outcomes?

- Would you like a reward system as a part of tracking the above? Reward for engaging with diet versus reward for success – what kind of goals would you set re improving food quality (goals re other health outcomes?)?
- Is this something you would be able to use independently, or share among family/friends/social group?

- Potential: show examples of different resources available (websites, brochures, etc) – what things do you like? What things do you not like?

EVALUATION (30 minutes):

- What other considerations need to be accounted for the older adult community?
- What would you see as some issues accessing this type of support online?
- Implementation – how would you want this implemented into your health care (independent, with a dietitian/other health professional)? Phone calls, text messages, etc.

Wrap up and thoughts (10 minutes)

- Questions
  Thoughts / feedback

CHAPTER FIVE

USABILITY AND ACCEPTABILITY OF AN ONLINE NUTRITION EDUCATION RESOURCE

Preface

With the increasing availability of digital health solutions, there has been a significant increase in the number of consumers, including older adults, using the internet and digital tools to access health and nutrition information. Despite facing some unique barriers to technology use, older adults express a strong interest in and motivation to engage with digital health solutions and report frequently searching for nutrition-related information online. In this context, the Low InFlammaTory (LIFT) diet website, initially designed with and for patients with liver disease, emerges as a potential solution for delivering cost-effective, scalable, and evidence-based nutrition education with appropriate tailoring to the technology needs and preferences of older adults. By leveraging features of the LIFT website, it can effectively serve as a valuable resource for providing educational content on anti-inflammatory dietary patterns to this population.

The aim of this study was to evaluate the usability and acceptability of the LIFT website for older adults. It also investigated whether engaging with the LIFT website improved nutrition knowledge and dietary intake over a 4-week period.

The existing LIFT website was chosen to test with older adults as it includes many of the necessary features that were identified by participants in Chapter 4, such as general nutrition information (e.g., foods to consume and foods to limit or avoid as part of a low-inflammatory diet), practical advice on meal planning and suggestions to what to order when eating out, and recipes. It also aligned with the identified general design principles including use of clear categories, large and simple fonts, and dark type on a white background. However, it is important to acknowledge that the LIFT website did not arise directly from the participatory design research presented in Chapter 4.

This chapter is being prepared for submission.

5.1 Abstract

Background: Non-communicable chronic diseases impose a significant burden on global healthcare systems, particularly in the context of the increasing ageing population. Systemic low-grade inflammation is associated with the development and progression of many chronic diseases, making it a target for promoting healthy ageing. There is evidence to suggest that consuming an anti-inflammatory diet, such as the Mediterranean diet, can reduce inflammation and chronic disease risk. However, adherence to the Mediterranean diet is low among older adults, which may be attributable to unfamiliarity with this style of eating. This study explores the potential of digital health technologies, specifically the Low InFlammaTory (LIFT) diet website, to deliver anti-inflammatory nutrition education to older adults. The study evaluates the usability and acceptability of the LIFT website, as well as the impact of the content on nutrition knowledge and dietary intake.

Methods: Participants were adults 55 years and older. They completed a series of web-based questionnaires regarding their background, nutrition knowledge and Mediterranean diet adherence and subsequently were invited to engage with the LIFT website for a period of 4-weeks. Following this, participants were asked to complete the same questionnaires plus additional measures of engagement, patterns of use and overall feedback on the LIFT website.

Results: A total of 57 participants consented to participate in the study; however, only the data from 28 participants who completed the survey after 4 weeks were included in the analyses. Although there was no change in overall nutrition knowledge, there was an increase in knowledge of core Mediterranean diet dietary patterns, foods, and meal choices. This coincided with a modest but statistically significant increase in adherence to the Mediterranean diet (mean score 62.6 vs 66.2, $p = 0.04$). In relation to the LIFT website, ease of use, the nature of the information, and the aesthetic of the website were favoured features. Participants suggested that improvements could be made by incorporating personalised advice based on health conditions and dietary requirements, and providing expanded and more specific information with links to additional resources with further supporting evidence or research.

Conclusions: Digital health technologies are inherently well placed to improve access to evidence-based, cost-effective and scalable interventions to improve the dietary habits of older adults. Although access to the LIFT website did not change overall nutrition knowledge, it did facilitate increased adherence to the Mediterranean diet. Feedback from participants will be used to inform the iterative redesign and development of the resource, with the aim of enhancing usability and engagement with the website for the target population.

5.2 Introduction

Non-communicable chronic diseases are the leading cause of disease burden and disability in older adults worldwide [1], imposing a significant economic burden on healthcare systems across the globe [2]. Chronic low-grade inflammation is a common feature in both ageing and the development of many chronic conditions – including cardiovascular disease, type 2 diabetes, metabolic syndrome, and obesity [3] – and may represent a key mechanistic target for reducing chronic disease risk and promoting overall healthy ageing. While inflammation is not the only driver of these conditions, there is ample evidence that supports the role of lifestyle behaviours, such as diet, in modifying chronic inflammation [4]. Indeed, several large-scale epidemiological studies have documented the relationship between dietary patterns and inflammatory markers. These studies have demonstrated that Western dietary patterns – generally characterised by high intake of red meat, processed foods and foods high in added sugar, and low intake of fruits, vegetables, and whole grains – are positively associated with markers of inflammation [5].

In contrast, anti-inflammatory dietary patterns focus on foods and nutrients that ameliorate inflammatory processes. Known for its anti-inflammatory properties, the Mediterranean diet emphasises consumption of fruits, vegetables, wholegrains, legumes, and nuts, with healthy fats primarily from extra virgin olive oil [6,7]. It has been linked to a wide range of health benefits, including a reduced risk of cardiovascular disease in older adults [8]. Importantly, the positive health effects observed in older adults indicate that it is never too late to improve health status through dietary modifications. Thus, it appears that low- or anti-inflammatory diets could offer a viable opportunity to minimise the impacts of chronic disease and support healthy ageing [9].

In Western countries, overall diet quality tends to be poor. In Australia, for example, less than 80% of the older adult population meets current dietary recommendations for fruit and vegetable intake [10], and around one third of their daily energy intake is derived from discretionary food choices [11]. This pattern holds true across other countries, including the United States and New Zealand [12,13]. Encouraging individuals to substitute their energy-dense, nutrient-deficient eating habits with healthier dietary patterns is a significant public health challenge. Behaviour change is complex and there are numerous factors that influence health behaviour and one's capacity for behaviour change. Alongside determinants such as access, preference, and cost, knowledge and understanding are essential for informing and changing health- and nutrition-related behaviours [14]. There is a plethora of evidence supporting the link between nutrition knowledge and dietary behaviours, with studies demonstrating that those who possess a higher level of knowledge of what constitutes a

healthy diet are more likely to consume more fruits and vegetables [15,16]. Additionally, nutrition education programs delivered to older adults have been shown to increase their overall nutrition knowledge, and subsequently resulted in improved dietary intake [17,18].

In Mediterranean diet interventions specifically, the use of education to improve knowledge and understanding (generally delivered in an in-person group-based or individual lecture format) is the most commonly utilised behaviour change strategy [19]. Tools such as food hampers containing essential Mediterranean diet components (e.g., extra virgin olive oil, legumes), recipes, and checklists for monitoring adherence are also commonly used to guide individuals in adopting this dietary pattern [20,21]. While the use of food provision and traditional in-person lectures have been shown to be effective in small-scale studies [17,18], this approach is not be well-suited for population-level approaches, particularly when considering who assumes the financial burden associated with food provision and the impact of physical limitations or transportation barriers. While many national dietary guidelines across the globe are based on an anti-inflammatory Mediterranean-style dietary pattern, nutrition and dietetic professionals in non-Mediterranean regions have identified a gap in the availability of patient education resources tailored to the Mediterranean diet [22], emphasising need for targeted educational materials that can be delivered in a way that suits the needs of older adults.

Digital health solutions are a potential alternative to traditional educational programs and with increasing access to technology and the internet, may be a feasible option for older adults [23,24]. Online interventions are cheaper, more efficient, and can be delivered on a larger scale compared to standard models of care, making them ideal for major public health issues [25]. The increasing availability of digital health solutions has led to a rise in consumers using the internet to find health- and nutrition-related information [26]. Importantly, emerging evidence supports the use of digital health technologies to support and reinforce health behaviours [27,28], and in the self-management and treatment of various health conditions, including diabetes, obesity, and depression and anxiety [29-31]. Although there are several unique barriers to technology use for older adults, including technology-related anxiety and lack of digital literacy [32,33], many older adults report a high level of interest and motivation to use digital health technologies to support healthy ageing [34].

With the proliferation of easily accessible, online health-information and near universal access to the internet, there is an overwhelming amount of nutrition information available that is rapidly transmitted from reputable and qualified individuals as well as non-credentialed “experts” [35]. This has resulted in conflicting and often misleading information available online. As such,

there is a need for credible and trustworthy resources that provide evidence-based nutrition information to help older adults make informed decisions about their diet and guide them towards healthier food choices.

The Low InFlammaTory (LIFT) diet resource

The Low InFlammaTory (LIFT) diet website is an online, interactive resource that provides educational material relevant to an anti-inflammatory way of eating (Figure 5.1). Although the Mediterranean diet is the most commonly referenced type of anti-inflammatory diet, the choice of website name was to acknowledge the various styles of cuisines that follow the basic principles of an anti-inflammatory diet but are not limited to the Mediterranean region [9]. This was thought to be particularly important within the multicultural context of Australia, and likely applicable for other diverse populations [36]. The LIFT materials were developed by researchers and nutrition and dietetic professionals at the University of Sydney (led by VMF) and the Western Sydney Local Health District (WSLHD), with funding support from WSLHD. The website has been designed to be viewed on a desktop computer but is also mobile responsive for users who prefer to use a smartphone and/or tablet. The educational content provides users with information on what the LIFT diet is and how to adhere to it, based on a traffic light system (i.e., foods to eat regularly are categorised as ‘green’, foods to eat occasionally as ’amber’, and foods to be avoided or limited are categorised as ‘red’). There is also information on the best cooking methods to use while following the LIFT diet, a shopping guide with a quick list of anti-inflammatory foods to be kept in the fridge, freezer and pantry, and a range of recipes using a variety of low-inflammatory ingredients to cover meals for breakfast, lunch, and dinner. Several of the more popular recipes have a demonstration video with written step-by-step instructions attached, both of which are available in multiple languages. There are a range of featured articles that provide more detailed information about specific components of the LIFT diet, for example, information about types of and ways to cook legumes, the benefits of cooking with extra virgin olive oil, and tips for dining out when following the LIFT diet including suggestions of low-inflammatory options from different cuisines (e.g., Asian, Italian, Middle Eastern and Indian).

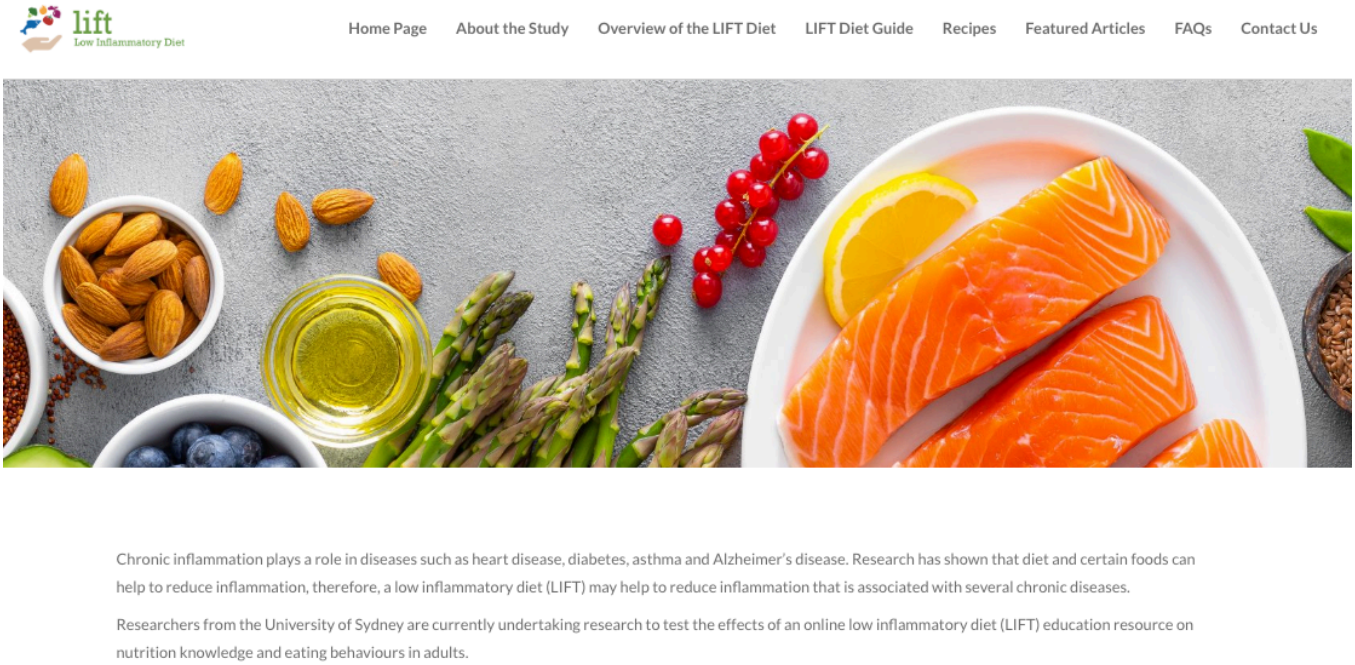

Figure 5.1. Screenshot of the LIFT website landing page

The LIFT website may be an appropriate resource to deliver low-cost, wide-reaching, and evidence-based nutrition education specific to a low-inflammatory way of eating that meets the unique needs and preferences of older adults. The website was originally developed to assess the impacts of a low-inflammatory diet among people with liver disease, and this research is still ongoing. This study aims to evaluate the usability and acceptability of a version of the original LIFT that was adapted for this study's purpose. This study also investigates the effect of using the adapted LIFT website on nutrition knowledge and dietary intake.

5.3 Methods

5.3.1 Participants

Participants were adults 55 years and older who were proficient in English, lived in Australia, and completed the informed consent procedure. Due to the naturalistic study design, the sample size of participants who could interact with the website was not predetermined. Aligning with our previous work, we defined older adults as aged ≥55 years as this represents the age range when addressing risk factors for healthy ageing (e.g., cardiovascular disease, diabetes, obesity) is typically recommended [37]. Participants were recruited via advertisements posted on Facebook and the JoinUs research register between September 2022 and April 2023. JoinUs is a national register that matches eligible volunteers to research studies based on the inclusion and exclusion criteria. Interested participants were directed to a study-specific webpage on REDCap (Research Electronic Data Capture) where they were

able to read detailed study information and provide electronic informed consent. This study was approved by the University of Sydney Human Research Ethics Committee (#2022/423).

5.3.2 User engagement with the LIFT website

Participants were invited to engage with the LIFT website naturalistically (i.e., at their own discretion) for 4 weeks. Participants were informed that they could use the website as little or as much as they liked, and no further specifications were set in terms of frequency or patterns of use.

5.3.3 Data collection

Before website access was granted, participants were asked to complete an online survey. Survey data were collected and managed using REDCap, hosted at the University of Sydney [38,39]. REDCap is a secure, web-based software platform designed to support data capture for research studies, providing 1) an intuitive interface for validated data capture; 2) audit trails for tracking data manipulation and export procedures; 3) automated export procedures for seamless data downloads to common statistical packages; and 4) procedures for data integration and interoperability with external sources. The survey was divided into three sections:

Section 1 consisted of open- and closed-ended questions related to the participants' demographic characteristics, including age, sex, level of education, country of birth, language spoken at home, diagnosed health conditions, height, and weight.

Section 2 included the Mediterranean Diet Nutrition Knowledge Questionnaire (Med-NKQ) [40]. The Med-NKQ is a 20-item tool, validated to assess knowledge of the Mediterranean diet in an Australian population. The questionnaire assesses three main domains of knowledge: 1) dietary patterns, foods, and nutrients to reduce cardiac risk factors (four questions, scores ranging from 0 – 10); 2) nutrient content of foods, quantification, and food label reading (seven questions, scores ranging from 0 – 15); and 3) core Mediterranean diet foods, dietary patterns, and meal selection (nine questions, scores ranging from 0 – 15). A total score ranging from 0 – 40 is calculated by summing the domain scores, with higher scores indicating greater knowledge.

Section 3 included the Mediterranean Diet and Culinary Index (MediCul) [41]. The MediCul is a 50-item dietary survey to assess adherence to a traditional Mediterranean dietary pattern within a Western population. It measures consumption of nine dietary elements that are desirable features of a traditional Mediterranean diet, and four elements that are undesirable

features of a Western diet. A total adherence score is calculated (ranging from 0 to 100), with a higher score indicating greater adherence. The MediCul was selected to assess Mediterranean diet adherence as it was developed in Australia and validated for use with older adults, it is relatively quick to complete and compute scoring for (compared to a traditional food frequency questionnaire), and it measures some unique aspects and lifestyle factors of the Mediterranean diet that aren't captured in other tools [41]. It can also be used to derive scores for the Mediterranean Diet Adherence Screener (MEDAS), used in the PREvención con DIeta MEDiterránea (PREDIMED), ranging from 0 to 14 with higher scores indicating greater adherence [42]. Participants were also asked about barriers and facilitators to changing their habitual diet.

After 4 weeks, participants were invited to complete a series of follow-up questionnaires, including sections 2 and 3 of the baseline survey and two additional surveys: 1) the User Engagement Scale – short form (UES-SF); and 2) self-reported frequency of use and feedback on the LIFT website. These questions have been piloted with a sample of adults with liver disease in relation to their experience using the LIFT website. The UES-SF is a 12-item tool that has been validated to assess user engagement with digital technologies in Western populations [43]. Engagement is measured across four domains:

- Aesthetic appeal: The attractiveness and visual appeal of the interface.
- Focused attention: Feeling absorbed in the website and losing track of time.
- Perceived usability: Negative affect experienced as a result of the website and the degree of control and effort expended.
- Reward: The overall success of the website, curiosity and interest in the website, and the sense of being "drawn in" and having fun.

Each question is rated on a 5-point Likert scale, ranging from strongly disagree (1) to strongly agree (5). Scores for each domain are calculated by adding the values of responses for the three items contained in each subscale and dividing by three (range 1 – 5). A total score is calculated by adding all the items together and dividing by 12 (range 1 – 5), with higher scores indicating greater user experience.

5.3.4 Data analysis

Data were analysed using Statistical Package for the Social Sciences (SPSS, Version 28). Descriptive data are reported as mean ± standard deviation (SD) for continuous data and frequencies and percentages for categorical data. Paired t-tests were used to compare pre- and post-website engagement nutrition knowledge and Mediterranean diet adherence.

McNemar's tests were used to analyse within-group differences for categorical variables. Associations between variables were analysed using Pearson's correlation for continuous variables and Fisher's exact test for categorical variables, as appropriate for data distribution. All analyses were two-tailed and used an alpha level of 0.05.

5.4 Results

5.4.1 Demographics

A total of 57 participants consented to participate in the user testing. Of these, 34 participants completed the baseline questionnaires and were given access to engage with the LIFT website. Only data from the 28 participants who completed the follow-up survey after 4 weeks were included in the analyses. The demographic information of this sample is presented in Table 5.1. Overall, the sample ranged in age from 56 – 74 years (63.9 ± 5.0), were mostly female (*n* = 26, 92.9%), and had a tertiary-level education (*n* = 21, 75.0%).

Table 5.1. Demographic characteristics of study participants

Continuous variables	**M**	**SD**
Age, years	63.9	5.0
Body mass index, kg/m^{2a}	26.9	4.6
Categorical variables	**n**	**%**
Sex		
- Male	2	7.1
- Female	26	92.9
Education level		
- Postgraduate	13	46.4
- Bachelors	8	28.6
- Advanced certificate/diploma	6	21.4
- Secondary (Year 7-12)	1	3.6
Country of birth		
- Australia	21	75.0
- United Kingdom	4	14.3
- New Zealand	1	3.6
- Other[b]	2	7.1
Language spoken at home		
- English only	27	96.4
- Other[c]	1	2.9
Living circumstances		
- Living on my own and independent	9	32.1
- Living with family	19	67.9
Diagnosed health condition, % yes		
- Cancer	2	7.1
- Diabetes (Type 2)	3	10.7
- Heart disease	2	7.1

- Kidney disease	1	3.6
- Lung condition	2	7.1
- Mental health condition	10	35.7
- Other[d]	16	57.1
- No long-term health condition/s	6	21.4
Main grocery shopper		
- Yes	19	67.9
- I share the responsibility	9	32.1
Self-rated diet quality		
- Excellent	8	28.6
- Very good	9	32.1
- Good	9	32.1
- Average	1	3.6
- Poor	1	3.6

[a] Data missing for n = 1.
[b] Includes El Salvador and Canada.
[c] Includes German.
[d] Includes osteoporosis, osteoarthritis, Hashimoto's disease, rheumatoid arthritis, glaucoma, lupus, chronic fatigue syndrome, and sleep apnoea.

5.4.2 Self-reported dietary intake

The scores for the MediCul and MEDAS are presented in Table 5.2. The mean MediCul score at baseline was 62.6/100 (*SD* = 10.4). Adherence to the Mediterranean diet significantly increased at follow-up, with an increase in the mean MediCul score to 66.2/100 (*SD* = 12.2, *p* = 0.04).

Table 5.2. Self-reported dietary intake according to the MediCul at baseline and follow-up

	Baseline			Follow-up				
Domains	**M**	**SD**	**Range**	**M**	**SD**	**Range**	**t**	**p**
MediCul score, /100	62.6	10.4	37.5 – 81	66.2	12.2	41 – 85	-2.2	0.04
MEDAS score, /14	7.5	1.6	5 – 10	7.8	1.7	5 – 11	-1.1	0.27

Abbreviations. MEDAS, Mediterranean Diet Adherence Screener.

The mean MEDAS score at baseline was 7.5/14 (*SD* = 1.6) and did not increase significantly at follow-up (*M* = 7.8/14, *p* = 0.27). At baseline, only three participants (10.7%) achieved a MEDAS score of >10, which has been classified as a high adherence that is associated with better health outcomes in PREDIMED. At follow-up, five participants (17.9%) achieved this level of adherence, a difference that was not statistically significant.

At baseline, less than half of the sample reached defined Mediterranean thresholds for consumption of selected foods and 'traditional' aspects of the cuisine [41], including for olive oil (*n* = 0, 0%), vegetables (*n* = 8, 28.6%), fruit (*n* = 8, 28.6%), legumes (*n* = 9, 32.1%), sofrito (sauce made with tomato, onion, garlic and olive oil) (*n* = 10, 35.7%), and dark leafy green vegetables (*n* = 11, 39.3%) (Figure 5.2). Less than half had an adequate intake of nuts (*n* = 12, 42.9%) and fish (*n* = 11, 39.3%). Although 22 participants (78.6%) reported that olive oil was the main type of fat consumed (90.9% extra virgin olive oil), almost half of this group consumed less than two tablespoons of olive oil per day (*n* = 10, 45.5%).

There was a small proportion of the sample who were consuming alcohol on five or more days of the week (*n* = 3, 10.7%). Of these participants, two were consuming more than 14 standard drinks (7.2%) and one was consuming almost ten standard drinks across drinking occasions (3.6%). One participant was consuming more than 14 standard drinks across less than five occasions in a week (3.6%). The majority reported cooking most of their main meals at home (*n* = 27, 96.4%) and limiting sugar-sweetened beverages (*n* = 25, 89.3%) and takeaway foods (*n* = 25, 89.3%).

After engaging with the LIFT website, there was an increase in the proportion of the sample consuming >4 tablespoons of olive oil per day (*n* = 3, 10.7%), >3 serves of legumes per week (*n* = 14, 50.0%), >5 serves of nuts per week (*n* = 16, 57.1%), and <1 cup of sugar-sweetened beverages per week (n = 28, 100%), although these differences were not statistically significant (all *p* >0.05).

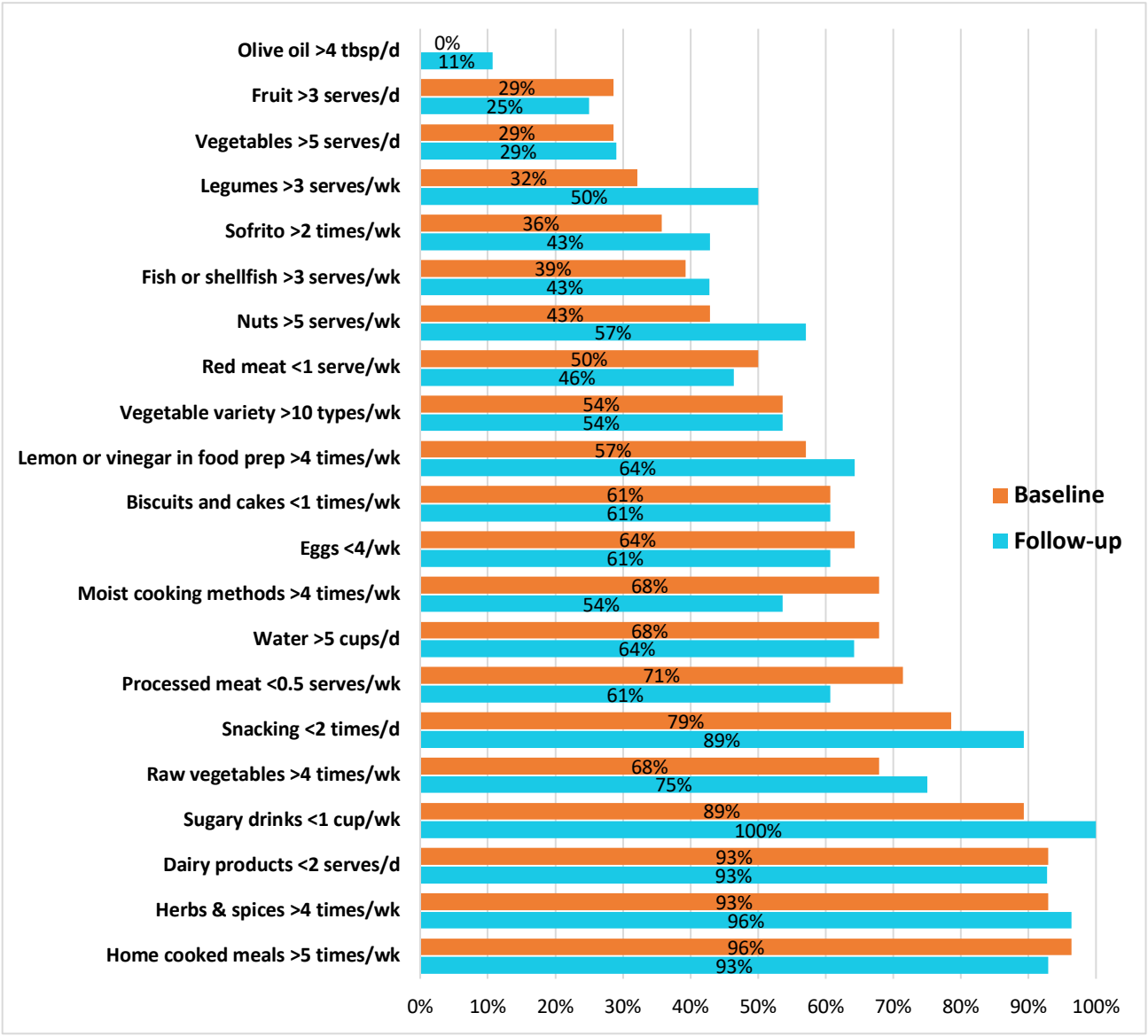

Figure 5.2. Percentage of participants who reached Mediterranean diet thresholds for intake at baseline and follow-up

5.4.3 Nutrition knowledge

As shown in Table 5.3, the mean Med-NKQ score at baseline was 30.6/40 (*SD* = 4.9, range 11 – 37). This increased to 31.8/40 (*SD* = 5.3, range = 16 – 39) at follow-up, however this difference was not statistically significant ($p = 0.09$). There were no participants who scored full points on the total questionnaire at baseline or follow-up (*n* = 28, 100%).

Table 5.3. Nutrition knowledge according to the Med-NKQ at baseline and follow-up

	Baseline			Follow-up				
Domains	**M**	**SD**	**Range**	**M**	**SD**	**Range**	**t**	**p**
Domain 1 score, /10	8.3	1.8	1 – 10	8.6	1.9	1 – 10	-1.5	0.13
Domain 2 score, /15	10.2	2.5	6 – 15	10.5	2.8	5 – 15	-0.5	0.63

Domain 3 score, /15	12.1	2.2	4 – 14	12.7	2.9	4 – 15	-2.1	0.04
Total	30.6	4.9	11 – 37	31.8	5.3	16 – 39	-1.8	0.09

Note. Domain 1, Dietary patterns, foods, and nutrients for reducing cardiac risk factors; Domain 2, Nutrient content of foods, quantification, and food label reading; Domain 3, Core Mediterranean diet foods, dietary patterns, and meal selection.

5.4.3.1 Domain 1: Dietary patterns, foods, and nutrients for reducing cardiac risk factors

The mean score on Domain 1 was 8.3/10 (*SD* = 1.8) at baseline and 8.6/10 (*SD* = 1.9) at follow-up. This increase was not statistically significant ($p = 0.13$). At baseline, there was one question covering general nutrition facts where 75% or more of the participants scored full points. At follow-up, there was one additional question asking about foods likely to raise blood cholesterol where 75% or more of the sample scored full points, although the proportion of participants who were able to correctly answer this question was not different between baseline and follow-up ($p = 0.07$).

5.4.3.2 Domain 2: Nutrient content of foods, quantification, and food label reading

The mean score on Domain 2 was 10.2/15 (*SD* = 2.5) at baseline, and increased by 0.3 points to 10.5/15 (*SD* = 2.8) at follow-up, a difference that was not significant ($p = 0.63$). At both timepoints, there were three questions within this domain where 75% of more of the sample scored full points. These questions covered the recommended number of servings of vegetables per day, foods with a good source of fibre, and the ability to accurately read a nutrition information panel to identify the product with the most amount of salt. On a question that asked participants to select the alcoholic beverage with the lowest number of standard drinks (200mL red wine *vs.* 375mL full-strength beer *vs.* 60mL dark spirit), less than half of the participants were able to do so at both timepoints (32.1% at baseline, 42.9% at follow-up, not statistically significant [$p = 0.51$]).

5.4.3.3 Domain 3: Core Mediterranean diet foods, dietary patterns, and meal selection

The mean score on Domain 3 was 12.1/15 (*SD* = 2.2) at baseline and significantly increased to 12.7/15 (*SD* = 2.9) at follow-up ($p = 0.04$). There were six questions within this domain where 75% or more of the participants scored full points at both timepoints. These questions covered meal options that align with the Mediterranean diet, foods used to add flavour to meals and drinks typically consumed as a part of the Mediterranean diet. At baseline, less than 20% of participants ($n = 5$) were able to correctly identify the cooking methods typical of the Mediterranean diet. At follow-up, the number of participants who were able to correctly identify

cooking methods typical of the Mediterranean diet increased (*n* = 13, 46.4%) with a simultaneous decrease in the number of participants identifying incorrect cooking methods such as high heat stir-frying and barbeque (*n* = 15, 53.6%) (*p* = 0.02).

5.4.4 Barriers and facilitators to dietary change

5.4.4.1 Barriers

Almost half of the participants (*n* = 13, 46.4%) stated that cost was a barrier to making changes to their current diet. Just under one-third of participants (*n* = 8, 28.6%) stated that they were satisfied with their current diet and 21% (*n* = 6) stated that a lack of knowledge would make it more difficult to adopt a new dietary pattern. A small proportion of the sample (*n* = 3, 10.7%) reported that being unable to access healthy food, a lack of time for cooking, and inconvenience were barriers to change. There were no significant relationships between the number of barriers identified and nutrition knowledge (total or domain scores) or Mediterranean diet adherence (all *p* >0.05).

5.4.4.2 Facilitators

Seventy-one percent (*n* = 20) of participants stated that educational information would help them make dietary changes. Approximately 60% (*n* = 17) stated that ongoing nutritional support and access to meal preparation resources, such as meal plans and recipes, would help them make changes to their diet. Just under half (*n* = 12, 42.9%) would like one-on-one support from a nutritionist and/or dietitian. There were no significant relationships between the number of facilitators identified and nutrition knowledge (total, domain 2, and domain 3) and Mediterranean diet adherence (all *p* >0.05). The number of facilitators identified was significantly related to their knowledge of foods and nutrients to reduce cardiac risk factors (*r* = 0.39, *p* = 0.04).

5.4.5 Use of the LIFT website

Table 5.4 shows the patterns of use of the LIFT website, with most participants having used the website once or twice in the 4 weeks since the point of invitation (*n* = 14, 50.0%).

Table 5.4. Patterns of use of the LIFT website

Question	Participant, *n (%)*
When did you first use the LIFT website?	
Today	0 (0)
Less than a week ago	4 (14.3)
Less than a month ago	12 (42.9)
More than a month ago	12 (42.9)
How often did you use the platform?	

Every day or almost every day	0 (0)
Once or twice a week	5 (17.9)
Once or twice a month	14 (50.0)
Less than once a month	9 (32.1)
How many times (in total) have you logged into the LIFT website?	
1 time	8 (28.6)
2-5 times	18 (64.3)
6-10 times	2 (7.1)
11-20 times	0 (0)
>20 times	0 (0)
When using the LIFT website, how long did you normally stay logged on?	
1-5 mins	3 (10.7)
6-10 mins	12 (42.9)
11-20 mins	9 (32.1)
20-30 mins	4 (14.3)
When would you most commonly use the LIFT website?	
Early morning (5am to 9am)	3 (10.7)
Mid-morning (9am to noon)	5 (17.9)
Early afternoon (noon to 3pm)	4 (14.3)
Mid-afternoon (3pm to 6pm)	9 (32.1)
Evening (6pm to 11pm)	7 (25.0)
What device did you most commonly use to access the LIFT website?	
Personal laptop	11 (39.3)
Smartphone	10 (35.7)
Tablet	4 (14.3)
Personal desktop computer	2 (7.1)
Shared desktop computer	1 (3.6)

5.4.6 Usability and acceptability of the LIFT website

Table 5.5 shows the results of user engagement with the LIFT website as measured by the UES-SF. The highest rated subscales of the UES-SF were reward (*M* = 3.6/5, *SD* = 0.9) and aesthetic appeal (*M* = 3.5/5, *SD* = 0.6).

Table 5.5. User engagement with the LIFT website as measured by the UES-SF

UES-SF factor	**Score, /5**
Focussed attention	2.4 ± 0.9
Perceived usability	2.7 ± 0.8
Aesthetic appeal	3.5 ± 0.6
Reward factor	3.6 ± 0.9
Total	3.0 ± 0.4

Note. Data are presented as mean ± SD.

Table 5.6 represents general feedback on the LIFT diet and its delivery through the online website. The majority of participants reported there was just the right amount of information

provided on the website (*n* = 18, 64.3%), the information was easy to understand (*n* = 25, 89.3%) and helped them to follow the LIFT diet (*n* = 15, 53.6%).

First impressions of the LIFT website were generally positive, with participants commenting that it looked good and was aesthetically pleasing, and included clear and useful information. When asked about their preferred features of the website, participants stated that they liked the access to background information, recipes, and the practical advice on food staples to have in the fridge and pantry. Participants also provided valuable suggestions of how to best improve the LIFT website to enhance the user experience and promote engagement, including providing more information relevant to specific diets and conditions (e.g., Hashimoto's disease), links to additional resources, and more recipes (further qualitative feedback is provided in Supplementary Material 5.1).

Table 5.6. User feedback on the LIFT diet and the LIFT website

Question	Participant, *n (%)*
The LIFT diet was easy to stick to	
Strongly agree	3 (10.7)
Agree	12 (42.9)
Neutral	10 (35.7)
Disagree	2 (7.1)
Strongly disagree	1 (3.6)
I found that the LIFT diet involved	
Too many changes from my usual diet	2 (7.1)
Some changes from my usual diet	9 (32.1)
Not many changes from my usual diet	17 (60.7)
I found that the amount of information provided on the website was	
Not enough	7 (25.0)
Just right	18 (64.3)
Too much	3 (10.7)
I found that the information provided on the website was useful and helped me to follow the LIFT diet	
Strongly agree	4 (14.3)
Agree	11 (39.3)
Neutral	11 (39.3)
Disagree	1 (3.6)
Strongly disagree	1 (3.6)
I found that the information provided on the website was easy to understand	
Strongly agree	6 (21.4)
Agree	19 (67.9)
Neutral	2 (7.1)
Disagree	1 (3.6)
Strongly disagree	0 (0)
I found the recipes easy to follow	
Strongly agree	1 (3.6)
Agree	19 (67.9)
Neutral	2 (7.1)

Disagree	1 (3.6)
Strongly disagree	0 (0)
The recipes used ingredients that I was familiar with	
Strongly agree	3 (10.7)
Agree	22 (78.6)
Neutral	2 (7.1)
Disagree	1 (3.6)
Strongly disagree	0 (0)
To what extent did you use the video recipes?	
Not at all	20 (71.4)
To some extent	8 (28.6)
To a large extent	0 (0)

5.5 Discussion

The purpose of this study was to assess the acceptability, usability, and impact of the LIFT website, an online anti-inflammatory diet education resource, for older adults. Having engaged with the LIFT website, participants did not report difficulty in using the resource, with many stating that the website was *easy to use, easy to read* and *easy to access.* Despite this, more than one-quarter of participants stated that they had only used the website once. Conventional perspectives of 'technology acceptance' revolve around an individual's intentions to adopt a particular technology [32]. Adoption is often conceptualised as a binary outcome, whether a technology is initially selected for use or not. However, this perspective does not consider post-adoption usage and it is important to acknowledge that initial adoption is not always followed by continued usage and engagement [44]. As the majority of participants subjectively rated their diet quality as excellent and self-reported that the LIFT diet did not involve many changes from their usual diet, they may not have seen a need for continued usage of the website. This aligns with previous findings that older adults tend to use technology only when they perceive it as personally relevant to their current or future needs [45]. It is worth noting that the participants in this study already had relatively high knowledge levels and did not necessarily require extensive education provided by the website. Therefore, the LIFT website may be more suitable for populations with lower baseline knowledge and poorer dietary intake, where educational resources can have a more significant impact [46]. In future research, it would be valuable to further explore strategies to encourage continued usage of digital health resources among older adults, including personalisation and tailored content to enhance perceived relevance.

In our cohort of healthy community-dwelling older adults, overall adherence to a Mediterranean dietary pattern increased following engagement with the online anti-inflammatory diet education resource. However, few reached Mediterranean diet criteria for adequate intake of certain core foods, including extra virgin olive oil, legumes, fruit, and

vegetables, and more than half had inadequate intakes of fish and nuts (see Figure 5.2). This is similar to findings from other older adult populations in Australia [41]. The mean scores from the MediCul tool and the derived MEDAS were moderate: 62.6/100 to 66.2/100 and 7.5/14 to 7.8/14, respectively. These scores are marginally higher than those found in other older adult populations in Australia [41,47], which may be due to the slightly younger and highly engaged sample in the present study. Inconsistencies in Mediterranean diet adherence across similar populations could also be due to inherent differences between tools, for example, differences in the methods of questioning used (e.g., measuring quantity versus frequency of intake) and varying approaches to determining cut-points for scoring (e.g., based on actual intake versus median intake of the population) [6].

There was a small but positive shift in Mediterranean diet adherence following engagement with the LIFT website, suggesting that digital health solutions can promote dietary changes in older adults. This was likely driven by intake of certain food groups moving in the right direction, including an increase in extra virgin olive oil and legume intake, and a reduction in sugar-sweetened beverages. However, we identified a number of key areas that need more attention, namely reducing intake of red and processed meats, and increasing intake of fruits and vegetables. Although the cut-off points suggest that an increasing MediCul score may be indicative of improved diet quality [41], the clinical relevance of the statistically significant four-point increase is unclear, albeit unlikely. Previous studies have reported that a MEDAS score of $\geq$10/14 is associated with health benefits in older adults (an increase of two-points from a baseline of 8.3-8.6), and this is equivalent to a score of $\geq$80/100 on the MediCul [41,48]. Nevertheless, the MediCul is a relatively new tool (first published in 2018) and the implications of the cut-off points for health outcomes are not well-defined, with little guidance on how scores can be interpreted to determine low, medium and high adherence. Further research is needed to establish the relationship between MediCul scores and health implications, as well as to provide clearer guidance on score interpretation. There is also a need for longer-term investigations to assess the sustained impact of engagement with the LIFT website on Mediterranean diet adherence among older adults.

Despite the overall shift in Mediterranean diet adherence, we observed no changes in overall nutrition knowledge as a result of engaging with the LIFT website. We did however note an increase in knowledge of core foods, dietary patterns and meals that align with the Mediterranean diet, driven by an increase in participants ability to identify cooking methods that are typical of the Mediterranean diet. Knowledge of cooking methods has been consistently shown to be lacking in Australian populations [40,49], and these findings demonstrate that the resources provided on the LIFT website are able to shift this. In

interpreting these findings, it is important to acknowledge that overall Mediterranean diet knowledge was relatively high at baseline. Indeed, a number of participants commented that the information provided on the LIFT website reinforced what they already knew. For this sample, this may have acted as a prompt to facilitate increased consumption of particular anti-inflammatory foods. Nevertheless, within this well-educated and informed sample, there are notable knowledge gaps that align with previous findings [40,49], including the nutrient content of foods less commonly consumed in the standard Australian diet (e.g., smoked salmon) and awareness of the alcohol content of different beverages. Based on the demographic bias of the sample, it is reasonable to assume that the actual situation in Australia is more unfavourable than suggested by these results.

It appears that older adults are aware of *what* foods fit within an anti-inflammatory dietary pattern, including fruits and vegetables, extra virgin olive oil and legumes. However, knowledge of simply what foods to consume is not sufficient for driving behaviour. For example, of the 96% of participants who were aware that legumes are a core component of the Mediterranean diet, only 50% were meeting the recommended guidelines and 36% were not consuming legumes at all. Similarly, of the 79% of participants who identified extra virgin olive oil as a main component of the Mediterranean diet and used it as their primary source of fat, there were no participants who met the recommended dose ($\geq$4 tablespoons/day). Legumes and extra virgin olive oil are not common food items found in a standard Australian diet and only 28% of the population consume legumes regularly [50]. Findings from Australia have reported several key barriers to consuming legumes, including perceived lengthy preparation time, and a lack of recipe ideas and knowledge of how to prepare them to be palatable [51,52]. While many people may have knowledge of what core foods are included in a Mediterranean-style diet, knowledge of how to incorporate these foods into their daily lives is likely to be an important driver of behaviour [53], emphasising the need for educational resources to include more information and practical advice around *how* to include unfamiliar foods within the diet. In its current iteration, the LIFT website only included three recipes that utilised legumes, suggesting that refinements to the content are needed to provide a larger variety of recipes and more detailed information or demonstrations of how to prepare legumes. Further research is needed to explore how more comprehensive nutrition information (i.e., including the *what* and the *how*) influences both nutrition knowledge and eating behaviours.

Sustained and meaningful dietary behaviour change probably requires a multi-level approach. Self-monitoring (i.e., completing self-assessments of dietary intake) is a commonly used strategy for increasing personal awareness of current versus ideal dietary intake. In older adults, it has been associated with improved dietary quality over time in online interventions

[54] and they have reported being willing and able, and finding it enjoyable, to use self-monitoring tools [55]. Tools that allow for self-monitoring can also be used to provide personalised and tailored nutrition information that can empower older adults to make informed decisions about their nutrition.

Based on the current diet quality of older adults across Western countries, appropriate changes to diet habits and behaviours will need to be significant. Evidence-based strategies, including motivational interviewing and cognitive behavioural therapy, aim to increase personal awareness alongside increasing motivation and overcoming barriers or ambivalence to behaviour change. These strategies are commonly utilised in traditional face-to-face nutrition counselling and increasingly in digital behaviour change interventions [56]. Ongoing developments of innovative conversational technologies, such as artificially intelligent nutrition chatbots and virtual assistants, offer a novel and accessible approach to digital health and behaviour change. They are easily integrated into existing web-based resources and when designed based on evidence-based behavioural models, they can provide additional behaviour change support and personalised information in a manner that simulates human-to-human interaction [57]. Preliminary findings from an Australian study have demonstrated their potential feasibility in older adults, suggesting that they could be useful in behaviour change programs and can support dietary behaviour change over a short period of time [58,59].

Opportunities for building relevant skills and behavioural capabilities related to preparing and cooking food is also important, particularly when considering the introduction of foreign or uncommon foods into the diet. This could be as simple as video recipes showing the steps involved in preparing and cooking a meal, or involve more interactive and hands-on practical cooking workshops. Conversational agents could also be used to provide assistance with the cognitive and physical aspects of cooking [60], offer a source of social support that is often requested by older adults, and enhance ageing in place and independence [61].

Given the observed disparities between nutrition knowledge and actual consumption, it is important to acknowledge other determinants of food intake. While studies conducted in Australia have demonstrated the possibility of changing dietary behaviours to adopt an anti-inflammatory dietary pattern [62], it is important to recognise the challenges associated with promoting widespread dietary behaviour change at the population level. The reality is that dietary behaviours are influenced by various factors that make changing eating habits complex, including individual food preferences, cultural influences, the social environment, and food availability and affordability. We also need to acknowledge the impact of individual

differences in beliefs and learning styles and how this may impact how people engage with, receive and absorb information. While healthcare providers often use written information to convey health-related knowledge to patients, older adults have expressed an interest in educational information presented in video format and using a multimedia approach can enhance the uptake and implementation of health behaviours by increasing motivation and confidence [63]. However, the LIFT website, although including recipe videos, does not utilise a multimedia approach for delivering educational content, potentially not catering to individuals with different learning styles. Participants in the study emphasised that simply providing access to information is insufficient for effective learning and expressed a desire for human interaction in addition to using the website. This aligns with previous research indicating that older adults are open to digital health, but still value the presence of healthcare providers and do not want them to be replaced [64]. The findings from this study underscore the importance of understanding the preferences and concerns of older adults in the context of their healthcare and the need to strike a balance between digital resources and human interaction to ensure optimal engagement. Further research is also needed to explore the impact of different content delivery approaches, such as multimedia versus written information, on information uptake, as well as how the LIFT website can be integrated and used alongside traditional healthcare models.

Web-based information, resources and interventions are becoming increasingly important for health promotion. However, the level of literacy required to access and utilise such resources is an important consideration. In Australia, almost half of adults have literacy skills below the level deemed suitable to meet societal needs [65]. Health literacy, in particular, is critical for obtaining, understanding, and using health information to make informed decisions about one's health [66]. It is directly linked to general literacy skills, and therefore clear and comprehensible health information is crucial for developing health literacy. While participants in this study reported that the provided information was clear and easy to read, they were highly educated and are unlikely to be representative of the broader population. They also reported regularly using the internet to search for health- and nutrition-related information, suggesting a higher level of health and digital literacy compared to the general older adult population [67].

There is ample evidence demonstrating the link between health literacy and health outcomes. Research shows that those with poorer health literacy are less responsive to health education [68] and may experience lower success in managing chronic health conditions [69], which makes them more susceptible to higher health care costs [70]. For online resources to be inclusive, they should be designed to meet the needs of those with limited literacy skills, as

they are likely to benefit from them the most [71]. However, evidence suggests that health information presented online does not meet the needs of low-literacy users. In Australia, for example, less than 1% of online health information is deemed readable for this demographic [72]. Advances in innovative tools are making it easier to develop and improve written health information [73]. These tools have been shown to be acceptable to health professionals for providing immediate and easily actionable feedback for applying health literacy principles to written health information [74]. Further research is needed to test the readability and comprehensibility of the LIFT website with individuals of varying literacy levels to consider whether an audit of the existing materials is required.

This study has a number of limitations. The sample included self-selecting participants who were highly educated. This is common in nutrition-related research in healthy populations, which tends to attract individuals who already have an interest in research or the topic and are looking to improve their health [75], creating a sample that is not representative of the broader population. Additionally, the small sample size may limit the applicability and generalisability of the findings to the general population. Due to the way the study was designed, a large proportion of participants who consented did so approximately 4-months before this study was available to participate in (48/57, 84.2%). Of this group, 37.5% did not respond to the invitation to complete a baseline assessment and engage with the website and were not able to be contacted to determine why they did not engage. Further, data analysis was only conducted for those participants who completed the naturalistic user testing study (i.e., baseline and follow-up), likely reflecting a highly motivated cohort, and we have no data to indicate why participants did not complete the follow-up assessment. Although the LIFT website included many features that have been identified by older adults as necessary in an online nutrition education resource [76], there were many additional features and functions that were not captured in the existing website. Many of these features, including social support, greater interactivity, and personalisation, may have been more applicable for enhancing interaction and engagement in this sample, particularly where a lack of knowledge is not the limiting factor to meaningful changes in dietary intake. Development of future iterations of the website should draw on ongoing feedback to ensure that it is fully meeting the needs of the target user population.

The study could have benefited from objectively tracking patterns of use to understand how participants engaged with the LIFT website. Although beyond the scope of the current study, the use of analytical tools (e.g., Google Analytics) should be considered for future evaluation studies to investigate the relationship between participant characteristics and usage data. We did not include a measure of digital literacy, and therefore it is not possible to make

conclusions about how the digital literacy levels of the sample might have influenced their feedback on the usability and acceptability of the website. Although participants reported little difficulty using the website, their level of digital literacy could have played a role in shaping their perceptions. Finally, while the Med-NKQ and MediCul tools have been tested for reliability and validity in similar populations [40,41], they are yet to be tested for their capacity to measure changes to knowledge and Mediterranean diet adherence over time. Future research would benefit from investigating the utility of these tools for measuring change to identify if there are critical cut-off points for how much knowledge is required to promote behaviour change and what constitutes a clinically relevant improvement in Mediterranean diet adherence.

5.6 Conclusions

In conclusion, the findings of this study suggest that the LIFT website is an acceptable and usable resource for providing nutrition education for older adults. Despite the positive feedback, a significant proportion of participants only used the website once, indicating a need to identify strategies to encourage post-adoption usage. A list of potential updates and improvements in future iterations of the LIFT website for older adults is presented in Box 5.1. Although overall nutrition knowledge did not change, use of the website led to an overall positive shift in Mediterranean diet adherence. However, there were still areas that need improvement, such as reducing red and processed meat, and increasing fruit and vegetable consumption. Given the discrepancy between knowledge and intake, it is clear that knowledge is not the only determinant of dietary intake and there is a need for interventions that address other behavioural factors. Such resources may be more suitable as a starting point for individuals with lower baseline nutrition knowledge and poorer dietary intake, as those with higher knowledge levels and better diets may not see a need for continued usage. Future research is needed to explore strategies to encourage continued usage of digital health resources among older adults, how such resources could be integrated and used within traditional healthcare models and alongside innovative technologies such as artificially intelligent nutrition chatbots, and address the challenges associated with behaviour change at the population level.

Box 5.1. Suggested updates and improvements for future LIFT website iterations

- Ongoing content updates and additional recipes
- Video delivery of educational content
- Discussion boards or web-based chat groups to facilitate peer support
- Incorporation of evidence-based behavioural strategies (e.g., self-monitoring)
- Greater interactivity (e.g., quizzes to self-test knowledge, meal planners, artificially intelligent nutrition chatbot or virtual assistant)
- Personalisation of content, advice, and recipes (based on current dietary intake, health conditions and food preferences)
- Optimisation for use across devices

5.7 References

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SUPPLEMENTARY MATERIAL

Supplementary Material 6.1. Qualitative feedback on the LIFT website

Initial Impressions of the LIFT Website

What were your first impressions of the LIFT website?

Positive

- "Great, very informative… made me hungry"
- "Easy to use and interesting"
- "Looked great, appealing pictures of healthy food choices, easy to navigate"
- "Clear and useful information"
- "Well organised, good balance of picture to text"
- "Easy to read and navigate"
- "Easy to access and follow major headline topics and links"
- "Nicely laid out and colourful"
- "It looked good and was aesthetically very exciting"

Negative

- "Some information assumed a one size fits all approach which was not useful"
- "A bit confusing"
- "I didn't think it was educational from a teaching perspective, education requires more than just access to information"
- "A bit bland"

Preferred Features of the LIFT Website

What do you like best about the LIFT website?

- "Access to background information"
- "Different recipes"
- "Confirmed I was mostly on the right track with a bit of tweaking"
- "It's ease of use"
- "The green, yellow and red categories of foods"
- "Recipes were both written and video based which caters to different learning styles"
- "Practical advice of staples to have in the pantry and fridge"
- "Excellent material and recipes"

- “Clear headings, easy to read front, colourful without being overpowering”

Suggested Improvements to the LIFT Website

What do you think could be improved about the website?

- “Perhaps you could include a print function with the recipe, rather than having to copy and paste”
- “Further resources included as optional links for those who might want to explore further”
- “Perhaps a little more info re nutritional benefits of food types for those of us who may need to increase specific nutrients”
- “Interaction with a human being during the course of the month to talk about how participants are getting on and whether they have questions or need support”
- “Additional information and extended varieties of quick easy recipes”
- “Not enough content, not enough recipes or quick meals/snack ideas”
- “I think the site is too passive, it needs a lot more interactive activities”
- “Tables did not work well on my phone”
- “Maybe have a meal plan and suggested alternatives if some of the foods are not preferred”
- “More main meal recipes would be better too”

CHAPTER SIX

DISCUSSION AND CONCLUSION

The overall aim of this thesis was to identify and address important gaps in effective strategies for improving knowledge of anti-inflammatory dietary patterns, with the Mediterranean diet serving as the exemplar throughout, and healthy eating among older adults. This final chapter discusses the key findings, their implications, and the contribution this thesis makes to the body of knowledge in the context of remaining gaps in the evidence base.

6.1 Summary of principal findings

This thesis brought together three broad fields of research: behavioural science, nutrition and digital health, with a specific focus on the importance of nutrition knowledge and the power of education for dietary behaviour change. Chapter 2 explored the use of education and other behaviour change techniques in Mediterranean diet interventions for older adults. Chapter 3 investigated the level of Mediterranean diet knowledge in a community-dwelling sample of older Australian adults. Chapter 4 qualitatively explored user needs and design preferences for an online nutrition education resource, and finally, Chapter 5 evaluated the usability, acceptability, and impact of one such digital health tool. Collectively, this body of work highlights that educational strategies are common across interventions (Chapter 2) and are needed for improving knowledge of the Mediterranean diet in the general older adult population (Chapter 3), and delivering educational information via digital health technologies is feasible, acceptable, and can facilitate improved knowledge and dietary intake in older Australian adults (Chapters 4 and 5).

The systematic scoping review of Mediterranean diet interventions (Chapter 2) found that while behaviour change techniques are commonly used, these interventions lack a strong theoretical foundation. The most common technique used is educational strategies, aimed at increasing knowledge and understanding of the Mediterranean diet. However, none of the studies included in the review measured nutrition knowledge as an outcome, leaving uncertainty about the impact of the educational information on participants' knowledge and subsequently, how this relates to improved dietary adherence. While there have been studies investigating knowledge and adherence to the Mediterranean diet in Mediterranean countries, studies on Mediterranean diet knowledge specifically targeting older adults in Australia and other non-Mediterranean countries is scarce. Additionally, the review identified a significant gap in the availability of online interventions focusing on the Mediterranean diet. Although a small number utilised hybrid and online only delivery methods, most interventions were delivered in-person, which is common across the broader landscape of nutrition interventions. Despite the potential for wide dissemination and accessibility in real-world settings, the use of digital health technologies in these interventions was limited, with only three studies incorporating digital methods for intervention delivery. Greater understanding of knowledge

levels and knowledge gaps in the Australian population will allow for the development of targeted educational programs aimed at increasing adherence to the Mediterranean diet, and there is scope for such programs to be delivered via digital health methods to increase reach and accessibility.

In light of these findings, Chapter 3 set out to investigate and understand the level of knowledge and familiarity with the Mediterranean diet among older adults in Australia. The results revealed a number of significant knowledge gaps within the well-educated and generally well-informed sample. These gaps specifically pertained to the nutrient content of foods less commonly consumed in a standard Australian diet, as well as the alcoholic content of beverages and cooking methods typical of a Mediterranean dietary pattern. Conversely, participants demonstrated awareness of fibre-rich foods and those high in cholesterol. They were also able to identify specific nutrients from the nutrition information panel of packaged foods, and recognise meal options that align with the Mediterranean diet. Notably, similar patterns have been observed in other Australian populations [1], indicating consistent strengths and weaknesses across different demographic samples, including among highly educated individuals. Given the demographic bias of the present sample, the real picture across the Australian population is likely to be worse than suggested by these results. Participants also highlighted several barriers to changing their habitual diet, including cost, lack of knowledge, and motivation. Given the scarcity of patient education resources tailored to the Mediterranean diet that are available in Australia [2], these findings underscore the importance of developing educational materials that are tailored to identified deficits in knowledge and address perceived barriers to dietary change.

The purpose of the participatory design study presented in Chapter 4 was to assess the potential value of an online nutrition education resource for older adults and qualitatively explore the desired features and functionalities that would enhance user engagement with such a resource. Our findings indicated that older adults are regularly using technology and feel comfortable using a range of different devices to access the internet, including smartphones, computers, and tablets. Participants also reported using the internet to engage with a range of health and nutrition-specific resources. Taken together, these findings highlight the potential feasibility and acceptability of a digital health resource for providing nutrition information to older adults.

Although not a concern for the participants in this study, a lack of familiarity with technology is a frequently cited barrier to engaging with digital health and is an important consideration when designing and developing online tools for older adults. During the participatory design process,

various design and presentation principles were identified as necessary to facilitate a positive user experience. These principles included using large and simple fonts, employing dark type on a light background, and implementing clear categories for easy navigation. The desired content for the tool was varied and encompassed a compilation of recipes and general nutrition information (e.g., food groups, nutrient groups, foods to combine to maximise nutrient absorption). Participants also noted a need for practical advice to assist users in making healthy food choices, such as guidance on reading food labels, meal planning resources, lists of seasonal produce, and recommendations for ordering when dining out. Considering the limited availability of online, self-directed and evidence-based nutrition education resources available for older adults, these findings provide valuable insights for informing the development and design of digital health resources that effectively cater to the needs and preferences of this population.

The final study presented in Chapter 5 of this thesis aimed to evaluate the usability and acceptability of an existing online anti-inflammatory diet education resource. Developed by a team of researchers and nutrition and dietetic health professionals at the University of Sydney and Western Sydney Local Health District, the Low InFlammaTory (LIFT) diet website is an online, interactive resource that provides educational material relevant to an anti-inflammatory style of eating. Our findings indicated that although overall nutrition knowledge did not significantly change after engaging with the website for a period of 4-weeks, participants become more competent at identifying foods, patterns, and meal options that align with the Mediterranean diet. This corresponded with an increase in adherence to the Mediterranean diet and highlighted some key areas that still require attention, including reducing red and processed meat, and increasing fruit and vegetable consumption. The findings also highlighted notable gaps in the concordance between nutrition knowledge and actual food intake. Many participants were able to correctly identify a number of foods that are typical of the Mediterranean diet, including fruits and vegetables, extra virgin olive oil, and legumes, however they had suboptimal intake quantities of these foods. Importantly, participants found the LIFT website to be user-friendly and easily accessible, indicating a positive user experience. Despite the website's usability, a significant proportion of the participants reported only using the website once, suggesting a lack of sustained engagement. While the findings from this study demonstrate that digital health approaches to nutrition education are feasible for older adults and can support more effective use of knowledge to improve dietary intake, there is a need to identify strategies that encourage continued usage of digital health technologies among older adults. The participants indicated a preference to still have a level of engagement with a health professional, alongside the web-based material, and this is an important consideration for future directions. This is consistent with existing evidence

indicating that incorporating human interaction or coaching alongside web-based material enhances satisfaction and drives more effective behaviour change [3]. Further research is needed to understand the usefulness of technology-based interactions (e.g., tailored text messaging or virtual chatbots) to provide the necessary support and behavioural counselling while addressing the barriers associated with face-to-face interactions.

Taken together, the findings presented in this thesis provide valuable insights into the potential of digital health solutions to support nutrition knowledge acquisition and facilitate healthy eating habits among older adults. Such resources would be particularly useful for those who are not familiar with the Mediterranean diet, as a starting point for building capacity to change their eating behaviours. However, it is clear that knowledge alone is not sufficient for meaningful behaviour change. The findings from the systematic scoping review underscore the importance of developing behavioural dietary interventions based on behaviour change theory and incorporating evidence-based strategies to effectively support individuals in adopting healthier behaviours. A number of strategies have been linked to more effective dietary behaviour change in older adults, and subsequent development of the LIFT website should consider implementing features that draw on these strategies [4]. This could include a feature that allows users to identify barriers and consider approaches to help overcome them, and a function that allows for social support (e.g., an online forum to connect and share advice with others who are using the resource and attempting to make similar dietary changes). Moreover, there is a need for further research to understand the various factors that influence eating behaviours in older adults, including determinants of motivation and opportunity that play a role in shaping dietary choices. Overall, this body of work highlights the potential of digital health and the importance of a holistic approach to behaviour change that addresses the multifaceted nature of eating behaviours in older adults. Further advancements in research and intervention development are needed to maximise the impact and effectiveness of nutrition education and dietary behaviour change initiatives targeting this population.

6.2 Strengths and limitations

There are several limitations of this thesis that need consideration. The studies presented in Chapters 3, 4 and 5 utilised various online recruitment methods, including advertisements on Twitter, Facebook, and the Join Us national research register. These online strategies offer innovative ways to reach a wide range of potential research participants. Facebook and research register advertising, in particular, provide unique opportunities for rapid and cost-effective recruitment of specific populations based on their demographic information, interests, and behaviours. In Chapter 5, 79% of participants were recruited through Facebook advertising, suggesting that this recruitment method can be effective in targeting older adults.

However, it is important to note that even though a high percentage of older adults in Australia have regular internet access (93% in 2020 [5]), only 55% of them use social networking sites. Furthermore, evidence suggests that online recruitment methods tend to attract individuals who are wealthier and better educated [6]. Indeed, 72% of the 89 participants across the studies in Chapters 3 and 5 had a tertiary level education. As a result, the samples recruited through social media may not represent the broader population, limiting the ability to generalise the findings of this thesis to the broader older adult population. Non-representative samples of self-selecting participants are common in nutrition research, particularly with healthy populations [7], and more work is needed to address the potential bias of samples in health-related research to recruit participant samples that are more inclusive and representative. While the studies aimed to include participants from diverse ethnic backgrounds, it is important to acknowledge that cultural diversity within the samples was limited. Future studies that include more diverse samples are warranted to determine Mediterranean diet knowledge needs and the capacity for digital health technologies to support and promote healthy eating habits across varied demographic groups.

The assessment tools used in Chapters 3 and 5 to measure nutrition knowledge and adherence to the Mediterranean diet have not been previously employed in an intervention study or evaluated for their ability to detect changes over time. While it was expected that some participants would score low on questions related to specific aspects of a Mediterranean-style dietary pattern not typical in the Australia diet (e.g., consumption of extra virgin olive oil, familiarity with moist cooking methods), the magnitude of change required to indicate a clinically meaningful increase in knowledge and Mediterranean diet adherence is unclear. Furthermore, the Med-NKQ and MediCul tools have primarily been administered to general population samples (e.g., cardiac patients and older adults with mild cognitive impairment), and there is a lack of data regarding performance at the higher end of the scoring ranges. To enhance their validity, it would be beneficial to compare results between two populations with anticipated differences in performance. For instance, assessing nutrition knowledge using the Med-NKQ in both nutrition professionals and the general population, and evaluating Mediterranean diet adherence using the MediCul in Australian and Mediterranean populations. The length of the Med-NKQ may also be considered a limitation. While shorter tools reduce respondent burden and increase participation rates [8], they may not capture the comprehensive range of factors associated with the Mediterranean diet. The Med-NKQ excludes certain elements of the diet pattern, such as specific quantities of core food groups like extra virgin olive oil, which could provide valuable insights when explored in greater detail in relation to actual quantities consumed.

Lastly, the studies presented across Chapters 4 and 5 did not involve a complete participatory or co-design process. The application of participatory design approaches, known for their ability to result in sustainable usage [9], holds promise for designing person-centred health interventions. Given the distinct challenges and barriers older adults face when using technology, it is critical to design and customise digital health technologies to cater to their diverse needs and promote engagement. While we identified that an online nutrition education resource would be useful and gained an understanding of user needs and preferences for such a resource, the website used in Chapter 5 was not originally developed based on the findings of Chapter 4. Rather, it utilised an existing website that was developed for use in liver disease patients by researchers at the University of Sydney in collaboration with the Western Sydney Local Health District. This website was chosen for user testing because many of the functions and features identified by participants as being a facilitator to engagement were present within the existing website. However, several other aspects that were sought after by the participatory design participants were not included. Many of these features, such as social support and personalisation, may be more applicable to samples where a lack of knowledge is not the limiting factor to meaningful behaviour change. It is possible that a more involved and iterative participatory design process would have prompted further revisions or suggestions to improve the existing website, and this may have facilitated increased use and engagement with the website. However, due to time constraints, it was not possible to do this within the bounds of this thesis.

This body of work also has several strengths. Firstly, the work presented in this thesis incorporated research from different fields, including behavioural science, nutrition and digital health. This approach uncovered several significant research gaps that had received little attention in their respective disciplines.

Another strength of this thesis was the use of participatory design methods to actively engage with the intended end-users. Participatory and user-centred design approaches are essential for the development of effective, useful, acceptable, and user-friendly digital health technologies. By involving end-users in the development process, their perspectives, insights, and experiences are considered, leading to solutions that are more relevant and impactful for their specific needs [10]. Engaging end-users also allows for the identification and resolution of usability issues. By considering the abilities and preferences of older adults, technologies can be optimised to accommodate their unique requirements and promote ease of use, which is a critical factor influencing technology adoption among this population [11]. For example, through participant feedback, several aesthetic features were identified that could enhance the usability of a digital health solution, including the use of large and simple font styles and

clear categories to facilitate easy navigation. Moving forward, these principles should be considered when developing and designing digital health technologies for older adults. Importantly, this work demonstrates the feasibility of using participatory design methods with older adults, as participants were actively engaged in the participatory design workshops and reported high acceptability and ease of use during user testing of the LIFT website. These findings emphasise the ongoing importance of employing participatory design approaches in the development of technologies for older adults, to ensure that they are better aligned with their needs to promote engagement and enhance overall user experience.

6.3 Implications and future directions

Anti-inflammatory dietary patterns, such as the Mediterranean diet, hold potential for improving the health and longevity of the ageing population. A recent umbrella review of observational studies and randomised trials revealed that greater adherence to the Mediterranean diet was associated with a reduced risk of various health conditions, including overall mortality, cardiovascular disease, coronary heart disease, myocardial infarction, overall cancer incidence, and neurodegenerative diseases [12]. It has also been reported that higher adherence to the Mediterranean diet is associated with reduced amyloid pathology accumulation in cognitively normal older adults, indicating a potential role in slowing cognitive decline and protecting against neurodegeneration [13]. Importantly, the Mediterranean diet already holds relevance in public health settings and its general principles are endorsed by dietary guidelines in Australia and other countries as a healthy eating pattern to reduce the risk and burden of chronic diseases [14,15]. Given its established benefits, it is reasonable that the Mediterranean diet is recommended to the ageing population as a means to improve chronic disease risk, however, further research is needed to explore strategies to support older adults to modify their current dietary practices and facilitate adherence to the principles of a Mediterranean-style dietary pattern.

The most important consideration of widespread dietary change is the feasibility of implementing unfamiliar dietary patterns. While research on the Mediterranean diet in non-Mediterranean regions is increasing, much of the evidence comes from Mediterranean regions where people are already familiar with the dietary pattern and the types of foods involved [16]. Australia, being a culturally diverse nation with a significant immigrant population, presents a unique context. Several trials in Australia that included food items have demonstrated the adaptability of the Mediterranean diet to non-Mediterranean countries [17,18], and its acceptability to adults from multicultural backgrounds [19]. However, ongoing provision of food on a population level is impractical and costly. Furthermore, there is limited evidence on

whether individuals in their everyday lives, outside of a research setting, can successfully adopt and sustain this style of eating.

The findings from this thesis highlight that whilst nutrition knowledge is a key element of making healthy food choices, it is not the only determinant. Helping individuals to modify their diet and behaviour is complex, and it is essential to tackle practical issues and overcome perceived barriers to achieve lasting dietary behaviour change. For example, holistic behaviour change approaches (e.g., counselling strategies based on motivational interviewing and cognitive behavioural therapy) work to address readiness to change and motivation, and aim to identify and challenge unhelpful thoughts and behaviours [20]. These approaches use client-centred counselling techniques to develop practical skills and strategies for implementing sustained dietary behaviour change. They can be used alongside other behaviour change techniques, such as goal setting and feedback, to provide further specialised support [4]. It is clear that more comprehensive behavioural approaches are needed alongside education, to allow individuals to effectively apply educational information and integrate their knowledge into practical skills and strategies to support meaningful behaviour change.

Additionally, a lack of cooking skills and equipment is commonly cited as a barrier to adopting a Mediterranean dietary pattern, especially among older adults who may also report diminished interest and motivation in cooking [21]. Resources such as those developed by George and colleagues [22] provide individuals with practical advice for assembling meals that require little preparation, while ensuring nutritious choices that align with the key elements of the Mediterranean diet, without the need for extensive cooking equipment or advanced skills. Such resources could be delivered via digital health technologies such as the LIFT website; however, further consumer-led research is needed to develop and refine educational materials based on user needs.

Older adults have also highlighted the perceived lack of social interaction as a significant barrier to engaging with digital health interventions [23]. Incorporating social support alongside nutrition education has been identified as an effective strategy to enhance adherence to health behaviour change programs among older adults [24]. There is scope for the development of culinary nutrition programs that incorporate group-based cooking classes to provide older adults with opportunities to learn and develop necessary skills for meal preparation, within a socially supportive environment. Such classes could serve as a platform for fostering social connections, promoting peer support, and creating a sense of community among older adults seeking to improve their dietary habits. By hosting such programs online, they can offer an

inclusive participation opportunity for older adults who may be constrained by location, transportation or health barriers. Future research should explore how additional strategies and supports, such as group cooking classes and healthcare integration, can be used in conjunction with digital health technologies to support positive behaviour change towards previously unfamiliar dietary patterns in older adults.

Other innovative conversational technologies, such as nutrition chatbots and virtual assistants, offer a novel approach to providing accessible and cost-effective support to overcome barriers to behaviour change. They are easily integrated into existing web-based resources and can be designed specifically based on models of behaviour change using principles of motivational interviewing and cognitive behavioural therapy [25,26]. Constrained chatbots are rule-based and well-structured, which ensures that content delivered to users is consistent and high quality [27]. However, they are unable to adapt to user inquiries or address unexpected questions, which makes them unsuitable for sustaining complex and natural interactions. Alternatively, unconstrained chatbots use artificial intelligence (AI), such as natural language processing, to mimic natural human-to-human interaction by providing responses based on context and user input. AI chatbots provide a new approach to communication that allows users to receive and utilise personalised information and suggestions, which can provide necessary social support and help to overcome a lack of self-efficacy [28]. To date, only one unconstrained chatbot has been developed to deliver a personalised lifestyle intervention amongst older adults. The findings from the proof-of-concept study with 81 participants (mean age = 56.2 years) demonstrated improvements in adherence to the Mediterranean diet over and above those that had been reported from other digital-based interventions and were similar to those found from interventions using intensive one-on-one dietary counselling [28]. However, a recent systematic review of 15 studies reported that the overall satisfaction rate of chatbots for health promotion was less than 50% [29].

While they can provide accessible, reliable and on-demand behavioural support, which overcomes some of the barriers associated with traditional in-person and telehealth services, there are several key pitfalls to chatbots including participants reporting a lack of personal connection and poor digital skills, and technological challenges associated with the functioning of the chatbot [29]. Similarly, while some individuals report that using a chatbot is equivalent to a human-to-human interaction, others believe they are impersonal, reactionless and lack a personal touch, which is likely to influence ongoing interactions and engagement [30]. While there is potential for innovative conversational chatbots to be used to support diet behaviour change, more research is needed to optimise their design and delivery, and explore their feasibility, acceptability, and effectiveness in older adult populations. As AI technology

advances and their use in health behaviour interventions continues to grow, there will be greater understanding of the utility of using chatbots for diet and health behaviour change to drive meaningful health promotion in the ageing population.

Behavioural interventions show promise for changing nutrition, however, current intervention strategies and public health campaigns using “one sizes fits all” recommendations show limited effect on population-level shifts in dietary intake [31]. In older adults, the key to changing dietary behaviour lies in each individual’s motivation and confidence to do so, which can be achieved by making feasible, modest, and specific plans for change [32]. Personalised nutrition approaches provide individuals with tailored dietary recommendations based on their unique characteristics, such as their health status, current diet, and personal preferences [33]. Older adults have reported that their motivation to change their diet comes from a desire to maintain their health and prevent disease and disability [34], and personalisation of health advice is a common request from this population [35]. Therefore, tailoring nutrition information to factors that influence behaviour change, such as addressing health concerns and emphasising the benefits of changing behaviours, may enhance the relevance of information and lead to more meaningful changes compared to generic nutrition advice.

A recent systematic review of randomised controlled trials has shown that personalised nutrition advice is more effective in promoting dietary behaviour change compared to generic “one size fits all” information [36]. Additionally, web-based delivery of personalised nutrition advice has been found to be effective and feasible. The Food4Me study, for instance, demonstrated that provision of personalised advice leads to greater increases in adherence to the Mediterranean diet, compared to general advice [37]. In the context of healthy eating, the No Money No Time (NMNT) website (https://nomoneynotime.com.au/) serves as a purpose-built platform that enables users to complete a personal assessment of their diet quality using the Healthy Eating Quiz (adapted from the validated Australian Recommended Food Score [38]), and receive automated tailored feedback based on the Australian Guide to Healthy Eating [14]. Although the NMNT website was designed for young adults, its principles of diet assessment, tailored feedback and recipe suggestions based on diet quality, and goal setting based on feedback could be adapted for the LIFT website or other online nutrition education resources targeting older adults. Tools such as the MediCul could be incorporated to provide real-time personalised feedback, along with dietary tips, recipes, and menus based on their overall adherence and consumption of specific food groups. Future research should investigate the feasibility and effectiveness of delivering personalised nutrition information based on the Mediterranean diet to older adults through digital health technologies. This would

contribute to our understanding of the potential benefits of personalised approaches and help guide the development of successful digital health interventions for this population.

Addressing eating habits also requires consideration of factors outside of the individual's control that impact their opportunity to consume a healthy diet. Price is one of the most important factors influencing food choice and the cost of food in Australia is a significant barrier to healthy eating [39]. Between 2019 and 2022, the cost of healthy foods such as fruits, vegetables, legumes, and wholegrains grew exponentially [40]. Moreover, the cost of consuming healthy foods within the recommended diet (according to the Australian Guide to Healthy Eating) increased more than the cost of unhealthy foods. Older adults, particularly those who rely on a fixed income from government pensions, often face financial constraints that can impact on their ability to prioritise healthy eating. With limited financial resources, they may need to choose between buying nutritious foods and meeting other essential expenses, such as housing, healthcare and utilities. This can lead to compromised food choices, where cheaper and less nutritious options become more accessible and affordable [41]. Of the 89 participants included across the studies in Chapters 3 and 5, approximately one-third reported that cost is a major barrier to changing their habitual diet, despite being highly educated and likely from a higher income bracket. This is a commonly reported barrier, especially in the context of consuming a Mediterranean-style dietary pattern [42,43].

Despite the increase in the cost of healthy foods, it remains more affordable to maintain a healthy diet compared to the typical Australian diet [40,44,45]. Recent food basket modelling data indicates that, compared to typical population food intake, consuming a Mediterranean diet can be just as, if not more, financially feasible. This is true even when including higher cost items like extra virgin olive oil, nuts, and fish [46]. Educational resources, such as the LIFT website, should include information on budgeting and meal planning to empower older adults to make healthier food choices within their financial constraints. However, it is clear that government action and policies are needed to ensure that older adults are able to access affordable healthy foods. One approach is to keep basic, nutritious food and drinks exempt from Goods and Services Tax (GST), which would help to make them more affordable and accessible. Further to this, modelling data suggests that increasing the GST to 20% on unhealthy foods and drinks could incentivise consumers to choose healthier food options [47]. Government initiatives should also address the adequacy of welfare support, such as the aged pension, to keep pace with the rising costs of living. By addressing these issues, policymakers can help older adults to overcome financial barriers and ensure access to affordable and nutritious food.

While there is a clear need for government action and policy changes to increase accessibility and affordability of healthy foods, it is equally critical to acknowledge and address the psychological barriers related to food choice and consumption. This includes considering factors such as perceptions of affordability, and attitudes towards healthy food options. There is evidence to support the use of targeted psychoeducational approaches for modifying negative perceptions of healthy food affordability. These approaches include providing information on how to make swaps from unhealthy foods to healthier alternatives, without increasing overall food cost [48]. There may also be benefit from increasing education around the use of frozen and canned fruits and vegetables. Although it was not considered within this body of work, negative perceptions of frozen produce are common, with many believing that fresh fruits and vegetables are nutritionally superior [49]. However, in reality, frozen fruits and vegetables offer a convenient alternative to fresh produce that offer comparable or better nutrient profiles, can be stored for longer periods of times without spoiling, and tend to be more affordable [50,51]. These psychological barriers to healthy food choices are important considerations for the development of nutrition education programs that aim to address the multifaceted nature of food choices and eating habits.

Online health programs may be of particular value and benefit to isolated groups, particularly those living in rural and remote regions who often lack access to crucial allied health services like dietitians [52]. Online resources, such as the LIFT website, offer the opportunity for inclusive participation and access to vital health information without the need for extensive travel or financial burden, which can empower older adults to take charge of their health and wellbeing in a way that is convenient to them. They can also provide unlimited access to evidence-based content, serving as a dependable and practical source of information. Despite the increasing internet usage among older adults, those residing in rural areas continue to face disadvantages due to limited internet access, inferior connectivity, and high costs for similar services [53]. It is evident that government policies and action to support infrastructure development and ensuring ongoing maintenance are imperative to improve internet accessibility in these areas. As the internet continues to bridge gaps and connect even the most isolated parts of the world, digital health technologies will be increasingly capable of improving access to health information and services for individuals in rural and remote regions.

Despite the numerous advantages of digital health technologies, it is important to acknowledge their limitations. Online programs require continuous efforts to ensure that the information provided remains up to date and evidence-based. Conducting ongoing research on the effectiveness of informatics in supporting the health of older adults would likely encourage government policies to allocate the necessary funding for the implementation,

maintenance, and sustainability of digital health programs into healthcare. In the context of the older adult population, it is crucial to recognise that online programs may not appeal to everyone. It is often observed that individuals who adopt and actively engage with technology and digital health tend to have higher levels of education [54,55]. Therefore, it is not surprising that highly educated group of participants referenced in Chapter 5 were comfortable using the LIFT website, reporting that it was acceptable and usable. However, it remains unclear the extent to which lower levels of education impede uptake, engagement, and sustained use, which should be a focus for future research. Significantly, there is increasing evidence to suggest that digital health approaches have the potential to alleviate pressures on traditional healthcare systems [56]. By building a strong evidence-based, we can advocate for the integration of digital health technologies into the current healthcare system, providing more comprehensive options and streamlined services for older adults.

6.4 Conclusions

In conclusion, this thesis addresses important gaps in understanding effective strategies for improving knowledge of anti-inflammatory dietary patterns, specifically the Mediterranean diet, and promoting healthy eating behaviours among older adults. It emphasises the importance of holistic approaches to dietary behaviour change by integrating behaviour change theory and strategies into behavioural interventions, as well as providing tools to address knowledge gaps and overcome barriers. Importantly, the use of digital health technologies that meet the needs and preferences of older adults, as identified through direct collaboration and participatory design research methods, are a viable and acceptable method of delivering such interventions. Following further development and testing, the availability of digital resources such as the LIFT website can support nutrition knowledge and its practical application. They also have the potential to be used within multifaceted behaviour change interventions to assist older adults in adopting and maintaining healthy eating habits aligned with the Mediterranean diet. Such interventions are likely to have ripple effects in reducing chronic disease risk and promoting healthy ageing, which are urgent priorities within the context of Australia's ageing population.

6.5 References

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APPENDIX

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APPENDIX A: CONFERENCE ABSTRACTS AND PRESENTATIONS

Published abstract: **Turner A**, LaMonica HM, Moroney C, O'Leary F, Flood VM. Assessment of Mediterranean diet knowledge among older adults in Australia. *Proceedings of the Nutrition Society.* 2023;82(OCE2):E141. doi: 10.1017/S0029665123001507

Presented at Nutrition Society of Australia, Annual Scientific Meeting, Perth (28th November – 2nd December 2022)

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Australia's population is ageing, with one in six people over 65 years [1]. Whilst many will experience negative effects of ageing on their health, this is not inevitable [2]. The Mediterranean dietary pattern (MD) is linked to healthy ageing and protects against a range of chronic conditions, including cardiovascular disease, type 2 diabetes, metabolic syndrome and impaired cognition [3]. However, older adults' dietary patterns tend to be poor and adherence to the MD is generally low to moderate at best [4]. Dietary behaviours are directly linked to nutritional knowledge and in Australia, a lack of knowledge is recognised as a major barrier to accepting, adopting and adhering to the MD [5]. This study aimed to assess the MD knowledge of older Australians. A cross-sectional online survey with Australian adults aged >55 years was conducted to assess knowledge of the MD. MD knowledge was assessed using the Mediterranean Diet Nutrition Knowledge Questionnaire, a 20-item tool validated for assessing nutrition knowledge in an Australian population [6]. The questionnaire focuses on three major themes: a) dietary patterns, foods, and nutrients for reducing cardiac risk factors (four questions); b) nutrient content of foods, quantification, and label reading (seven questions); and c) core MD foods, dietary patterns, and meal selection (nine questions). Scores were calculated for overall knowledge (ranging from 0-40, with higher scores indicating

greater knowledge) and the three MD themes. The average time taken to complete the survey was 15 minutes. The sample included 61 older adults who ranged in age from 55-89 years (mean (SD) 63.7 (8.1)), were mostly female (73.8%), had completed tertiary-level education (70.5%) and were born in Australia (67.2%). The mean total knowledge score was 30.5 (5.0, range 17.0-40.0). Participants scored highest on questions related to core MD foods and meals (12.2 (2.37), range 4-15 out of a possible 15) and cardiovascular risk factors (8.4 (1.6), range 1-10 out of a possible 10). Participants had the lowest level of knowledge for nutrient content of foods and label reading, with only two participants scoring full points (10.0 (2.8), range 2-15 out of a possible 15). There were four questions where less than 50% of participants scored full points (questions about foods for lowering cholesterol; foods high in salt; alcohol content of beverages; and MD cooking methods). The results demonstrate that whilst older Australians have some general knowledge of the MD, there are critical gaps, particularly relating to the nutrient content of foods and cooking methods. These findings are comparable to those obtained from a similar cohort [6]. Nutrition education programs for older adults should be targeted at these gaps to aid with acceptance, adoption, and adherence to the MD.

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Assessment of Mediterranean diet knowledge among older adults in Australia

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INTRODUCTION

In Australia, **1 in 6 Australians are aged 65 years or older.**[1]

Whilst many will experience negative health effects associated with ageing, **this in not inevitable.**[2]

The Mediterranean diet is linked to healthy ageing and protects against a range of chronic conditions.[3]

Dietary patterns of older adults tend to be poor and **adherence to a Mediterranean dietary pattern is low.**[4,5]

Dietary behaviours are directly linked to nutritional knowledge and **a lack of knowledge is recognised as a major barrier to accepting and adopting a Mediterranean dietary pattern in Australia.**[6]

Understanding nutrition knowledge levels can **help us to design targeted education programs** to increase knowledge and improve dietary intake.

AIM

To assess the Mediterranean diet knowledge of older adults in Australia

METHODS

Design: Web-based cross-sectional survey using Qualtrics

Participants: Adults aged 55 years and over

Measures: Mediterranean Diet - Nutrition Knowledge Questionnaire (Med-NKQ)[7]

- 20-item questionnaire (approx. 15-mins completion time)
- Total score ranging from 0-40
- 3 domains: dietary patterns, foods and nutrients for reducing cardiac risk (4 questions); nutrient content of foods and food label reading (7 questions); core Mediterranean diet foods, dietary patterns and meal selection (9 questions)
- Individual questions scored based on complexity

RESULTS

The sample included 61 older adults who ranged in age from 55-89 years (M = 63.7 years), were mostly female (73.8%), had completed tertiary-level education (70.5%) and were born in Australia (67.2%).

Survey completion time: 12 minutes (IQR = 8.7 - 15.5)

Domains	Score range	Mean score (SD)
CVD risk factors	0-10	8.36 (1.63)
Nutrient content, label reading	0-15	10.00 (2.79)
Core foods, meal selection	0-15	12.15 (2.37)
Total	0-40	30.51 (4.98)

CONCLUSIONS

While older Australians have some general knowledge of a Mediterranean dietary pattern, **there are critical gaps,** particularly for knowledge of **nutrient content of foods (foods for lowering cholesterol, foods high in salt), alcoholic content of different beverages, and cooking methods used within the Mediterranean diet.**

Nutrition education programs for older adults should be **targeted at these gaps to aid with acceptance, adoption, and adherence to a Mediterranean dietary pattern.**

THE UNIVERSITY OF SYDNEY

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Identifying the active ingredients for behaviour change in Mediterranean diet interventions in older adults: A systematic scoping review – *presented at The Australasian Society for Behavioural Health and Medicine, Annual Scientific Conference, Geelong (8th February – 10th February 2023)*

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Background/aims: Mediterranean diet interventions have demonstrated positive effects in the prevention and management of several chronic conditions in older adults. Understanding the effective components of behavioural interventions is essential for long-term health behaviour change and translating evidence-based interventions into practice. The aim of this scoping review is to identify behaviour change techniques applied in behavioural interventions designed to increase adherence to the Mediterranean diet in older adults.

Methods: A scoping review searched Medline, EMBASE, CINAHL, Web of Science, Scopus, and PsycINFO from inception until July 2022. Eligible studies were randomised and non-randomised experimental studies assessing the effectiveness of interventions promoting adherence to the Mediterranean diet or an anti-inflammatory diet. Screening was conducted independently by two authors with discrepancies being resolved by the senior author. The Behaviour Change Technique Taxonomy v1 (BCTTv1) was used to identify the behaviour change techniques of the interventions reported.

Results: From 2358 articles, 31 were included in the final analysis. Ten behaviour change taxonomy groupings and 19 techniques were reported across the 30 interventions. Common techniques included instruction on how to perform the behaviour (n=31), social support (n=24), providing information from a credible source (n=16), information about health consequences (n=15), adding objects to the environment (n=12), and behavioural goal setting (n=9).

Conclusions: Understanding of behaviour change techniques to inform intervention development is important for effectively targeting behaviour change in both research and

practice. Detailed and consistent reporting of the techniques included in interventions may enable replication and further investigation of such interventions.

Identifying the active ingredients for behaviour change in Mediterranean diet interventions in older adults: A systematic scoping review

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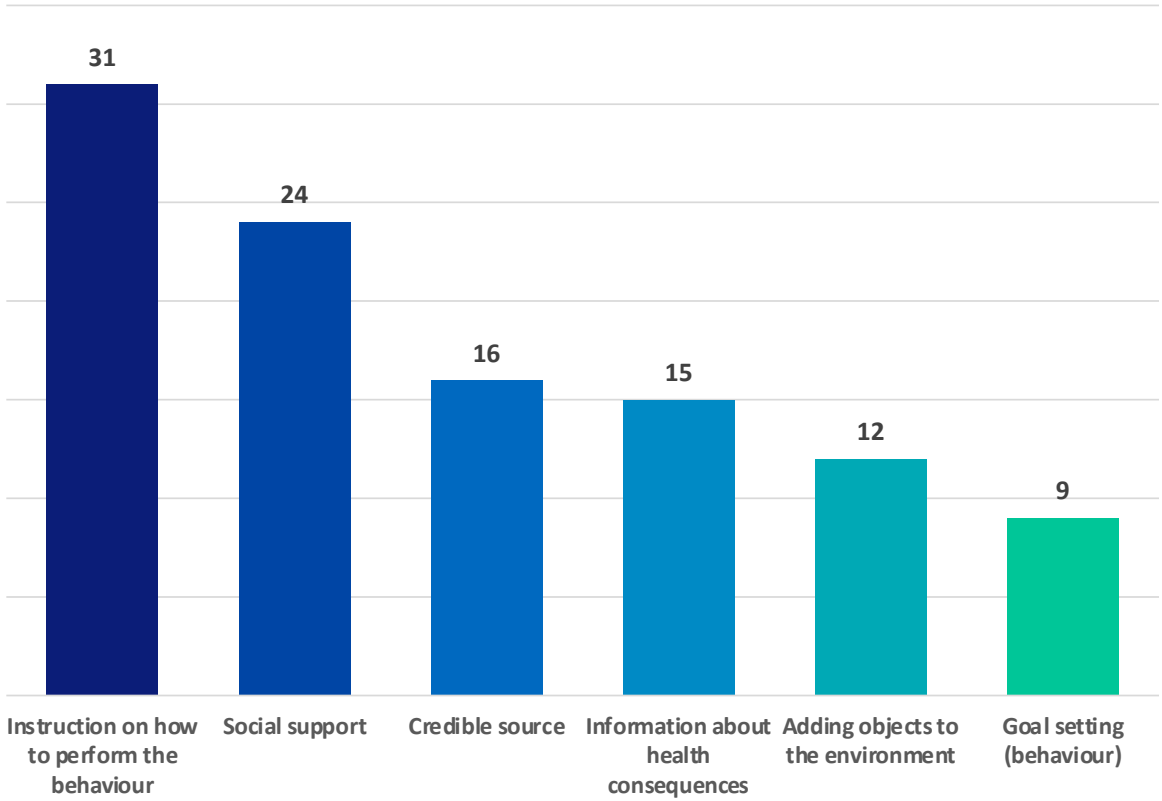
1. Sydney School of Health Sciences; 2. Translational Research Collective; 3. University Centre for Rural Health, Northern Rivers.

Aims: To identify the behaviour change techniques that have been applied in interventions designed to increase adherence to the Mediterranean diet in older adults.

Methods: A scoping review of randomised and non-randomised experimental studies.

Behaviour change technique taxonomy v1 (BCTTv1) [1]:

- 93 behaviour change techniques categorised into 16 groups



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[1] Michie S, et al. (2013)

Scoping user needs for an online nutrition education resource for older adults

– accepted for presentation at the Joint Conference of the Nutrition Societies of New Zealand and Australia, Auckland, New Zealand (28th November – 1st December 2023)

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As the global population continues to age, strategies that promote health and wellbeing among older adults are urgently required. This demographic faces an increasing burden of chronic diseases linked to inflammation [1], often associated with diets that are energy dense and nutrient poor [2]. Importantly, the impact of these conditions can be minimised by adopting an anti-inflammatory dietary pattern, such as the Mediterranean diet [3]. While there are numerous predictors of behaviour and an individual's capacity for behaviour change, nutrition knowledge is a fundamental influencer of eating behaviours [4]. However, knowledge of anti-inflammatory diets generally and the Mediterranean diet specifically is lacking among older adults [5], highlighting the need for effective educational programs targeting this group. Digital health technologies have the potential to provide cost-effective and accessible nutrition education, however, few technologies have been developed to meet older adults' unique needs and preferences. To address this gap, this study aimed to explore the specific needs and design preferences of older adults for an online nutrition education resource. A total of 20 adults aged 55 years and older participated in one of four 2-hour participatory design workshops, where prompted discussion questions were used to explore their use of technology and scope their needs and preferences for an online nutrition education resource. All participants were regularly using a range of different devices (e.g., smartphones, tablets, and computers) and reported being comfortable doing so. Participants wanted a website that could be accessed across devices (i.e., desktop and mobile friendly) that provided practical nutrition advice, recipes, and information on the link between diet and disease. A number of design principles were identified as essential to optimise the user experience, including large and simple fonts, use of dark type on a light background, and clear categories for easy navigation. To enhance engagement, participants sought a personalised resource that could

be adjusted to suit their needs, provided up-to-date information, and allowed for easy content sharing with others, such as by exporting information as a PDF. Participatory design methods offer new knowledge for developing and refining existing and future digital health technologies that are appropriate and useful for the target audience. Specifically, the older adult participants were motivated to access a user-friendly web-based nutrition resource provided it was able to be personalised to their health and nutrition needs, offered practical solutions such as adaptations to portion size or in relation to cost, and was easily shareable with others. Given the limited availability of online, self-directed and evidence-based nutrition education resources for older adults, these findings provide valuable insights to shape digital health resources that cater to the needs and preferences of this population and have the potential to support healthy eating habits and contribute to reducing diet-related chronic disease burden.

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APPENDIX B: CHAPTER TWO ADDITIONAL MATERIAL

Behaviour change techniques used in Mediterranean diet interventions for older adults: protocol for a scoping review

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Funding: AT is supported by an Australian Government Research Training Program (RTP) scholarship.

Methods

This review will follow the PRISMA [Preferred Reporting Items for Systematic Reviews and Meta-Analyses] extension for Scoping Reviews (PRISMA-ScR) guidelines [1]. The protocol will be conducted according to the Johanna Briggs Institute (JBI) methodology for scoping reviews [2].

The purpose of this scoping review is to:

1. Identify the available literature on Mediterranean diet interventions among older adults
2. Identify the key behaviour change techniques that can effectively contribute to the promotion of a Mediterranean dietary pattern

Search strategy

The search strategy will aim to locate published studies. The databases to be searched include Medline, Embase, Cinahl, Web of Science, Scopus and PsycINFO. The search will not be limited by date, beginning from inception and extending to 20/07/2021. The search strategy will be adapted for each database (see Box 1 for search strategy for Ovid MEDLINE database). A manual search of the reference lists of relevant articles will also be conducted to identify any studies missing using the search strategy.

Box 1. Search strategy for scoping review of Mediterranean diet interventions among older adults: database – Ovid MEDLINE

1	Diet, Mediterranean/
2	Mediterranean diet*.mp.
3	Mediterranean dietary pattern*.mp.
4	Cretan diet*.mp.
5	Anti-inflammatory diet*.mp.
6	MedDiet*.mp.
7	MeDi.mp.
8	MeDiet.mp.
9	Greek diet.mp.
10	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9
11	older adult*.mp.
12	senior*.mp.
13	Elderly.mp. or Aged/
14	11 or 12 or 13
15	10 and 14
16	Clinical Trials as Topic/ or Randomized Controlled Trials as Topic/
17	intervention.mp.
18	diet intervention.mp.
19	quasi-experimental*.mp.
20	16 or 17 or 18 or 19

21	10 and 14 and 20

Eligibility criteria

Inclusion criteria

- Population: community-dwelling older adults with an average age ≥55 years with or without health risk factors and conditions (e.g. cognitive impairment, metabolic syndrome).
- Intervention: any experimental single (i.e. Mediterranean diet only) or multi-component lifestyle intervention (i.e. Mediterranean diet and physical activity) with a follow-up of at least 4-weeks (including randomised controlled trials, non-randomised, quasi-experimental and pre/post studies where the effects of the diet component are reported independently);
- Outcomes: dietary change defined as – improved Mediterranean diet adherence assessed by established Mediterranean diet scores; quantitative analysis of diet components (e.g. change in number of portions/servings/weight consumed of fruit and/or vegetables, fish, olive oil or red meat; and improved biological markers of Mediterranean diet consumption (e.g. serum nutrient status, inflammatory markers, lipids).
- Language: full text available in English;
- Duplication: in cases with multiple publications arising from the same study (in this case, the paper with the most comprehensive description of the methodology, intervention and results will be used).

Exclusion criteria

Studies will be excluded if they are: randomised controlled trials with a crossover design (not intended to assess behaviour change), non-experimental publications (e.g. observational studies, conference abstracts, systematic reviews and meta-analyses), testing other dietary patterns (e.g. vegetarian), focusing on consumption of a single food, non-food based interventions testing dietary supplements (e.g. fish oil) or laboratory feeding trials.

Selection of articles and data extraction

Following the search, all identified articles will be imported into Covidence [3] for duplicate removal and review. The review process will consist of two phases of screening: (1) title and abstract review, and (2) full-text review. In the first phase of screening, titles and abstracts will be reviewed against inclusion criteria by two independent reviewers (AT and HL). In the second phase, full-text articles will be scanned in detail again by two independent reviewers (AT and HL) and studies that do not meet inclusion criteria will be excluded. Reasons for exclusion of full-text papers will be recorded and reported in the review. Any disagreements that arise between the reviewers during either phase of the review process will be resolved through discussion with a senior reviewer (VF), who will approve the final list of included

studies. The results of the search will be reported in full in the final scoping review and presented in a PRISMA-ScR flow diagram.

Data will be extracted by one reviewer (AT) and will include: (1) study design, (2) sample characteristics and setting, (3) study objective, (4) description of the dietary intervention, (5) delivery methods and format of the intervention, (6) outcome measures used, and (7) study results. Interventions will then be coded for behaviour change techniques using the Coventry Aberdeen London-Refined (CALO-RE) taxonomy [4]. The CALO-RE taxonomy describes 40 behaviour change techniques that are commonly used in intervention research [4].

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APPENDIX C: CHAPTER THREE ADDITIONAL MATERIAL

Research Integrity & Ethics Administration
HUMAN RESEARCH ETHICS COMMITTEE

Monday, 2 August 2021

Prof Victoria Flood
Exercise Health and Performance; Faculty of Medicine and Health
Email: vicki.flood@sydney.edu.au

Dear Victoria,

The University of Sydney Human Research Ethics Committee (HREC) has considered your application.

I am pleased to inform you that your project has been approved

Details of the approval are as follows:

Project No.:	**2021/543**
Project Title:	**Assessing the nutrition knowledge, attitudes and behaviours of older adults**
Authorised Personnel:	**Flood Victoria; O'Leary Fiona; Naismith Sharon; Turner Ashlee; LaMonica Haley; Moroney Carissa;**
Approval Period:	**02 August 2021** to **02 August 2025**
First Annual Report Due:	**02 August 2022**

Documents Approved:

Date Uploaded	Version Number	Document Name
01/07/2021	Version 1	Application Form
05/07/2021	Version 1	Email invitation - community organisations (v1, 05-07-2021)
05/07/2021	Version 1	Email invitation - other studies (v1, 05-07-2021)
07/06/2021	Version 1	Nutrition KAB survey (v1, 05-06-2021)
05/07/2021	Version 1	PIS_full (v1, 05-07-2021)
07/07/2021	Version 1	PIS_short (v1, 05-07-2021)
07/06/2021	Version 1	Print advertisement (v1, 07-06-2021)
05/07/2021	Version 1	Social media advertisement (v1, 05-07-2021)

Condition/s of Approval

- Research must be conducted according to the approved proposal.
- An annual progress report must be submitted to the Ethics Office on or before the anniversary of approval and on completion of the project.
- You must report as soon as practicable anything that might warrant review of ethical approval of the project including:
  - Serious or unexpected adverse events (which should be reported within 72 hours).
  - Unforeseen events that might affect continued ethical acceptability of the project.
- Any changes to the proposal must be approved prior to their implementation (except where an amendment is undertaken to eliminate *immediate* risk to participants).
- Personnel working on this project must be sufficiently qualified by education, training and experience for their role, or adequately supervised. Changes to personnel must be reported and approved.
- Personnel must disclose any actual or potential conflicts of interest, including any financial or other interest or affiliation, as relevant to this project.

Research Integrity & Ethics Administration
Research Portfolio
Level 3, F23 Administration Building
The University of Sydney
NSW 2006 Australia

T +61 2 9036 9161
E human.ethics@sydney.edu.au
W sydney.edu.au/ethics

ABN 15 211 513 464
CRICOS 00026A

- Data and primary materials must be retained and stored in accordance with the relevant legislation and University guidelines.
- Ethics approval is dependent upon ongoing compliance of the research with the *National Statement on Ethical Conduct in Human Research*, the *Australian Code for the Responsible Conduct of Research*, applicable legal requirements, and with University policies, procedures and governance requirements.
- The Ethics Office may conduct audits on approved projects.
- The Chief Investigator has ultimate responsibility for the conduct of the research and is responsible for ensuring all others involved will conduct the research in accordance with the above.

This letter constitutes ethical approval only.

Please contact the Ethics Office should you require further information or clarification.

Sincerely,

[redacted]

Associate Professor Michael Skilton
Chair, Health Review Committee (Low Risk)

The University of Sydney of Sydney HRECs are constituted and operate in accordance with the National Health and Medical Research Council's (NHMRC) National Statement on Ethical Conduct in Human Research (2018) and the NHMRC's Australian Code for the Responsible Conduct of Research (2018)

THE UNIVERSITY OF SYDNEY

Sydney School of Health Sciences
Faculty of Medicine and Health

ABN 15 211 513 464

Prof Vicki Flood
Professor of Allied Health

Susan Wakil Health Building
The University of Sydney
NSW 2006 AUSTRALIA
Telephone: 0412 118 977
Email: vicki.flood@sydney.edu.au
Web: http://www.sydney.edu.au/

Assessing nutrition knowledge, attitudes and beliefs of older adults

PARTICIPANT INFORMATION STATEMENT

(1) What is this study about?

You are invited to take part in a research study that is seeking to assess and understand older adults' knowledge of the Mediterranean diet, and their general attitudes and beliefs regarding their own food habits. The information from this study will help us to develop targeted educational interventions aimed at improving food and nutrition intake in older adults.

This Participant Information Statement tells you about the research study. Knowing what is involved will help you decide if you want to take part in the research. Please read this sheet carefully and ask questions about anything that you don't understand or want to know more about.

Participation in this research study is voluntary.

By giving your consent to take part in this study you are telling us that you:
✓ Understand what you have read.
✓ Agree to take part in the research study as outlined below.
✓ Agree to the use of your personal information as described.

You will be given a copy of this Participant Information Statement to keep.

(2) Who is running the study?

The study is being carried out by the following researchers:
- Prof Vicki Flood, Sydney School of Health Sciences, Faculty of Medicine and Health;
- Ashlee Turner, Sydney School of Health Sciences, Faculty of Medicine and Health;
- Prof Sharon Naismith, School of Psychology, Faculty of Science;
- Dr Haley LaMonica, Translation Research Collective, Faculty of Medicine and Health;
- Dr Fiona O'Leary, School of Environmental and Life Sciences, Faculty of Science;
- Carissa Moroney, Sydney School of Health Sciences, Faculty of Medicine and Health;

(3) What will the study involve for me?

If you agree to participate, you will complete an online survey that assesses your knowledge of the Mediterranean diet and asks about your general attitudes and beliefs towards food and nutrition. You will also be asked some general information questions.

(4) How much of my time will the study take?

The survey should take 10-15 minutes to completed.

(5) Who can take part in the study?

You are eligible to participate in this study if you:

- Are aged 55 years and over;
- Currently live in Australia; and
- Can read and write in English.

(6) Do I have to be in the study? Can I withdraw from the study once I've started?

Being in this study is completely voluntary and you do not have to take part. Your decision whether to participate will not affect your current or future relationship with the researchers or anyone else at the University of Sydney.

If you provide consent and decide to participate, you may withdraw from the study at any time before submitting the completed survey. As the survey is anonymous, you will not be able to withdraw your responses after submission.

(7) Are there any risks or costs associated with being in the study?

Aside from giving up your time, we do not expect that there will be any risks or costs associated with taking part in this study.

(8) Are there any benefits associated with being in the study?

We cannot guarantee that you will receive any direct benefits from being in the study. Your participation will help us to further understand older adult's general knowledge of the Mediterranean diet, which in turn may lead to better care in the form of tailored educational interventions aimed at improving food and nutrition intake.

(9) What will happen to information about me that is collected during the study?

By providing your consent, you are agreeing to us collecting some personal information about you for the purposes of this research study. Your information will only be used for the purposes outlined in this Participant Information Statement, unless you consent otherwise. We do not collect any identifying information about you.

Your information will be stored securely for 5 years. Study findings may be published, but you will not be individually identifiable in these publications.

(10) Can I tell other people about the study?

Yes, you are welcome to tell other people about the study.

(11) What if I would like further information about the study?

When you have read this information, Miss Ashlee Turner will be available to discuss it with you further and answer any questions you may have. If you would like to know more at any stage during the study, please feel free to contact Miss Ashlee Turner (study coordinator and PhD Candidate) on 02 9114 4198 or email her at ashlee.turner@sydney.edu.au.

(12) Will I be told the results of the study?

You have a right to receive feedback about the overall results of this study. If you would like a copy of the study results after completion, please email Ashlee Turner on ashlee.turner@sydney.edu.au.

(13) What if I have a complaint or any concerns about the study?

Research involving humans in Australia is reviewed by an independent group of people called a Human Research Ethics Committee (HREC). The ethical aspects of this study have been approved by the HREC of the University of Sydney [2021/543]. As part of this process, we have agreed to carry out the study according to the *National Statement on Ethical Conduct in Human Research (2007).* This statement has been developed to protect people who agree to take part in research studies.

If you are concerned about the way this study is being conducted or you wish to make a complaint to someone independent from the study, please contact the university using the details outlined below. Please quote the study title and protocol number.

The Manager, Ethics Administration, University of Sydney:

- **Telephone:** +61 2 8627 8176
- **Email:** human.ethics@sydney.edu.au
- **Fax:** +61 2 8627 8177 (Facsimile)

This information sheet is for you to keep

THE UNIVERSITY OF SYDNEY

HAVE YOU EVER HEARD OF THE MEDITERRANEAN DIET?

We want to know how much you know about the general principles of the Mediterranean diet, and your general attitudes or beliefs towards your current food habits.

WHO: Australian residents, aged 55 years and over.
WHAT: A quick 10-15 minute online survey.
HOW: Scan the QR code or use the following link, https://sydney.au1.qualtrics.com/jfe/form/SV_4GtWDUJcqDZk7BA

More info:
Ashlee Turner (PhD candidate,
University of Sydney)
ashlee.turner@sydney.edu.au

This research has been reviewed and approved by the University of Sydney Human Research and Ethics Committee (#2021/543). Version 1, 7th June 2021.

Have you ever heard of the Mediterranean diet? Our team at the University of Sydney want to find out how much you know about the general principles of the Mediterranean diet. Interested in helping us? Are you aged 55 year or over? Follow the link: bit.ly/39Hzk1a

@syd_health
@HBAProgram_USYD
@BrainMind_Usyd
@UsydPsych

Our team at the University of Sydney want to find out how much knowledge you have of the Mediterranean diet. By participating in this survey, you will help us to learn where the gaps are in Mediterranean diet knowledge so that we can develop targeted educational interventions. If you would like to participate or want more information, click the link below. Aged 55 or over, please spend 15 min completing the survey:

Insert Qualtrics link.

1. Which of the following statements is true if you want to lower your blood cholesterol? You may choose more than one.

- [x] Eat more fruits and vegetables
- [x] Eat more wholegrain foods
- [x] Eat less fatty and processed meats
- [ ] Eat more dairy products
- [ ] Eat less salt on your food

2. Which of the following statements are true if you want to lower your blood pressure? You may choose more than one.

- [x] If using packaged foods, choose products with less salt
- [x] If you are overweight, try to lose some weight
- [ ] Drink more alcohol
- [x] Eat more dark leafy greens
- [ ] Eat more white bread

3. What is the recommended number of servings of vegetables per day? 1 serve = ½ cup cooked vegetables **or** 1 cup raw vegetables/salad.

- [ ] 2 serves
- [ ] 3 serves
- [x] 5 serves
- [ ] 7 serves

4. Which of the following statements are true? You may choose more than one.

- [ ] The only nutritional benefit of fruits and vegetables is vitamins and minerals
- [ ] Fat is always bad for your health; you should therefore avoid it as much as possible
- [x] Dietary fibre is important for lowering your cholesterol

5. Which of the following foods are more likely to raise your blood cholesterol? You may circle more than one.

Wholemeal bread

Extra Virgin olive oil

Fried bacon

Butter

6. Circle the foods that are a source of healthy fats. You may circle more than one.

Unsalted nuts

Dark chocolate

Salmon fillet

Butter

7. Which of the following foods are a good source of fibre? You may circle more than one.

Rolled oats

Corn flakes

Rice crackers

Legumes

8. Which of the following foods are high in salt? You may circle more than one.

Smoked salmon

Boiled egg

Canned tuna in spring water

Deli ham

9. Which alcoholic beverage below contains the lowest number of standard drinks?

200mL red wine

375mL full strength beer

60mL of dark spirit

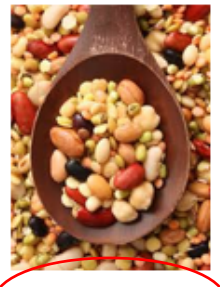
10. Which pasta meal better reflects the Mediterranean diet principles for heart health? Circle the correct response.

Pasta with tomato sauce

Pasta with mushroom and cream sauce

11. Which of the following foods are considered core components of the Mediterranean diet? You may circle more than one.

White rice



Legumes

Chicken breast

Extra Virgin olive oil

12. Which of the following foods are considered core components of the Mediterranean diet? You may circle more than one.

Leafy greens

Unsalted nuts

Salami

Blue cheese

13. Which of the below are used in the Mediterranean diet to add flavour to food? You may circle more than one.

Oregano

Lemon juice

Powdered stock cube

Garlic

14. Which of the following cooking methods is most typical of the Mediterranean diet? You may choose more than one answer.

- [ ] High heat stir-fry
- [x] Use of moist cooking methods such as stewing
- [ ] Barbeque
- [ ] Only eating raw foods

15. Which of the following statements is true about the Mediterranean diet? You may choose more than one answer.

- [x] Use of Extra Virgin Olive Oil as main oil
- [ ] Fruit juice consumed with all meals
- [ ] Eating red meat 3-4 times per week
- [ ] Mostly plant-based diet

16. Which of the following drinks is consumed the most as part of the Mediterranean diet?

- [x] Water
- [ ] Fruit juice
- [ ] Wine
- [ ] Coffee

17. Which of the following meals would be considered the best choice if following the Mediterranean diet for heart health?

Vegetable and lentil soup with wholegrain bread and olive oil

Carbonara

Oven baked crumbed fish and potato

Grilled steak and garden salad with fat free dressing

18. If you were having breakfast in a café, which menu option would best fit the Mediterranean diet?

Eggs benedict with smoked salmon on toast

Beans cooked in tomato and onion on toast

19. Looking at products 1 and 2, which one has the most amount of salt?

Pack Size: 425g **Serving Size: 69g** **Servings per packet: 4**		
	Per Serve	Per 100g
Energy	327kJ	474kJ
Protein	17.7g	25.7g
Fat, total	0.7g	1.0g
- Saturated	0.3g	0.4g
Carbohydrate, total -Sugars	<1g	<1g
Sodium	311mg	450mg
< means less than		

Canned tuna 1

Pack Size: 185g **Serving Size: 60g** **Servings per packet: 2**		
	Per Serve	Per 100g
Energy	284kJ	474kJ
Protein	15.46g	25.7g
Fat, total	0.6g	1.0g
- Saturated	0.2g	0.4g
Carbohydrate, total -Sugars	<1g	<1g
Sodium	210mg	350mg
< means less than		

Canned tuna 2

20. Which of these two products is better for heart health? Circle the best choice.

Nutrition Information Serving Size: 83g Servings per pack: 8		
	Per Serving	Per 100g
Energy	773kJ	931kJ
Protein	9.0g	10.8g
Fat, total	4.0g	4.8g
-saturated	0.5g	0.6g
Carbohydrate	25.0g	30.1g
-sugars	1.6g	1.9g
Dietary Fibre	6.1g	7.3g
Sodium	268mg	323mg

Bread 1

Nutrition Information Serving Size: 60g Servings per pack: 11		
	Per Serving	Per 100g
Energy	612kJ	1020kJ
Protein	5.0g	8.4g
Fat, total	1.2 g	2.0g
-saturated	0.4g	0.6g
Carbohydrate	27.8g	46.31g
-sugars	1.4g	2.4g
Dietary Fibre	1.6g	2.7g
Sodium	240mg	400mg

Bread 2

Source: Moroney C, O'Leary F, Flood VM. The Med-NKQ: A reliable Mediterranean diet nutrition knowledge questionnaire for cardiovascular disease. *Nutrients*. 2021;13(9):2949. doi:10.3390/nu13092949

APPENDIX D: CHAPTER FOUR ADDITIONAL MATERIAL

THE UNIVERSITY OF SYDNEY

Research Integrity & Ethics Administration
HUMAN RESEARCH ETHICS COMMITTEE

Friday, 22 July 2022

Prof Victoria Flood
Exercise Health and Performance; Faculty of Medicine and Health
Email: vicki.flood@sydney.edu.au

Dear Victoria,

The University of Sydney Human Research Ethics Committee (HREC) has considered your application.

I am pleased to inform you that after consideration of your response, your project has been approved.

Details of the approval are as follows:

Project No.:	**2022/423**
Project Title:	**Participatory design to inform a subsequent online nutrition education resource for older adults**
Authorised Personnel:	**Flood Victoria; Turner Ashlee; LaMonica Haley; Naismith Sharon;**
Approval Period:	**22/07/2022 – 22/07/2026**
First Annual Report Due:	**22/07/2023**

Documents Approved:

Date Uploaded	Version Number	Document Name
05/07/2022	Version 2	Demographics (v2, 05 July 2022) - clean
05/07/2022	Version 2	MediCul (v2, 05 July 2022) - clean
05/07/2022	Version 2	PICF (v2, 05 July 2022) - clean
05/07/2022	Version 2	Social media advertising (v2, 05 July 2022) - clean
30/05/2022	Version 1	Nutrition KAB questionnaire_v1
30/05/2022	Version 1	System Usability Scale_v1
30/05/2022	Version 1	Resource usage questionnaire_v1
30/05/2022	Version 1	Draft agenda_v1

Special Condition/s of Approval

Thanks for providing the "example of what sections of the PIS will be used to satisfy advertisement requirements" (for recruitment via third party platforms). I am approving the wording that you indicated (pasted below for your convenience). It is a condition of approval that you submit a modification should you need to change the wording of this recruitment advertisement (for third party platforms).

Approved wording for recruitment via third-party recruitment platforms.

Description/purpose: “You are invited to take part in a research study that is seeking to gather insights from a representative group of older adults in Australia to determine how new and emerging technologies can be co-designed and developed to enhance nutrition knowledge, to suit the specific needs and preferences of this group. Specifically, we want to know how an online anti-inflammatory diet education resource could be designed and tailored for the provision of evidence-based nutrition education for the older adult population.”

What’s involved: “This study involves two components, of which you can choose to participate in one or both. On the Participant Consent Form, you can tell us which component(s) you wish to participate in.

Component 1. Participatory design workshop
You will be asked to participate in a group workshop to discover, evaluate and prototype design solutions (e.g. platform content, language, look, feel) to ensure that the education resource is built and tailored to meet the needs of older adults. During the session, you can choose which questions you wish to answer and respond to. If you don’t want to talk about something, that is okay.

You will be asked to attend a focus group held via video conference using the Zoom software. If needed, we can provide training and assistance prior to telehealth sessions to help with familiarising yourself with the video conferencing program. The session will last approximately 2-3 hours and will involve a group of 5-7 participants. The groups will be coordinated by one facilitator and will be audio recorded using the Zoom recording functionality.
Time commitment: Up to 2 hours.

Component 2. User acceptance testing
You will be invited to engage with the nutrition education resource for a period of 4-weeks to demonstrate how users interact with and experience the platform. During the 4-weeks, you will be able to use the platform and its features at your own discretion. You will be asked to complete a brief series of questionnaires before and after engaging with the platform.
Time commitment: 4 weeks"

Recruitment criteria: "You are eligible to participate in this study if you:
- Are aged 55 years and over;
- Currently live in Australia;
- Can read and write in English; and
- Have reliable access to the internet and a device that can connect to Zoom video conferencing software."

Condition/s of Approval

- Research must be conducted according to the approved proposal.
- An annual progress report must be submitted to the Ethics Office on or before the anniversary of approval and on completion of the project.
- You must report as soon as practicable anything that might warrant review of ethical approval of the project including:
  - Serious or unexpected adverse events (which should be reported within 72 hours).
  - Unforeseen events that might affect continued ethical acceptability of the project.
- Any changes to the proposal must be approved prior to their implementation (except where an amendment is undertaken to eliminate *immediate* risk to participants).
- Personnel working on this project must be sufficiently qualified by education, training and experience for their role, or adequately supervised. Changes to personnel must be reported and approved.
- Personnel must disclose any actual or potential conflicts of interest, including any financial or other interest or affiliation, as relevant to this project.
- Data and primary materials must be retained and stored in accordance with the relevant legislation and University guidelines.
- Ethics approval is dependent upon ongoing compliance of the research with the *National Statement on Ethical Conduct in Human Research*, the *Australian Code for the Responsible Conduct of Research*, applicable legal requirements, and with University policies, procedures and governance requirements.
- The Ethics Office may conduct audits on approved projects.
- The Chief Investigator has ultimate responsibility for the conduct of the research and is responsible for ensuring all others involved will conduct the research in accordance with the above.

THE UNIVERSITY OF SYDNEY

This letter constitutes ethical approval only.

Please contact the Ethics Office should you require further information or clarification.

Sincerely,

[redacted]

Professor Michael Skilton
Chair, Health Review Committee (Low Risk)

The University of Sydney of Sydney HRECs are constituted and operate in accordance with the National Health and Medical Research Council's (NHMRC) National Statement on Ethical Conduct in Human Research (2018) and the NHMRC's Australian Code for the Responsible Conduct of Research (2018)

THE UNIVERSITY OF SYDNEY

Research Integrity & Ethics Administration
HUMAN RESEARCH ETHICS COMMITTEE

Tuesday, 21 March 2023

Prof Victoria Flood
Exercise Health and Performance; Faculty of Medicine and Health
Email: vicki.flood@sydney.edu.au

Dear Victoria,

Your request to modify this project, which was submitted on 21/02/2023, has been considered.

This project has been approved to proceed with the proposed amendments.

Protocol Number: **2022/423**

Protocol Title: **Participatory design to inform a subsequent online nutrition education resource for older adults**

Addition of Authorised Persons:

Removal of Authorised Persons: **Sharon Naismith**

New Completion Date:

Annual Report Due: **22/07/2023**

Documents Approved:

Date Uploaded	Version Number	Document Name
21/02/2023	Version 2	Resource Usage survey (v2, 21 Feb 2023) - clean
21/02/2023	Version 1	User Engagement Scale - short form (v1, 21 Feb 2023)

Please contact the ethics office should you require further information.

Sincerely,

[redacted]

Dr Joanne Hart
Chair
Modification Review Committee Chair (MRC 3)

The University of Sydney of Sydney HRECs are constituted and operate in accordance with the National Health and Medical Research Council's (NHMRC) National Statement on Ethical Conduct in Human Research (2018) and the NHMRC's Australian Code for the Responsible Conduct of Research (2018)

PARTICIPANT INFORMATION STATEMENT

Participatory design to inform a subsequent online nutrition education resource for older adults

Prof Vicki Flood (Principal Investigator)
Head of Clinical School, Northern Rivers
Director, University Centre for Rural Health
Faculty of Medicine and Health
Email: vicki.flood@sydney.edu.au

Ashlee Turner (Study Coordinator)
PhD Candidate
Sydney School of Health Sciences, Faculty of Medicine and Health
Email: ashlee.turner@sydney.edu.au

---

(1) What is this study about?

You are invited to take part in a research study that is seeking to gather insights from a representative group of older adults in Australia to determine how new and emerging technologies can be co-designed and developed to enhance nutrition knowledge, to suit the specific needs and preferences of this group. Specifically, we want to know how an online anti-inflammatory diet education resource could be designed and tailored for the provision of evidence-based nutrition education for the older adult population.

This Participant Information Statement tells you about the research study. Knowing what is involved will help you decide if you want to take part in the research. Please read this sheet carefully and ask questions about anything that you don't understand or want to know more about.

Participation in this research study is voluntary.

By giving your consent to take part in this study you are telling us that you:

✓ Understand what you have read.
✓ Agree to take part in the research study as outlined below.
✓ Agree to the use of your personal information as described.

You will be given a copy of this Participant Information Statement to keep.

(2) Who is running the study?

The study is being carried out by the following researchers:

- Prof Vicki Flood, Director of the University Centre for Rural Health, Faculty of Medicine and Health;
- Ashlee Turner, PhD Candidate, Faculty of Medicine and Health;
- Dr Haley LaMonica, Senior Research Fellow, Faculty of Medicine and Health;
- Prof Sharon Naismith, School of Psychology, Faculty of Science.

(3) What will the study involve for me?

This study involves two components, of which you can choose to participate in one or both. On the Participant Consent Form, you can tell us which component(s) you wish to participate in.

Component 1. Participatory design workshop

You will be asked to participate in a group workshop to discover, evaluate and prototype design solutions (e.g. platform content, language, look, feel) to ensure that the education resource is built and tailored to meet the needs of older adults. During the session, you can choose which questions you wish to answer and respond to. If you don't want to talk about something, that is okay.

You will be asked to attend a focus group held via video conference using the Zoom software. If needed, we can provide training and assistance prior to telehealth sessions to help with familiarising yourself with the video conferencing program. The session will last approximately 2-3 hours and will involve a group of 5-7 participants. The groups will be coordinated by one facilitator and will be audio recorded using the Zoom recording functionality.
Time commitment: Up to 3 hours.

Component 2. User acceptance testing
You will be invited to engage with the nutrition education resource for a period of 4-weeks to demonstrate how users interact with and experience the platform. During the 4-weeks, you will be able to use the platform and its features at your own discretion. You will be asked to complete a brief series of questionnaires before and after engaging with the platform.
Time commitment: 4 weeks

(4) How much of my time will the study take?
The time commitment for Component 1 will be up to 2 hours, and 4 weeks for Component 2, with a required time committment of 1 hour in total to complete the online surveys (30 minutes pre-testing, 30 minutes post-testing). There is no minimum time commitment required in relation to the nutrition education platform. It is important to know that you can choose to take part in one or both phases of the study.

(5) Who can take part in the study?
You are eligible to participate in this study if you:

- Are aged 55 years and over;
- Currently live in Australia;
- Can read and write in English; and
- Have reliable access to the internet and a device that can connect to Zoom video conferencing software.

(6) Do I have to be in the study? Can I withdraw from the study once I've started?
Being in this study is completely voluntary and you do not have to take part. Your decision whether to participate will not affect your current or future relationship with the researchers or anyone else at the University of Sydney.

If you decide to take part in the study and then change your mind later, you are free to stop participating at any stage or refuse to any of the questions. We will delete any responses to online questionnaires. However, it will not be possible to withdraw your individual comments from our records once the focus groups has started, as it is a group discussion. With that being said, as no identifying information is collected during the group discussions, your responses will not be identifiable (i.e. anonymous).

(7) Are there any risks or costs associated with being in the study?
Aside from giving up your time, we do not expect that there will be any risks or costs associated with taking part in this study.

(8) Are there any benefits associated with being in the study?
We cannot guarantee that you will receive any direct benefits from being in the study. Your participation will help us to further understand older adult's wants and needs in relation to nutrition education for healthy ageing. This will directly inform the way we are able to develop and design a nutrition education resource to promote healthier eating behaviours in older adults. For those who choose to engage in Component 2, you may benefit from increased levels of nutrition knowledge which may in turn assist you to improve your dietary habits.

(9) What will happen to information about me that is collected during the study?
All information collected electronically will be kept on a secure server hosted by the University of Sydney, which only the above-named researchers will have access to.

Information collected during this study will be stored securely for 5 years and then destroyed. Study findings may be published, but you will not be individually identifiable in these publications. Your data will only be used for the purposes outlined in this Participant Information Statement, unless you consent otherwise.

We will keep the information we collect for this study, and we may use it in future projects. By providing your consent, you are allowing us to use your information in future projects. We don't know at this stage what these other projects will involve. We will seek ethical approval before using the information in these future projects.

(10) Can I tell other people about the study?
Yes, you are welcome to tell other people about the study.

(11) What if I would like further information about the study?
When you have read this information, Miss Ashlee Turner will be available to discuss it with you further and answer any questions you may have. If you would like to know more at any stage during the study, please feel free to contact Miss Ashlee Turner (study coordinator and PhD Candidate) on 02 9114 4198 or email her at ashlee.turner@sydney.edu.au.

(12) Will I be told the results of the study?
You have a right to receive feedback about the overall results of this study. This feedback will be provided in the form of a one-page lay summary and/or newsletter. You will receive this feedback after the study is finished.

(13) What if I have a complaint or any concerns about the study?
Research involving humans in Australia is reviewed by an independent group of people called a Human Research Ethics Committee (HREC). The ethical aspects of this study have been approved by the HREC of the University of Sydney [2022/543]. As part of this process, we have agreed to carry out the study according to the *National Statement on Ethical Conduct in Human Research (2007).* This statement has been developed to protect people who agree to take part in research studies.

If you are concerned about the way this study is being conducted or you wish to make a complaint to someone independent from the study, please contact the university using the details outlined below. Please quote the study title and protocol number.

The Manager, Ethics Administration, University of Sydney:

- **Telephone:** +61 2 8627 8176
- **Email:** human.ethics@sydney.edu.au
- **Fax:** +61 2 8627 8177 (Facsimile)

Facebook advertisement
Facebook advertisements will be targeted directly to users aged 50 years and over.

Looking for volunteer research participants to help us design, develop and evaluate an online nutrition education resource for older adults
<image to be used as link to REDCap>

OR

Aged you aged 55 years and over? Help us design, develop and evaluate an online nutrition education resource for older adults
<images to be used as link to REDCap>

OR

Help us to design, develop and evaluate an online education resource for older adults
<image to be used as link to REDCap>

Twitter
Twitter advertisements will be posted by members of the research team and shared to their networks.

Our team at the University of Sydney want your help to design, develop and evaluate an online nutrition education resource for older adults. Have your say on what you want and need from an online nutrition education program! Click the link to find out more https://bit.ly/3RdwyVE

@syd_health
@HBAProgram_USYD
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Version 2, 05 July 2022

Mediterranean Diet and Culinary Index (MediCul)

This is a survey about the food you eat. Read it carefully and identify the amounts that best describe your usual intake over the last six months. It is important that the answers you provide reflect what you personally eat, rather than what you think you should or shouldn't be having, or what someone else wants you to eat. When there are options, please choose **one response** most relevant to you.

1. How many serves of vegetables do you usually eat each day? (1 serve is ½ cup cooked vegetables or 1 cup of salad vegetables). Please choose one response most relevant to you.

   _____ serves per day

   OR

   _____ serves per week

   OR

   _____ serves per month

   OR

   ☐ I don't eat vegetables or salad

2. How many different types of vegetables do you usually eat in one week? Count each type only once.

   _____ different vegetables are eaten over the week

3. How often do you usually eat raw vegetables such as salads, carrot sticks, and sprouts? Don't count small garnishes. Please choose one response most relevant to you.

   _____ times per day

   OR

   _____ times per week

   OR

   _____ times per month

   OR

   ☐ I don't eat raw vegetables

4. How many times per week do you usually eat raw or cooked green vegetables? Write a number next to each of the two groups below. Place a '0' (zero) on the line if you don't usually eat any greens on a weekly basis. SEE PICTURE BELOW FOR EXAMPLES OF DARK GREEN LEAFY VEGETABLES.

   _____ times per week of broccoli, peas, beans, zucchini, brussel sprouts, cabbage, bok choy

   AND

   _____ times per week of dark green leafy varieties such as kale, spinach, silverbeet, amaranth, dandelion, chicory, endive, rocket

5. How often do you usually eat onions, garlic, spring onions or shallots? Count those used in cooking and eaten raw in salads. Please choose one response most relevant to you.

   _____ times per day

   OR

   _____ times per week

   OR

   _____ times per month

   OR

   ☐ I don't eat onions, garlic, spring onions or shallots

6. How many times per week do you usually eat dishes cooked in sauce made with tomato and onion simmered in olive oil? The sauce may also include garlic and herbs. (Exclude canned/bottled sauces if onion and olive oil are not used). Please choose one response most relevant to you.

   _____ times per week

   OR

_____ times per month

OR

☐ I don't eat dishes cooked in a sauce made with tomato and onion simmered in olive oil

7. How often do you usually eat hot chips, French fries, wedges or fried potatoes? Please choose one response most relevant to you.

   _____ times per day

   OR

   _____ times per week

   OR

   _____ times per month

   OR

   ☐ I don't eat hot chips, French fries, wedges or fried potatoes

8. Do you grow any of your own vegetables?
   ☐ No
   OR
   ☐ Yes

9. How often do you usually use herbs or spices? For example, in cooking, salads or desserts. This includes fresh or dried varieties such as parsley, oregano, cinnamon, cumin, pepper, etc. Please choose one response most relevant to you.

   _____ times per day

   OR

   _____ times per week

   OR

   _____ times per month

   OR

   ☐ I don't use herbs or spices

10. How often do you usually use lemon or vinegar when preparing food? For example, to make salad dressing, stirred into soup or for basting meat or seasoning vegetables before roasting. Please choose one response most relevant to you.

    _____ times per day

OR

_____ times per week

OR

_____ times per month

OR

☐ I don't use lemon or vinegar when preparing food

11. How often do you usually eat olives? This includes black, green, kalamata or stuffed olives and tapenade (a paste) made from olives. Please choose one response most relevant to you.

    _____ times per day

    OR

    _____ times per week

    OR

    _____ times per month

    OR

    ☐ I don't eat olives or tapenade

12. How many serves of fruit do you usually eat each day? Do not count juice. (1 serve is 1 medium piece or 2 mall pieces or fruit, or 1 cup of diced/canned fruit or 30g of dried fruit e.g. 4 dried apricot halves, 1 ½ tablespoons of sultanas). Please choose one response most relevant to you.

    _____ serves per day

    OR

    _____ serves per week

    OR

    _____ serves per month

    OR

    ☐ I don't eat fruit

13. How many serves of red meat such as beef, veal, lamb, kangaroo or pork do you usually eat each day? Include all steaks, chops, roasts, mince, stir-fries and casseroles. (1 serve of red met equals 100-150g). Please choose one response most relevant to you.

    _____ serves per day

    OR

_____ serves per week

OR

_____ serves per month

OR

☐ I don't eat red meat

14. How many serves of processed meat such as sausages, ham, devon, frankfurts, salami, luncheon meats or meat pies do you usually eat each day? (1 serve equals 1 ½ thick or 2 thinner sausages, 2 rashers bacon, 4 slices processed meats – 100g, 1 meat pie/pastie/sausage roll, 6 chicken nuggets). Please choose one response most relevant to you.

    _____ serves per day

    OR

    _____ serves per week

    OR

    _____ serves per month

    OR

    ☐ I don't eat processed meat

15. How many serves of white meat such as chicken, turkey or rabbit do you usually eat each day? Include all fillets, pieces, roasts, mince, stir-fries and casseroles. (1 serve of white meat equals 100-150g). Please choose one response most relevant to you.

    _____ serves per day

    OR

    _____ serves per week

    OR

    _____ serves per month

    OR

    ☐ I don't eat white meat

16. How many serves of fish or shellfish do you usually eat each week? Include fresh and canned. (1 serve is 1 small fish fillet or 1 small can of fish or 200g of shellfish). Please choose one response most relevant to you.

    _____ serves per day

OR

_____ serves per week

OR

_____ serves per month

OR

☐ I don't eat fish or shellfish

17. Which do you usually eat more often? Please choose one response most relevant to you.

☐ Chicken, turkey or rabbit

OR

☐ Beef, pork, hamburgers or sausages

OR

☐ I don't eat chicken or meat

18. How many eggs do you usually eat each day? Please choose one response relevant to you.

_____ per day

OR

_____ per week

OR

_____ per month

OR

☐ I don't eat eggs

19. How many serves of legumes do you usually eat each day? Legumes include baked beans, canned 4 bean mix, lentils, split peas, chickpeas and any other canned or dried beans. (1 serve is 1 cup/150g cooked or canned beans). They do not include fresh peas or green beans. Please choose one response most relevant to you. SEE PICTURE BELOW FOR EXAMPLES.

_____ serves per day

OR

_____ serves per week

OR

_____ serves per month

OR

☐ I don't eat legumes

20. How many times per week do you usually eat each of the following types of bread or wraps? Don't worry about amounts. Place a '0' (zero) on the line if you don't usually eat certain types of bread or wraps.

_____ times per week **white** e.g. Tip Top, Wonder White, Molenberg

_____ times per week **wholegrain** e.g. Burgen, Helga's, Schwob's Swiss Bakery

_____ times per week **wholemeal** e.g. Buttercup, Glicks, Bill's, Lawson's

_____ times per week **rye** e.g. Country Life, Abbott's Village Bakery, Van Der Meulin

_____ times per week **sourdough** e.g. Coles Bakery, Bill's Macro, Woolworths

21. How many serves of dairy products do you usually eat each day? (1 serve is 1 cup/250mL milk, 2 slices/40g hard cheese, ½ cup/120g ricotta/cottage cheese, 80g feta cheese or ¾ cup/200g yoghurt). Don't count dairy alternatives such as rice milk or soy yoghurt. Please choose one response most relevant to you.

_____ serves per day

OR

_____ serves per week

OR

_____ serves per month

OR

☐ I don’t eat dairy products

22. What type of milk do you usually have? Please choose one response most relevant to you.

☐ Regular dairy milk (whole or full cream)

OR

☐ Low or reduced fat dairy milk

OR

☐ Skim dairy milk

OR

☐ Other (please specify) _____

OR

☐ I don’t have milk

23. How often do you usually eat the fermented dairy products below? Please choose one response most relevant to you.

a) **Yoghurt?** This includes low fat, full cream, Greek yoghurt, probiotic yoghurt, fruit yoghurt and kefir.

_____ times per day

OR

_____ times per week

OR

_____ times per month

OR

☐ I don’t eat yoghurt

b) **Feta cheese?**

_____ times per day

OR

_____ times per week

OR

_____ times per month

OR

☐ I don't eat feta cheese

24. How many serves of nuts do you usually consume per day or per week? Nuts include peanuts, walnuts, Brazil nuts, cashews, etc. (1 serve is 30g of nuts or 1 ½ tablespoons of nut paste/peanut butter). SEE PICTURE BELOW FOR EXAMPLES.

_____ serves per day

OR

_____ serves per week

OR

_____ serves per month

OR

☐ I don't eat nuts

25. How many days per week do you usually use each of the following fats and oils? Fats and oils may be used in your cooking, as spreads or on salads. Don't worry about amounts. Place a '0' (zero) on the line if you don't usually eat certain types of fats/oils.

_____ days per week butter

_____ days per week margarine

_____ days per week mayonnaise

_____ days per week vegetable oil e.g. sunflower, grapeseed, canola, rice bran

_____ days per week olive oil

26. How many serves of butter or cream do you usually eat each day? Please choose one response most relevant to you.

_____ serves per day

OR

_____ serves per week

OR

_____ serves per month

OR

☐ I don't eat butter or cream

27. How many serves of margarine do you usually eat each day? (1 serve is 1 tablespoon). This includes all types/brands of margarine such as those formulated with olive oil, plant sterols and omega-3. For example, Flora, Meadow Lea, Olive Grove, Bertolli, Gold N Canola, Logical. Please choose one response most relevant to you.

    _____ serves per day

    OR

    _____ serves per week

    OR

    _____ serves per month

    OR

    ☐ I don't eat margarine

28. How many tablespoons of olive oil do you usually eat each day? (1 tablespoon = 20mL). This includes oil used in cooking, drizzled on salads or bread and food eaten away from home. Please choose one response most relevant to you.

    _____ tablespoons per day

    OR

    _____ tablespoons per week

    OR

    _____ tablespoons per month

    OR

    ☐ I don't use olive oil

29. a) Do you use olive oil as the main fat in your diet when considering all the types of fats/oils/spreads used in your cooking, food preparation and on your bread?

    ☐ Yes

    OR

    ☐ No

    b) If yes, what type of olive oil do you usually use? Please choose one response most relevant to you.

    ☐ Light

    OR

☐ Classic/Mild/Pure

OR

☐ Extra Virgin

OR

☐ Other (please specify) _____

30. How often do you usually have meals or snacks from takeaway food stores? Examples include McDonalds, Hungry Jacks, Pizza Hut, KFC, Red Rooster, fish/chicken shop or local takeaway food places and foods such as burgers, pizza, hot dogs, battered chicken or fish and chips.

_____ times per day

OR

_____ times per week

OR

_____ times per month

OR

☐ I don't eat takeaway foods

31. How many times per week do you eat biscuits or cakes of any type? This includes sweet biscuits, muffins, sponge cakes, sweet buns, donuts and pastries. Please choose one response most relevant to you.

_____ times per day

OR

_____ times per week

OR

_____ times per month

OR

☐ I don't eat biscuits or cakes

32. How many times per week do you usually consume custard or ice cream? Place a '0' (zero) on the line if you don't usually consume any.

_____ times per week custard

_____ times per week ice cream

33. How many cups of sugar sweetened/carbonated beverages do you usually drink each day? (1 cup is 250mL, 1 can of soft drink is 1.5 cups). This includes soft drink, cordial, sports drinks, vitamin water and energy drinks. Don't forget any used to mix with spirits. Don't count 'diet' drinks. Please choose one response most relevant to you.

    _____ cups per day

    OR

    _____ cups per week

    OR

    _____ cups per month

    OR

    ☐ I don't drink sugar sweetened/carbonated beverages

34. How many cups of fruit juice do you usually drink each day? (1 cup is 250mL). Fruit juice includes all types of fruit juices, fresh or commercial. Please choose one response most relevant to you.

    _____ cups per day

    OR

    _____ cups per week

    OR

    _____ cups per month

    OR

    ☐ I don't drink fruit juice

35. What type of fruit juice do you usually drink? Please choose one response most relevant to you.

    ☐ Fruit juice commercially packaged in bottles or tetra paks

    OR

    ☐ Freshly squeezed fruit juice

36. How many cups of water do you usually drink each day? (1 cup is 250mL, 1 litre equals 4 cups).

    _____ cups per day

    OR

    _____ cups per week

    OR

_____ cups per month

OR

☐ I don't drink water

37. a) How many cups of coffee do you usually drink each day? Please choose one response most relevant to you.

_____ cups per day

OR

_____ cups per week

OR

_____ cups per month

OR

☐ I don't drink coffee

b) If you drink coffee, which type do you mostly drink?

☐ Caffeinated

OR

☐ De-caffeinated

38. How many cups of tea do you usually drink each day? Please choose one response most relevant to you.

_____ cups per day

OR

_____ cups per week

OR

_____ cups per month

OR

☐ I don't drink tea (if so, skip the next question)

39. What type of tea do you mostly drink? Please choose one response most relevant to you.

☐ Black tea, with milk

OR

☐ Black tea, no milk

OR

☐ Green tea

OR

☐ Herbal tea (this contains no caffeine)

40. How often do you usually drink alcoholic beverages? Please choose one response most relevant to you.

_____ days per week

OR

_____ days per month

OR

☐ I don't drink alcoholic beverages (if so, skip the next two questions)

41. a) If you drink full strength beer, how many stubbies/cans (375mL) do you usually have? Please choose one response most relevant to you.

_____ stubbies/cans per day

OR

_____ stubbies/cans per week

OR

_____ stubbies/cans per month

OR

☐ I don't drink full strength beer

b) If you drink light beer, how many stubbies/cans (375mL) do you usually have? Please choose one response most relevant to you.

_____ stubbies/cans per day

OR

_____ stubbies/cans per week

OR

_____ stubbies/cans per month

OR

☐ I don’t drink light beer

c) If you drink wine, how many glasses (150mL) do you usually have? Please choose one response most relevant to you?

_____ glasses per day

OR

_____ glasses per week

OR

_____ glasses per month

OR

☐ I don’t drink wine

d) If you drink spirits, how many pub-sized nips (30mL) do you usually have? Please choose one response most relevant to you.

_____ nips per day

OR

_____ nips per week

OR

_____ nips per month

OR

☐ I don’t drink spirits

42. a) If you drink wine, what type do you usually have? (If not, skip this question).

☐ White wine

OR

☐ Red wine

b) When do you usually drink the wine?

☐ Only with main meals

OR

☐ With meals and/or at other times, outside of main meal occasions

Finally, we would like to ask you a few questions about your personal eating and lifestyle habits as well as the cooking methods used to prepare your foods.

43. How often is your **main or evening meal** cooked at home? This may be prepared by you, your family or your friends.

    _____ times per week

    OR

    _____ times per month

    OR

    ☐ I don't eat home cooked meals

44. How many of your **main or evening meals** do you eat alone (without company)?

    _____ meals per week

45. During the **warmer weather**, how many times per week do you usually eat foods/meals prepared using each of the following cooking methods? Place a '0' (zero) on the line if you don't use a certain cooking method.

    _____ times per week prepared by grilling, BBQing or deep frying in a pan

    _____ times per week prepared by shallow or deep frying

    _____ times per week prepared by roasting or baking

    _____ times per week prepared by boiling or stewing

    _____ times per week prepared by steaming

    _____ times per week prepared by stir frying

46. During the **cooler weather**, how many times per week do you usually eat foods/meals prepared using each of the following cooking methods? Place a '0' (zero) on the line if you don't use a certain cooking method.

    _____ times per week prepared by grilling, BBQing or deep frying in a pan

    _____ times per week prepared by shallow or deep frying

    _____ times per week prepared by roasting or baking

_____ times per week prepared by boiling or stewing

_____ times per week prepared by steaming

_____ times per week prepared by stir frying

47. a) How many times per day do you usually snack? Snacking is an eating occasion that occurs between main meals. Count snacks such as morning/afternoon tea, supper, eating while driving or while watching TV. If you snack multiple times between meals, count each occasion once if it is separated by 15 minutes.

    _____ times per day

    OR

    ☐ I don't usually snack between meals or I snack less often than daily

    b) If you do snack daily, name the three most frequent types of snacks you usually have.

    _____

    _____

    _____

48. How often do you usually fast? Fasting means deliberately abstaining from eating all foods or avoiding certain types of foods for given periods. For example, Lent, Ramadan, 5:2 diet. It does not mean occasionally skipping meals or missing breakfast.

    _____ days per week

    OR

    _____ days per month

    OR

    _____ days per year

    OR

    ☐ I don't fast (if so, skip the next question and go straight to the last question)

49. What option would best describe the type of fasting you usually practise? Please choose one response most relevant to you.

    ☐ I avoid certain types of foods when I fast e.g. avoid meat and dairy

    OR

☐ I restrict the amount of food for a given period e.g. reduce portion sizes or calories

OR

☐ I avoid all foods for a given period of time e.g. don't eat at all during the day

OR

☐ Other (please specify) _____

50. a) How many days per week do you usually take a nap after lunch?

_____ days per week

OR

☐ I don't take a nap after lunch (if so, you are finished the survey)

b) If you nap after lunch three days per week or more often, how long do you usually nap for? Please pick one option.

☐ Less than 30 minutes

OR

☐ 30 minutes or longer

Source: Radd-Vagenas S, Fiatarone Singh MA, Inskip M, Mavros Y, Gates N, Wilson GC, et al. Reliability and validity of a Mediterranean diet and culinary index (MediCul) tool in an older population with mild cognitive impairment. *Br J Nutr*. 2018;120(10):1189-1200. doi:10.1017/S0007114518002428

The purpose of this short interview is to gain your feedback on the LIFT diet and its delivery through the online website. We would like to understand how you felt about the diet, the website materials including the recipes, videos, nutrition information and how these materials were delivered. Your honest feedback is important to us, as this will help guide us when developing new research projects in the future.

Part 1: The LIFT diet
This section will ask you questions about the LIFT diet.

1. The LIFT diet was easy to stick to

☐ Strongly agree
☐ Agree
☐ Neutral
☐ Disagree
☐ Strongly disagree

2. I found that the LIFT diet involved:

☐ Too many changes from my usual diet
☐ Some changes from my usual diet
☐ Not many changes from my usual diet

3. Please provide any further comments about the LIFT diet (e.g. if you found it difficult to stick to, why?)

_____
_____
_____

Part 2: The website content
This section will ask you questions about the website content.

4. I found that the amount of information provided on the website was:

☐ Not enough
☐ Just right
☐ Too much

5. I found that the information provided on the website was useful and helped me to follow the LIFT diet

☐ Strongly agree
☐ Agree
☐ Neutral
☐ Disagree
☐ Strongly disagree

6. I found that the information provided on the website was easy to understand

☐ Strongly agree
☐ Agree

☐ Neutral
☐ Disagree
☐ Strongly disagree

7. I found that the recipes were easy to follow
☐ Strongly agree
☐ Agree
☐ Neutral
☐ Disagree
☐ Strongly disagree

8. The recipes used ingredients that I was familiar with
☐ Strongly agree
☐ Agree
☐ Neutral
☐ Disagree
☐ Strongly disagree

9. To what extend did you use the video recipes?
☐ Not at all
☐ To some extent
☐ To a large extent

Part 3: Engagement with the website
This section will ask you questions about how you engaged with the website and its content.

10. When did you first use the online resource?
☐ Today
☐ Less than a week ago
☐ Less than a month ago
☐ More than a month ago

11. How often did you use the platform?
☐ Every day or almost every day
☐ Once or twice a week
☐ Once or twice a month
☐ Less than once a month

12. How many times (in total) have you logged into the platform?
☐ 1 time
☐ 2-5 times
☐ 6-10 times
☐ 11-20 times
☐ >20 times

13. When using the platform, how long did you normally stay logged in?

☐ 1-5 minutes
☐ 6-10 minutes
☐ 11-20 minutes
☐ 20-30 minutes

14. When would you most commonly use the platform?

☐ Early morning (5am to 9am)
☐ Midmorning (9am to noon)
☐ Early afternoon (Noon to 3pm)
☐ Mid-afternoon (3pm to 6pm)
☐ Evening (6pm to 11pm)

15. What device did you most commonly use to access the platform?

☐ Personal laptop
☐ Smartphone
☐ Tablet
☐ Personal desktop computer
☐ Shared desktop computer

16. What was your first impression of the platform?

_____
_____
_____

17. What did you like best about the platform?

_____
_____
_____

18. What do you think could be improved about the platform (e.g., design, content, functionality)?

_____
_____
_____

User Engagement Scale – short-form (UES-SF)
Please read the statements below and rate your experience on a scale of 1 to 5.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1. I lost myself in this experience.					
2. The time I spent using the LIFT Diet Website just slipped away.					
3. I was absorbed in this experience.					
4. I felt frustrated while using the LIFT Diet Website.					
5. I found the LIFT Diet Website confusing to use.					
6. Using the LIFT Diet Website was taxing.					
7. The LIFT Diet Website was attractive.					
8. The LIFT Diet Website was aesthetically pleasing.					
9. The LIFT Diet Website appealed to my senses.					
10. Using the LIFT Diet Website was worthwhile.					
11. My experience was rewarding.					
12. I felt interested in this experience					

Source: O'Brien HL, Cairns P, Hall M. A practical approach to measuring user engagement with the refined user engagement scale (UES) and new UES short form. *Int J Hum Comput Stud*. 2018;112:28-39. doi:10.1016/j.ijhcs.2018.01.004

User Engagement Scale – short form (UES-SF)
Version 1, 21 February 2023