



**Exploring and understanding the barriers and drivers to adopting the
sustainable plant-rich Mediterranean diet**

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Certification

I certify that the ideas, experimental work, results, analyses, software and conclusions reported in this thesis are entirely my own effort, except where otherwise acknowledged. I also certify that the work is original and has not been previously submitted for any other award, except where otherwise acknowledged.

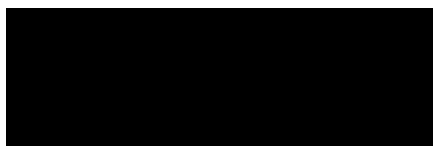


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Preface

The important measurement is not the distance from unattainable perfection, but from unforgiveable inaction.

I don't know.

Let me ask you a question: What's the opposite of someone who leaves lights on in empty rooms, buys inefficient appliances, and pumps the air-conditioning even when no one is home?

Someone who is attentive to energy use?

And what's the opposite of someone who takes cars everywhere he goes, no matter the distance, and no matter the convenience of public transportation?

Someone who is attentive to how much he drives?

What is the opposite of someone who eats a lot of meat, dairy, and eggs?

A vegan.

No. The opposite of someone who eats a lot of animal products is someone who is attentive to how often he eats animal products. The best way to excuse oneself from a challenging idea is to pretend there are only two options.

This is an excerpt from Jonathan Safran Foer's book, "We Are the Weather—Saving the planet begins at breakfast." In his chapter "Dispute with the Soul," Jonathan judges himself for eating animal products a handful of times over the past decade and questions his commitment to the climate change crisis. But as his "soul" stresses, aiming for perfection can increase hopelessness and inaction. I hope this work reduces this hopelessness by offering active hope, to use the environmental activist, Joanna Macy's term. Plant-rich eating is a challenging idea for many, but we cannot look away. The good news—there *are* more than two options here—it is not just a matter of eating a lot of meat or eliminating meat entirely. There are other ways; and as shown in the title of this work, eating a

Mediterranean diet offers us the chance to overcome our inaction and make the dietary changes our planet implores us to make.

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Thesis Abstract

High-meat consumption negatively impacts our planet and our health, especially in high-income countries where this eating pattern is the norm. Shifting peoples' eating patterns to align with a plant-rich diet is now considered crucial to reduce greenhouse gas emissions generated from agricultural production and improve human health and animal welfare. This thesis presents research that aims to: (1) explore which plant-rich diet to promote to Australian adults; (2) understand the barriers and drivers to the target plant-rich diet; and (3) develop and test an intervention to increase uptake of the target plant-rich diet, based on the barriers and drivers identified in the previous study.

In the first study, we assessed a range of plant-rich diets (Mediterranean, flexitarian/semi-vegetarian, pescatarian, vegetarian, and vegan) using the community-based social marketing framework (CBSM) (McKenzie-Mohr, 2011). Each diet was assessed using three metrics, the first relating to the environmental, human health, and animal welfare impact of each plant-rich diet, with the second and third metrics being self-reported data ($N = 253$ Australian adults) on current adoption and willingness to adopt each of these diets, respectively. Following the CBSM calculation for impact, the Mediterranean diet was identified as the target plant-rich diet, as it had the greatest projected positive impact score.

Using a combination of different research methodologies, the next two studies assessed the barriers and drivers to Mediterranean diet adoption using the capability-opportunity-motivation model of behaviour (COM-B) of the behaviour change wheel (BCW) (Michie et al., 2011). The first study was a qualitative study whereby 16 Australian adults who ate an omnivore or plant-rich diet were interviewed. Inductive and deductive analyses were applied using reflexive thematic analysis (Braun & Clarke, 2019; Braun et al., 2022) and the COM-B, respectively. Key barriers identified were: 1) *changing ingrained meat habits*; 2) *lack of physical and mental availability*; 3) *household influences*; 4) *meat*

perceived as tasty and Mediterranean diet foods as bland; and 5) minimal knowledge of the nutritional benefits of Mediterranean diet foods.

The next study was a quantitative study. Informed by the qualitative study results, an online sample of 443 Australian adults was surveyed to assess predictors of Mediterranean diet adoption. Exploratory factor analysis revealed four main factors (*Lack of Time and Knowledge, Food Allergies and Clean Eating, Meat Dependence, and Household Dietary Preferences*), that together with *Mediterranean Diet Familiarity* and *Not Having to Cook for Others*, predicted 44% of the variability in Mediterranean diet adoption. Assessing existing eating behaviours also highlighted that omnivores, on average, ate red meat more often, and legumes less often, than their meat-reducing counterparts.

The final study involved the development and evaluation of 11 legume-focused message attributes to increase legume consumption intentions within a sample of 201 Australian residents. Multilevel modelling revealed that message attributes referencing taste and convenience significantly increased intentions to consume legumes. In contrast, for high meat eaters, message attributes promoting enablement strategies or referring to health and financial benefits significantly decreased (and may be detrimental to) legume consumption intentions.

Overall, it can be concluded that shifting people from eating a high-meat diet to eating the Mediterranean diet requires a multifaceted approach that encompasses one's capability, opportunity, and motivation. Creating greater systemic opportunities for sustainable eating environments also needs to be considered in addition to promoting individual behaviour change.

Chapter 1

General Introduction

Global population is predicted to increase from 8 billion (2022) to 9.7 billion by 2050 (United Nations [UN] Department of Economic and Social Affairs, Population Division, 2022), prompting the question - how will we adequately feed the world? With a population of this size, combined with increasing urbanisation and consumer incomes (specifically in developing countries), total food consumption is projected to increase by 50.1% (from 2010 to 2050) (van Dijk et al., 2021). To support this demand, our food system needs to be sustainable; that is, it must have a low environmental footprint, be nutritionally adequate, and be available to both current and future generations (Food and Agriculture Organization [FAO] of the United Nations, 2010). Livestock production is now known to be a major contributor to climate change, with global greenhouse gas (GHG) emission estimates ranging from 16.5% to 30% coming from the livestock sector (Twine, 2021). Despite these alarming figures, global meat and dairy demand continues to grow (Alexandratos & Bruinsma, 2012; Organisation for Economic Co-operation and Development [OECD] & FAO, 2019), with growth expected until 2075 (OECD & FAO, 2023). Clearly, these food trends are not sustainable and place enormous pressure on our already strained planet (Aleksandrowicz et al., 2016). Meat consumption is especially concerning, with beef—by far—emitting the most global GHG emissions in the food sector, followed by lamb, prawns, and cheese, respectively (Ritchie et al., 2022). As such, meat consumption is the main focus of the current thesis.

Further to these negative environmental impacts are the human health (Batlle-Bayer et al., 2020) and animal welfare costs of eating meat (Scherer et al., 2019). High-meat diets, particularly those high in red and processed meat, are linked to multiple chronic diseases (Demeyer et al., 2016; Li et al., 2018; Micha et al., 2010; Pan, et al., 2011), while eating a

healthy plant-rich diet can reduce these health risks (Baden et al., 2019; Musicus et al., 2022). The rise of intensive livestock farming in response to our growing population and meat consumption trends (Gregory & Grandin, 2007; Thompson, 2015) also raise animal welfare concerns. While this farming style maximises production and profit, it comes at enormous costs to the health and wellbeing of animals due to overcrowding (Mpofu, 2020). Higher animal concentrations also pose greater risk of disease spreading amongst animals *and* humans (e.g., zoonotic diseases) with far-reaching implications for human health, the economy, and social functioning (Mpofu, 2020).

Clearly what we eat matters, with extensive consequences for the planet, people, and animals. As such, to truly understand and address the meat crisis, we need an approach that considers all these factors. One potentially suitable model is the ‘One Health’ approach. This framework promotes a holistic understanding of health – one that recognises the interdependent relationships among humans, animals, and the planet. To support a healthy eco-system, one cannot be considered without the other (Zinsstag et al., 2011). To that end, this more-inclusive framework helps understand the many risks of eating too much meat and, in-turn, provides guidance on which strategies to target.

In response to this complex issue, new initiatives are clearly needed across the food system. Dietary change is one solution that can reduce these risks (Intergovernmental Panel on Climate Change [IPCC], 2019, 2022) by aligning people’s eating patterns with a sustainable diet, i.e., one that is lower in meat and higher in plants. Reducing meat levels has greater environmental benefits than supply-focused ones (Poore & Nemecek, 2018), and promotes positive human health and animal welfare, as advocated in the ‘One Health’ framework. Furthermore, with broader adoption, the largest impacts would be seen in high-income, high meat-eating countries (Nelson et al., 2016; Springmann et al., 2018). High-

meat diets, however, remain the norm in most high-income countries (Whitton et al., 2021), signifying the urgent need to develop interventions aimed at changing these dietary patterns.

Despite the apparent environmental, human health, and animal welfare gains from dietary change innovations, supply-focused initiatives appear to have gained more traction. This was emphasised at the last two UN Climate Change Conferences (Cop28, 2023; Cop29, 2024), with hundreds of food and agricultural representatives attending. The conversation was therefore skewed towards strategies that favoured their bottom line, namely production ‘tech’ solutions, rather than dietary change (Sherrington et al., 2023; Sherrington, 2024). This prompted many critics to question if these summits are for *all* climate change solutions or only those that benefit the ‘powerful’ food and agricultural firms (Sherrington et al., 2023; Sherrington, 2024). As we edge closer to surpassing several climate tipping points (Wunderling et al., 2021), we simply cannot afford to prioritise profits over the planet. To reach a sustainable food system, all valid strategies need to be considered, and that means giving ‘meat reduction solutions’ a seat at the table.

Thesis Aims and Objectives

Meat consumption largely remains high in high-income countries and continues to grow in developing countries (Alexandratos & Bruinsma, 2012; OECD & FAO, 2019; Whitton et al., 2021). Given the negative environmental, human health, and animal welfare impacts from livestock production and the overconsumption of meat, this thesis aimed to explore ways to increase pro-environmental meat consumption behaviours in a high-meat, high-income country, such as Australia (Whitton et al., 2021). The objectives of this research were to:

1. Understand which plant-rich diet (i.e., Mediterranean, flexitarian/semi-vegetarian, pescatarian, vegetarian, and vegan) to target based on environmental (GHG emissions, land, and water use), human health, and animal welfare benefits, people’s

likelihood of adoption, and current low penetration rates (i.e., a diet many people are not already eating).

2. To explore both internal (individual) and external (environmental) barriers and drivers that influence a person's adoption of the target plant-rich diet.
3. To design and implement a behaviour change intervention aimed at increasing adoption of the target plant-rich diet.

Thesis Structure

To address the above objectives, four research studies were conducted and reported in four individual articles. Three have been submitted to journal articles, with one already published and two under review. Each article is presented as a separate chapter with a summary provided between each article to explain the shift to the next research study. The structure of the thesis is outlined below:

Chapter Two. This chapter presents a literature review using the 'One Health' approach by assessing the environmental, human health, and animal welfare impacts of livestock production and meat consumption, including growing meat consumption trends. Current initiatives to minimise the risks from livestock production and meat over-consumption are then discussed with specific reference to the benefits of eating a plant-rich diet, especially in high-income countries. Pro-environmental behaviours and meat eating are then reviewed with reference to behaviour change models (specifically the behaviour change wheel [BCW]) (Michie et al., 2011) and their currently limited application in this field. Drawing from the meat reduction literature, the barriers and drivers to decreasing meat levels are then discussed using the capability-opportunity-motivation model (COM-B) of behaviour from the BCW (Michie et al., 2011). This is followed by a review of existing meat-reduction interventions. Finally, limitations in the field of meat reduction and behaviour change are discussed, including a rationale for the current research.

Chapter Three. Study 1 addressed the first research objective, which was identifying which plant-rich diet to target in a later intervention. Using the community-based social marketing (CBSM) model (McKenzie-Mohr, 2011), five plant-rich diets (Mediterranean, flexitarian/semi-vegetarian, pescatarian, vegetarian, vegan) were assessed based on their environmental, human health, and animal welfare impacts, with the omnivore diet used as a baseline high-meat diet. Following the impact assessment, a survey was conducted with a representative sample of Australians to assess current penetration (i.e., number of people already eating each diet), and their likelihood of adopting each plant-rich diet. Impact, penetration, and adoption scores were used in a behaviour prioritization matrix formula, with the Mediterranean diet identified as the plant-rich diet to target due to it having the highest assessed potential impact.

Chapter Four. Study 2 partly assessed the second research objective, using qualitative measures to evaluate the barriers and drivers to Mediterranean diet adoption in an Australian sample ($N = 16$). Inductive (reflexive thematic analysis) (Braun & Clarke, 2019; Braun et al., 2022) and deductive (COM-B) (Michie et al., 2011) methods were applied to analyse the semi-structured interviews. Themes ranged across the capability, opportunity, and motivation factors, with automatic eating habits and lack of time (physical and mental availability) key barriers identified.

Chapter Five. Extending upon Study 2, Study 3 further explored the barriers to Mediterranean diet adoption in an online survey with a representative Australian adult sample ($N = 443$). Using the results from Study 2 and the Mediterranean diet and meat-reduction literature (Lacroix & Gifford, 2019; Malek et al., 2019; Stoll-Kleemann & Schmidt, 2017), a COM-B survey was developed, with the results subjected to exploratory factor analysis and hierarchical regression to predict potential Mediterranean diet adoption. Identified barriers ranged across the COM-B, with low Mediterranean diet familiarity, not

having to cook for others, and lack of time and knowledge the top predictors of Mediterranean diet adoption. Additionally, current eating habits were quantitatively assessed, with *high* red meat and *low* legume eating habits identified (comparative to the Mediterranean diet), specifically for omnivore eaters.

Chapter Six. Study 4 used the data from the previous studies to design a messaging study aimed at increasing the consumption of legumes, a core Mediterranean diet food. Two hundred and one university students reviewed twelve messages, with 11 attributes (per the COM-B intervention functions) embedded across the messages. Using multilevel modelling, taste and convenience message attributes significantly increased intentions to consume legumes across all participants, while attributes promoting enablement strategies or referring to health and financial benefits significantly *decreased* legume consumption intentions for high-meat eaters.

Chapter Seven. In this final chapter, the results of the previous chapters are summarised and compared to the existing literature. The implications and limitations of this research is discussed, as are future directions.

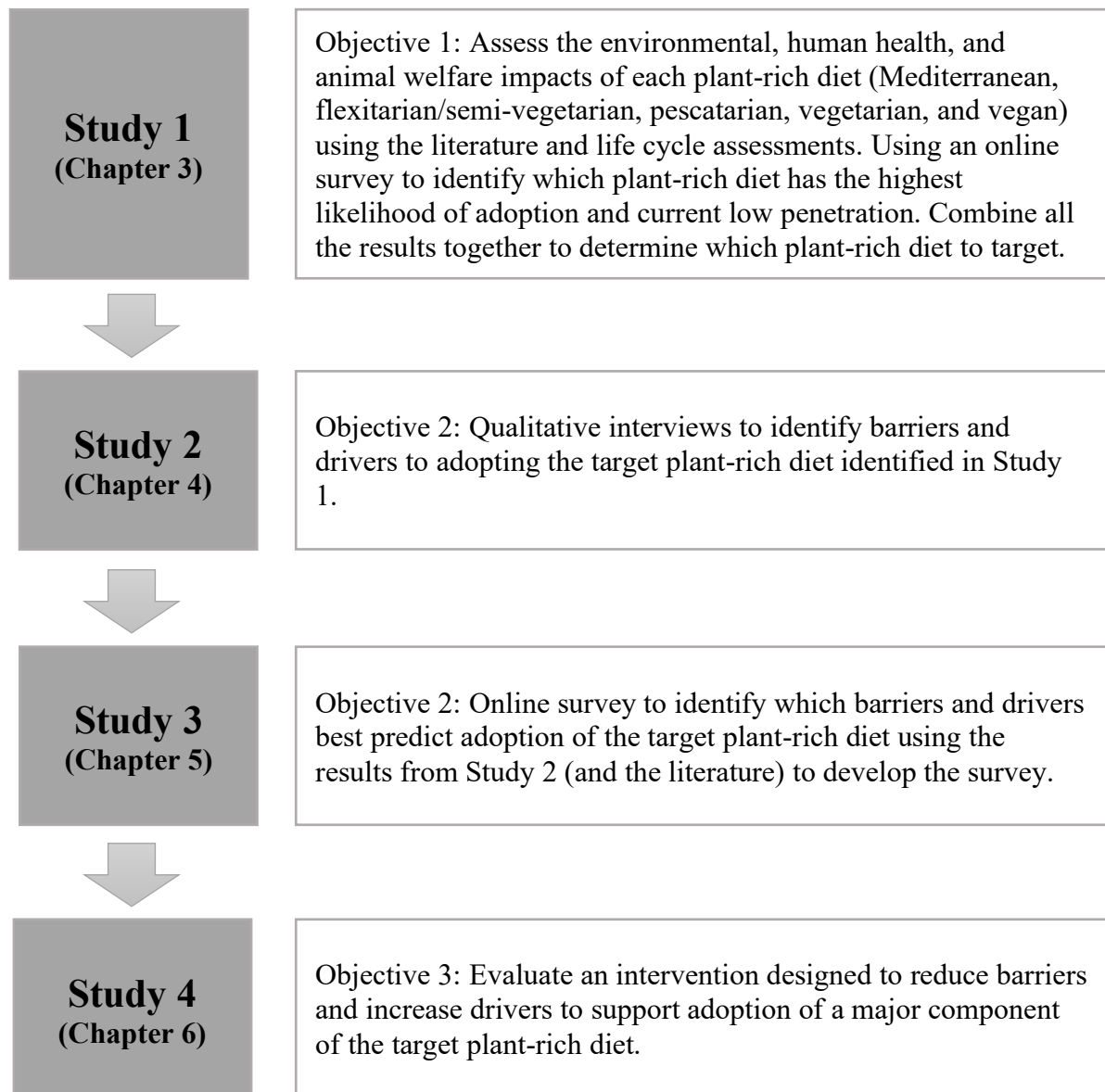


Figure 1.1

Outline of Research Studies that Comprise this Thesis

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Chapter 2

Literature Review

Meat Consumption

Meat is a source of nutrition and is attributed to having shaped our evolutionary history (Leroy & Praet, 2015). Over the last century, however, a significant shift in many people's food habits emerged, with the relatively scarce meat becoming more common place, especially in Western diets (Beardsworth & Bryman, 2004). Economic growth, changes in the food industry, and increased urbanisation all contributed to these dietary changes (Organisation for Economic Co-operation and Development [OECD] & Food and Agriculture Organization [FAO] of the United Nations, 2019; Stabler, 2011), with meat demand now growing in developing countries (Alexandratos & Bruinsma, 2012; FAO, 2017b; Whitton et al., 2021). Given the many negative environmental, human health, and animal welfare impacts from high meat consumption (Aleksandrowicz et al., 2016; Batlle-Bayer et al., 2020; Scherer et al., 2019), we urgently need to reassess our consumption levels, particularly in high-income countries where high-meat diets are well established (Whitton et al., 2021). Using the holistic 'One Health' approach (Zinsstag et al., 2011), we turn to a review of the literature to first outline these negative environmental, human health, and animal welfare impacts, followed by a discussion on initiatives.

The Impact of our Increasing Demand for Meat

Environmental. Food systems are estimated to be responsible for over one third of global greenhouse gas (GHG) emissions (Crippa et al., 2021), with the majority (59%) from livestock production (i.e., meat, dairy, aquaculture, and eggs) (Poore & Nemecek, 2018). Enteric fermentation and feed production are the main sources of livestock emissions, accounting for 44% and 41%, respectively. During the enteric fermentation (digestive) process, ruminant animals (e.g., cattle and sheep) release methane, with one third of global

methane emissions now attributed to livestock production (Saunois et al., 2020). Feed production also releases carbon dioxide and nitrous oxide from fertilisers and pesticides, transportation and processing, land clearing, and the application of manure in pastures and crop fields. Both methane and nitrous oxide have significant impacts on global warming, being 28 and 265 times stronger than carbon dioxide, respectively (FAO, 2017a; Myhre et al., 2013). Additionally, GHG emissions differ by meat type, with beef production emitting the most, followed by pork, lamb and, to a lesser extent, white meat (e.g., poultry) (Cesari et al., 2018; Lupo et al., 2013; Six et al., 2017; Wiedemann et al., 2015). To emphasise these emission differences, the USA could cut more than 35% of their total GHG emissions if their citizens simply switched from eating beef to eating chicken (Grummon et al., 2023).

Further to these emissions is the considerable land used for livestock production. Almost 80% of total agricultural land is dedicated to pastures and arable land (i.e., land dedicated to the production of animal feed), with only 16% used to grow other food for humans (Ritchie & Rosa, 2019). A primary cause of deforestation is also from livestock production, further releasing carbon emissions and contributing to land degradation, soil erosion, biodiversity loss, and contaminated water (FAO, 2017a, 2020; Pendrill et al., 2019; Westhoek et al., 2011). Despite the scale of these negative environmental impacts, deforestation continues at exponential rates, with global meat demand a key driver (Guglielmi, 2022). One area significantly affected by deforestation is the Amazon region (Curtis et al., 2018). Traditionally, this area has absorbed one quarter of the world's carbon dioxide (Pan et al., 2011; Phillips et al., 2009), but extensive land clearing primarily for beef and feed production, combined with hotter temperatures and droughts from climate change, means the Amazon now emits more carbon dioxide than it can absorb (Gatti et al., 2021). This is new territory for our planet, with Gatti and colleagues (2021) warning of an even greater acceleration of the climate crisis due to this change.

Further to these GHG and land impacts are the negative impacts on water (Farchi et al., 2017). The livestock sector uses 41% of total consumptive water (Heinke et al., 2020) for animal intake, growing feed crops, and meat processing (Thornton et al., 2009). As temperatures rise from climate change, these water demands are set to increase, with multiple sectors (e.g., livestock, crops, and non-agricultural) competing for this precious and essential resource (Fader et al., 2016; Gerten et al., 2011). Evidently, the negative environmental impacts of livestock production is wide-ranging; to further highlight this point, the below example demonstrates the staggering difference between producing 1kg of beef compared to 1kg of beans.

“...producing 1kg of protein from beef needs 18 times more land, 10 times more water, 9 times more fuel, 12 times more fertilizer, and 10 times more pesticides than the same amount of proteins obtained from kidney beans...” (Sabaté et al., 2015).

Human Health. In addition to the numerous environmental risks from livestock production are the human health impacts from consuming too much meat. Meat is a source of several important nutrients such as iron, zinc, and vitamin B12 (Pereira & Vicente, 2013); however, eating a high-meat diet is linked to cardiovascular disease, some cancers, and type 2 diabetes, with processed meat associated with higher mortality rates (Demeyer et al., 2016; Du et al., 2020; Li et al., 2018; Luan et al., 2020; Micha et al., 2010; Pan et al., 2011; Shannon et al., 2023). In their assessment of 164 countries, Ranabhat et al. (2020) also found life expectancy to be negatively impacted by red meat consumption, particularly in high-and middle-income countries, where consumption is higher. Given these risks, the International Agency for Research on Cancer (2015; Red Meat and Processed Meat Report, Vol. 114) now classifies both processed and red meat as carcinogenic (Group 1) and probably carcinogenic (Group 2A), respectively. They noted that while the risks are small, they increase with greater consumption and therefore should be considered a public health concern.

Another possible health implication from meat eating is the impact of consuming environmental (chemical) contaminants, which are often found in meat and meat products. Given the carcinogenic elements of these chemical pollutants, there is a possible link to cancers (Domingo & Nadal, 2016), with red meat typically containing more contaminants than white meat (e.g., poultry) (Domingo, 2017; González et al., 2019; González et al., 2018). In contrast, eating a diet high in plants and low in meat (particularly red and processed meat), as found in traditional Mediterranean diets, is associated with reduced heart failure, stroke, total mortality, dementia, and some cancers (Di Maso et al., 2019; Ibsen et al., 2019; Martinez-Gonzalez & Martín-Calvo, 2016; Trichopoulou & Vasilopoulou, 2000). Clearly, how much meat we eat can have multiple health implications. To that end, eating less meat has considerable potential to improve human health and reduce environmental pressures, creating a win/win situation.

Animal Welfare. A third benefit of reducing meat demand is the often-overlooked animal welfare concerns. Greater demand for meat has had a significant influence on farming practices, with intensified livestock farming (often termed ‘concentrated animal feeding operations,’ or ‘CAFOs’ for short) becoming more commonplace (Gregory & Grandin, 2007; Thompson, 2015). It is difficult to determine how many animals are intensively farmed globally, but estimates from the Sentience Institute (2019) (using data from the United States Department of Agriculture, 2017, and definitions from the United States Environmental Protection Agency, n.d.) indicate that 99% of livestock in the US are now farmed using this method, though this of course would vary from country to country.

Greater farm animal concentration is linked to negative welfare consequences such as lame birds and increased aggressive behaviours in pigs and cows (Bessei, 2006; Dawkins et al., 2004; Park et al., 2020; Peden et al., 2018). These farming practices also impact human health, increasing the risks of antibiotic resistance (i.e., due to a reliance on antibiotics to

combat diseases and rapidly increase weight in livestock) (Angelakis, 2017; Kivits et al., 2018) and zoonoses (e.g., Hendra virus, Avian influenza, and coronaviruses) (Allen et al., 2017). While zoonoses can emerge from deforestation practices (Rohr et al., 2019), the concentration and confines of farm animals and their waste also pose substantial risk, more so with the rise of these farming practices (Hayek, 2022). Additionally, greater animal waste pollutes water bodies, further contributing to biodiversity destruction (Mpofu, 2020).

Animal welfare concerns also extend to non-farm animals, with human actions resulting in the reduction and extinction of several species via habitat loss, toxification (e.g., through synthetic chemicals), and invasive organisms, to name a few (Ceballos et al., 2017). Considered to be the sixth major extinction event in Earth's history, the current loss of species is far-reaching, impacting the entire range of ecological networks—animals, plants, and microorganisms (Ceballos & Ehrlich, 2002; Dirzo et al., 2014; Gaston & Fuller, 2008). Thus, reducing meat demand for animal welfare has multiple benefits; it can alleviate animal suffering for both farm and non-farm animals, reduce environmental destruction, and provide further protection for human health.

Growing Demand for Meat. Despite these environmental, human health, and animal welfare threats, meat consumption has been increasing since the 1960s (in most countries), showing an acceleration in the 1980s (Basu, 2015). Indeed, researchers estimate a 204% increase in meat products between 1960 and 2010 (Basu, 2015), with this figure rising to 500% between 1992 and 2016 (Katare et al., 2020). Recent growth is most prominent in developing countries, particularly those with increased personal incomes (e.g., China, Brazil) (Alexandratos & Bruinsma, 2012; FAO, 2017b; Whitton et al., 2021). In fact, 85% of increased meat consumption occurred in developing countries between 1998 and 2018 (FAO, 2017b; OECD & FAO, 2019). This trend is expected to continue, with global meat consumption projected to increase by 76% between 2007 and 2050 (Alexandratos &

Bruinsma, 2012; OECD & FAO, 2019). In contrast, meat consumption has remained relatively high in developed countries. Australians, for example, continue to consume over 100kg of meat per capita (Whitton et al., 2021), compared to 34.1kg per global capita (Salter, 2018), with an observed increase in total meat consumption between 2000 and 2019 (Whitton et al., 2021). These trends are clearly alarming and highlight the need to advocate for dietary change to achieve a sustainable global food system now and for the future.

Initiatives to Minimise Risk from Livestock Production and Meat Over-Consumption

Across the food system, several initiatives have been developed to reduce the above risks. On the production side, changes to manure management, feed conversion, and feed additives can reduce methane emissions, and sustainable agricultural practices (e.g., conservation agriculture, sustainable and ecological intensification, agro-ecological and diversified farming systems, and organic) can reduce environmental damage (Beach et al., 2015; IPCC, 2022). These much-needed supply-focused initiatives, however, have not delivered change fast enough (Beach et al., 2015; Honan et al., 2022; OECD, 2023) and do not address the increasing demand for meat, which impacts supply levels. Moreover, the adverse human health and animal welfare consequences largely are not considered in these practices.

From a demand perspective, food manufacturers have developed alternatives to traditional meat such as plant-based meat alternatives (PBMAs) (e.g., plant-based burgers) and cultured meat (i.e., meat grown in a lab from animal cells) (Datar & Betti, 2010). In recent years, the PBMAs market has grown significantly, with a 47% increase in Australia from 2020 to 2023 (Kalocsay et al., 2024). However, most growth was observed in food services rather than retail sales, with price (higher than traditionally produced meat) identified as a key barrier (Kalocsay et al., 2024). Plant-based meat alternatives are also classified as an ultra-processed food, with taste and nutritional concerns acting as additional

barriers to consumption (Bryant & Barnett, 2019; Kalocsay et al., 2024; Szenderák et al., 2022). Cultured or lab grown meat is another food initiative that is gaining momentum (Datar & Betti, 2010; Post et al., 2020), though access remains limited and cost and health concerns continue to impact acceptance and adoption (Bryant & Barnett, 2019). Younger people, however, may be more open to consuming this product (Zhang et al., 2020).

Eating a plant-rich sustainable diet is another demand-based initiative and is endorsed by the International Panel of Climate Change (IPCC, 2022). Some countries (e.g., Germany) have included meat reduction as part of their climate goals (Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, 2017), while international campaigns (e.g., Meatless Monday) have also emerged (Laestadius et al., 2013). Most dietary guidelines already promote limited red meat and no processed meat for health reasons, and the increased attention on sustainable eating has prompted several countries to incorporate sustainability measures in their guidelines (James-Martin et al., 2022). Australia, for example, has added sustainability to their agenda for their latest guideline review (due for release in 2026) (National Health and Medical Research Council, n.d.). Dietary shift, however, needs to occur sooner than this timeline allows. Furthermore, dietary guidelines typically have produced limited behaviour change, with many people continuing to over-consume meat and under-consume vegetables and legumes (Australian Bureau of Statistics [ABS], 2022a; World Health Organisation, 2023). Overall, there is enormous scope to shift high-meat dietary patterns to support a sustainable food system. Changing the meat/plant ratio not only reduces meat demand, but supply and production, benefitting the planet, human health, and animal welfare.

Sustainable Plant-rich Diets. Eating a sustainable diet is clearly one way to reduce meat demands and it aligns well with a more holistic ‘One Health’ response to the meat crisis (Zinsstag et al., 2011). Several studies have attempted to determine which foods constitute a

sustainable healthy diet, with one study applying a life cycle assessment to 38,700 farms, 1600 processors (i.e., post-farm food processing), packaging types, and retailers (Poore & Nemecek, 2018). While varied environmental impacts were noted due to different agricultural practices and geographics, overall, even the lowest-impact animal products typically exceeded those of plant substitutes. Poore and Nemecek's (2018) analysis also highlighted that 37% of our protein and 18% of our calories comes from animal-based products. In comparison, plant-based foods typically have better 'environmental impact to nutritional value' conversion rate (e.g., protein) (Aiking & de Boer, 2018; Clark & Tilman, 2017). This imbalance signifies the far-reaching environmental benefits of eating less meat and the limits of supply-focused strategies.

Another study assessing the environmental, food security, and health effects of different diets across 150 countries found that four low meat diets (flexitarian, pescatarian, vegetarian, vegan), have the potential to reduce GHG emissions and other negative environmental impacts, if broadly adopted, more so than diets higher in animal-based foods (e.g., meat and dairy). These diets were all nutritionally adequate (apart from a small number of nutrient supplements needed for some), led to large reductions in premature mortality, and reduced environmental impacts (i.e., greenhouse gases, freshwater use, nitrogen and phosphorus application, and cropland use) (Springmann et al., 2018). The greatest gains were in high-income countries with high-meat eating levels. The plant-rich Mediterranean diet, known for its positive health benefits, also has a low environmental footprint when compared to a high meat omnivore diet (Martinez-Gonzalez et al., 2016). Taken together, these results clearly highlight the benefits of eating a plant-rich diet, but changing long-standing meat-eating habits is difficult, as has been observed in the health and meat-reduction literature discussed below.

Pro-environmental Behaviour and Meat Eating

The strong links between meat consumption and climate change have prompted a growing interest in the pro-environmental field (Abrahamse, 2020; Stoll-Kleemann & Schmidt, 2017). Several studies have assessed the barriers and drivers to meat reduction in general (Graves & Roelich, 2021; Kemper, 2020; Malek et al., 2019), with others assessing specific plant-rich diets (Lea & Worsley, 2003; Rattenbury & Ruby, 2023; Rosenfeld & Tomiyama, 2020). Meat-exclusionary diets (e.g., vegetarian) have typically been the focus, though research assessing meat-reduced diets (e.g., flexitarian, Mediterranean) is growing. Additionally, interventions aimed at shifting dietary behaviours also remain limited (Kwasny et al., 2022).

The application of behaviour change models is also limited in the meat reduction field (Tsofliou et al., 2022), despite this approach being considered best practice for intervention design. Applying a relevant model enables a more comprehensive understanding of a behaviour (including which behaviour to target) to enhance the success of an intervention (McKenzie-Mohr, 2011; Michie et al., 2011). In the health field, time and money has been wasted on interventions that do not work, prompting the greater use of behaviour change models (e.g., behaviour change wheel) to change specific (and often complex) behaviour patterns (e.g., smoking cessation programs, enhancing healthy eating) (Michie et al., 2011). Pro-environmental behaviours (i.e., behaviours that have as minimal harm on the environment as possible) also depend on human behaviour patterns, so it is appropriate to apply these models to this context (Steg & Vlek, 2009). Given the urgent need for people to adopt sustainable practices, these models are starting to be used to enhance pro-environmental behaviours (e.g., sustainable palm oil consumption, adoption of renewable energy sources, and wild dog management) (Frantz et al., 2016; Hine et al., 2020; Please et al., 2017; Sundaraja et al., 2020).

Using a behaviour change model is clearly beneficial; but which model is best suited to meat reduction? The theory of planned behaviour (TPB) is one model that has been used to understand pro-environmental meat-eating behaviours (Carfora et al., 2017; Weibel et al., 2018; Scannell et al., 2020). This model proposes that behavioural intentions and behaviour itself are primarily predicted by a person's attitude (i.e., how positive pro-environmental behaviour is evaluated), subjective norms (i.e., social influences that shape pro-environmental behaviour) and perceived behaviour control (i.e., how easy or difficult it is to demonstrate a certain pro-environmental behaviour) (Ajzen, 1991). Attitudes, personal norms, problem awareness, and perceived behavioural control have all been identified as significant in reducing meat consumption, both in general and when applied to different phases of change (i.e., pre-decision, pre-action, action, and post-action) (Weibel et al., 2018; Zur & Klöckner, 2014). While the TPB model provides significant insights into the factors influencing meat consumption, it has come under criticism due to its focus on rational thinking as opposed to sub-conscious behaviours (e.g., habits), which are considered key to understanding food choices such as meat consumption (Klöckner, 2013; Moore & Boldero, 2017). Given these limitations, a behaviour change model that incorporates habitual behaviours, such as the behaviour change wheel (BCW) (Michie et al., 2011), is likely to be a more appropriate framework (Michie et al., 2011).

Behaviour Change Wheel

The behaviour change wheel (BCW) was developed by Michie et al. (2011) who incorporated the core elements of 19 behaviour change models. Consisting of three layers (sources of behaviour, intervention functions, and policy categories), this comprehensive framework can be applied to any behaviour and is well suited to individuals, groups, subpopulations, and populations (see Figure 2.1). The first step of the BCW is identifying the target behaviour or behaviours to be changed, followed by a comprehensive analysis of these

behaviours to better understand why they occur and how they can be changed (Michie et al., 2011). Michie et al. stress the importance of understanding the context (or external influences) of a behaviour—a key though often under-explored component in intervention designs and implementation. The behavioural analysis section assesses behaviour using the COM-B model—capability, opportunity, and motivation. These three interacting components form the inner layer of the BCW and are described below.

- Capability can be psychological (i.e., knowledge or psychological skills, strength or stamina to engage in the necessary mental processes) or physical (i.e., physical skills, strength, or stamina).
- Opportunity incorporates context, focusing on factors that lie outside of an individual. Opportunity can be physical (i.e., environmental resources) and/or social (social norms).
- Motivation can be reflective (i.e., intentions, beliefs, and goals) or automatic (habitual processes, emotions, and rewards).

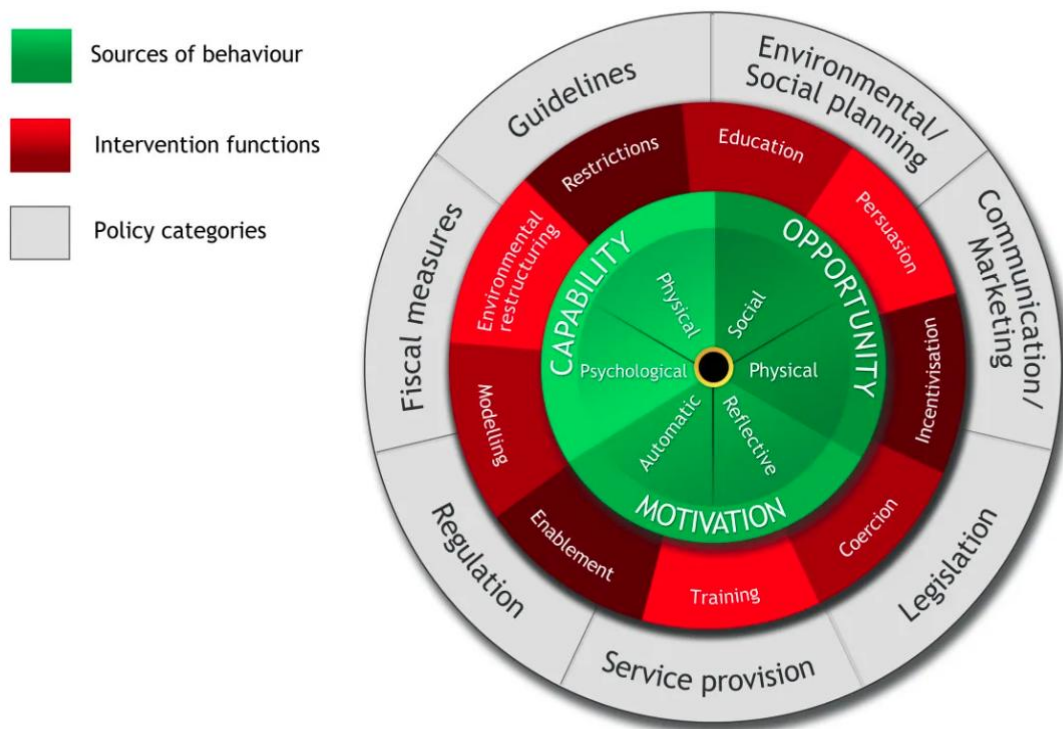


Figure 2.1

The Behaviour Change Wheel

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The COM-B model is then used to inform which intervention functions to apply for the greatest chance of success, with nine interventions included in the second layer (see Table 2.1).

Table 2.1*Definitions of Interventions*

Intervention	Definition	Examples
Education	Increasing knowledge or understanding	Providing information to promote healthy eating
Persuasion	Using communication to induce positive or negative feelings or stimulate action	Using imagery to motivate increases in physical activity
Incentivisation	Creating expectation of reward	Using prize draws to induce attempts to stop smoking
Coercion	Creating expectation of punishment or cost	Raising the financial cost to reduce excessive alcohol consumption
Training	Imparting skills	Advanced driver training to increase safe driving
Restriction	Using rules to reduce the opportunity to engage in the target behaviour (or to increase the target behaviour by reducing the opportunity to engage in competing behaviours)	Prohibiting sales of solvents to people under 18 to reduce use for intoxication
Environmental Restructuring	Changing the physical or social context	Providing on-screen prompts for GPs to ask about smoking behaviour
Modelling	Providing an example for people to aspire or imitate	Using TV drama scenes involving safe-sex practices to increase condom use
Enablement	Increasing means/reducing barriers to increase capability or opportunity ¹	Behavioural support for smoking cessation, medication for cognitive deficits, surgery to reduce obesity, prosthesis to promote physical activity

¹Capability beyond education and training; opportunity beyond environmental restructuring

Note. Reprinted from *The behaviour change wheel: A new method for characterising and designing behaviour change interventions* by Michie, van Stralen & West (2011), retrieved from <http://www.implementationscience/content/6/1/42> Copyright 2011 by Michie et al; licensee BioMed Central Ltd.

Predominantly used in the health field (e.g., healthy eating for at-risk patients, physical activity) (McEvoy et al., 2018, Timlin et al., 2021; Willmott et al., 2021), the BCW has more recently extended to pro-environmental behaviours including palm oil purchasing behaviours (Sundaraja et al., 2021) and biodiversity conservation (Marselle & Golding,

2022). Two recent studies have applied the BCW to meat eating, with one incorporating elements of the BCW to assess the barriers to flexitarian eating in Denmark (Halkier & Lund, 2023). Another study (van den Berg et al., 2022) used the COM-B to assess meat reduction across different life transitions (e.g., leaving home) for young Dutch adults. Findings highlighted taste, perceived high prices of meat alternatives, and habits as key barriers. This preliminary research highlights the applicability of the BCW to assess pro-environmental behaviours, and more specifically, reducing meat consumption. Thus, the BCW is well suited to increase plant-rich eating and is discussed below in the context of the meat reduction literature.

Physical Capability. Physical capability relates to one having the physical ability and skills to engage in a specific activity (Michie et al., 2011). Cooking skills have been identified as a main barrier to reducing meat consumption due to people lacking the skills to cook a meat-free meal or prepare and use meat substitutes (Dibb & Fitzpatrick, 2014). This is further highlighted by two-thirds of Australians having ten or fewer recipes in their repertoire, with most meat-based (McCrindle, 2017). People also tend to eat out more, with total fast food and restaurant expenditure increasing from 25% (1988-1989) to 34% (2015-2016) in Australia (ABS, 2015-2016). This trend has occurred across all ages but has been most prominent in adults under 34 years, potentially impacting cooking skills (Hogan, 2018). These food trends are somewhat continuing, though the COVID-19 pandemic has made it difficult to obtain accurate trend estimates (ABS, 2024). Furthermore, in the context of rising cost of living in Australia, people are spending less (ABS, 2024), with fast food companies seemingly preferred to mid-tier restaurants (Barrett, 2024). Meat consumption is also impacted by price and affordability (Edjabou & Smed, 2013; Lanfranco & Rava, 2014), with Australians consuming more poultry and less beef in line with price changes (i.e., beef prices increasing) (Malek & Umberger, 2021; Wong et al., 2015). Organic meat is also perceived as

expensive, influencing the purchase of the oft-termed ‘better’ meat (Stoll-Kleemann & Schmidt, 2017). Perceived cost also appears to act as a barrier to healthier eating (Seguin et al., 2014), particularly among low-income earners (Stolz et al., 2011).

Skills training and enablement are two intervention functions aimed at enhancing physical capability (Michie et al., 2011). In line with the limited cooking skills highlighted above, training is clearly needed. Lack of time, however, can affect training opportunities and is discussed further in the physical opportunity section below. Enablement has also occurred via technology advances in food products. Plant-based meat alternatives have grown significantly, with growth predicted to continue in Australia (ABS, 2022b) and other Western countries such as the United States (MarketsandMarkets, 2024). However, taste (Michel et al., 2021) and health concerns remain barriers (Melville et al., 2023; Szenderák et al., 2022).

Another food innovation is cultured meat whereby meat is produced using animal cell cultures (Tuomisto & de Mattos, 2011). Notably, this industry is still in its infancy and products remain both expensive and hard to access (Post et al., 2020). Most people also prefer conventional meat over cultured meat due to concerns about taste, cost, and safety (Bryant & Barnett, 2019; Post et al., 2020). Interestingly, research found that people’s intentions to reduce meat were stronger when the unnatural aspects of conventional meat (i.e., antibiotics, hormones, unsanitary farming conditions, viruses and bacteria, additives, colouring and preservatives) were emphasised compared to the natural aspects of cultured meat (Bryant & Barnett, 2019). Increasing meat prices through taxes is another enablement strategy that has been suggested at the policy level (Klenert et al., 2023; Stoll-Kleemann & O’Riordan, 2015) and may be an effective way to reduce livestock GHG emission levels (Edjabou & Smed, 2013).

Psychological Capability. Knowledge and awareness are two core psychological capability factors that can function as barriers to meat reduction. Knowledge can relate to

both factual knowledge (e.g., knowledge of issues) and procedural knowledge (e.g., having the skills to engage in action strategies) (Stoll-Kleemann & Schmidt, 2017). Factual knowledge linking meat consumption and climate change is growing, with 30% of people agreeing that meat production has a negative impact on the environment in both Australian and international studies (Garnett et al., 2015; Malek et al., 2017; Malek et al., 2019). However, people more committed to eating meat are less likely to believe the negative links between livestock and climate change (Malek et al., 2019), potentially showing evidence of motivated reasoning (Sanchez-Sabate & Sabaté, 2019). Health is another driver that motivates people to eat less red and processed meat (Malek et al., 2019) though awareness of the negative impacts of overconsuming red and processed meat (Grummon et al., 2022), and of the nutritional value of plant-rich diets (Consavage Stanley et al., 2023; Lea et al., 2006; Povey et al., 2001) remains relatively low. High meat eaters also tend to perceive plant-rich diets as nutritionally inadequate (Malek et al., 2019). As noted above, low skill level (i.e., procedural knowledge) is a barrier to cooking meat-free meals, in part due to less knowledge of meat-free recipes (Corrin & Papadopoulos, 2017; Kwasny et al., 2022; Lea et al., 2006; Schüz et al., 2005). This lack of knowledge is particularly relevant to Western countries, where a meal is often structured around meat (e.g., steak and salad) (McKindle, 2017; Schösler et al., 2012).

Education, training, and persuasion are all intervention functions that enhance psychological capability (Michie et al., 2011). Given the apparent lack of knowledge and skill level in this area, education appears to be a relevant intervention function. One study assessing people's awareness about the negative environmental impacts of meat (via environmental consciousness and problem awareness) found most people to be 'highly unsure' (40%) or 'rather conscious' (20%), of meat related environmental issues, with only 8% 'highly conscious' (Pohjola et al., 2016). Not surprisingly, people who were highly

conscious were in favour of reducing meat consumption. However, education as a stand-alone intervention is less effective in enhancing healthy eating due to the highly habitual and routine nature of eating (van't Riet et al., 2011). This disconnect between knowledge and behaviour was highlighted in an Australian study (Marinova & Bogueva, 2019), whereby 88% of people who knew the links between meat and climate change continued to consume meat, with 30% doing so daily. Denial mechanisms, such as cognitive dissonance, can block the update of new knowledge and is discussed further in the automatic motivation section below (Piazza et al., 2015; Stoll-Kleemann & Schmidt, 2017). As such, simply raising awareness and knowledge is unlikely to shift people towards a more sustainable diet (Dibb & Fitzpatrick, 2014).

Training can also be used to build knowledge in the form of step-by-step guidelines (e.g., other sources of protein and nutrients) (de Boer et al., 2014) and plant-based recipes as part of larger campaigns (e.g., Meatless Mondays) (Laestadius et al., 2013). Persuasive messaging strategies have focused on 'less' (i.e., smaller portion sizes) but 'better' (i.e., free-range and organic) meat (de Boer et al., 2009; Sutton & Dibb, 2013), though the term 'better' is not always clear and knowledge of healthy portions is often limited. This is due to portion sizes being influenced by normative cues (i.e., indicators of how much one should eat), thus incorporated in one's automatic (unconscious) processing, and is further discussed below (Herman & Polivy, 2008; Sutton & Dibb, 2013).

Physical Opportunity. Physical opportunity refers to the environmental resources available to the individual (Michie et al., 2011). Convenience is a main barrier to reducing meat consumption, with vegetarian meals often considered inconvenient (Malek et al., 2019). In response to this perceived 'lack of time', convenient and ready-made foods are now common and continue to grow (Stoll-Kleemann & Schmidt, 2017; Wooldridge et al., 2021). Traditionally skewed towards the meat market, convenient meat replacement products are

increasing (ABS, 2022b) in supermarkets and fast-food establishments (e.g., KFC) (Jiang, 2019). As previously mentioned, the health credentials of these products continue to be questioned (Bryant & Barnett, 2019; Kalocsay et al., 2024; Szenderák et al., 2022) as does the environmental impact of additional packaging (Smetana et al., 2015). These food innovation products are an enablement intervention function per the COM-B model (Michie et al., 2011). Environmental restructuring is another intervention function that enhances physical opportunity (Michie et al., 2011). An example of this would be having more vegetarian-friendly dining environments, which appears to support reduced meat eating (Garnett et al., 2019; Kurz, 2018; Stoll-Kleemann & Schmidt, 2017; Wansink & Love, 2014).

Social Opportunity. The social opportunity factor represents external influences such as cultural norms and influences from other people (Michie et al., 2011). The presence of other people appears to have a strong effect on food choices due to social learning and approval seeking (Higgs, 2015). In Western countries, meat has long been considered an essential component of a meal, and this is deeply imbedded in the culture and social norms (Tsofliou et al., 2022). Given the routine nature of eating meat in these countries, most meat eaters perceive eating animals as a cultural norm rather than a choice (Joy, 2011). As such, following these eating norms may influence a person's desire to 'fit in' socially (Higgs, 2015). In one study, people were more likely to eat meat and more of it when eating with others than when alone (Horgan et al., 2019). It is difficult to infer a link between meat consumption and social norms as the reasons for these varied eating behaviours were not included; nevertheless, social norms may be an effective meat-reducing strategy.

There is limited research assessing household context and meat consumption (Stoll-Kleemann & Schmidt, 2017), with some insights gained from the general food consumption literature. In Australia, 68% of families reported being too busy to find recipes that the whole household would enjoy, with over half of parents (with dependent children) indicating that

children were the most difficult to cook for (McCrindle, 2017). Given these factors, it is not surprising that most families stick to a select range of meals, though better understanding is needed to determine how other household members influence meat consumption.

Restriction, modelling, environmental restructuring, and enablement are all intervention functions to enhance social opportunities (Michie et al., 2011). Role models and celebrities who eat a reduced meat diet have been used previously to model plant-rich eating (Bamberg, 2013; Ohnmacht et al., 2017). Social norms can also motivate people to reduce their meat levels, with research finding this to be a useful strategy for those in the *inactive* stage of change. For example, observing others' meat reducing behaviours can prompt a person to consider their own behaviour (Lippke et al., 2007). Gender differences may also need to be considered, as meat is often viewed as a food of strength and vigour for men and is reflected by the often-held view that male vegetarians are less masculine (Kildal & Syse, 2017; Nath, 2010). This meat perception may also explain why men generally eat more meat than women and are typically less willing to reduce their consumption (Ruby & Heine, 2011). Promoting male vegans and vegetarians who fit a masculine stereotype (e.g., athletes) may help alter these perceptions (Rothgerber, 2013).

Automatic Motivation. Automatic motivation incorporates emotions and impulses that can arise via learning and/or innate dispositions (Michie et al., 2011). Automatic processes are key to understanding meat consumption, as eating is mostly habitual (Rees et al., 2018). Modelling, persuasion, and enablement are all example of intervention functions used to target barriers associated with automatic motivation.

Habits. Habits are behaviours that are repetitive, routine, reliable, reinforcing, and rewarding (Lally et al., 2011). They are one of the most influential factors of food choices, with consumption, purchasing, and preparation behaviours mostly determined by unconscious routines (Rees et al., 2018; Stoll-Kleemann & Schmidt, 2017). Habits require

less information in the decision-making process and are often triggered by external cues (de Boer et al., 2014; van't Riet et al., 2011). For meat consumption, this may include where you eat (home or restaurant), who you eat with (family or alone), sensory cues (taste), and normative cues (portion sizes) (Dibb & Fitzpatrick, 2014). This is why habits can be hard to change, with intentions being poor predictors of actual behaviour (van't Riet et al., 2011). Rees et al. (2018) found that interventions aimed at reducing meat consumption are more likely to be effective when incorporating *habit strength* as opposed to modifying individual attitudes and perceived behavioural control over meat consumption. Additionally, if people perceive a new experience as positive, it is more likely to be repeated and become habitual (Moore & Boldero, 2017). Thus, it is vital to understand not only how to get people to adopt a plant-rich diet but how to ensure they maintain it.

Enablement is an intervention function that may change meat eating habits through goal setting and forming intentions (e.g., committing to two meat-free days per week) (van't Riet et al., 2011). Changes in the food environment by way of nudges (Sunstein, 2014) may also enable the adoption of smaller meat portions (Vandenbroele et al., 2020), tapping into one's automatic thinking (Sunstein, 2014; Thaler & Sunstein, 2008).

Taste. Eating food is a sensory experience and can act as a taste and reward cue for meat consumption (Farrar & Papies, 2023). In Western countries, taste preferences are skewed towards meat, with vegetarian meals generally considered 'bland' (Lacroix & Gifford, 2019; Lea & Worsley, 2001). Taste preferences can therefore impede meat reduction, and this needs to be considered when developing interventions (Corrin & Papadopoulos, 2017; de Boer et al., 2007; Graça et al., 2015). Building on existing familiar food experiences (savoury, flavoursome, and satisfying) has been suggested as a possible approach to increasing meat-free meals, as it activates parts of the brain that represent how food is likely to taste and how rewarding it will be (de Boer & Aiking, 2017). When people

eat, the visual region of the brain is activated (Simmons et al., 2005). Thus, showing people visually appealing pictures of plant-rich meals may *enable* people to eat these meals by tapping into the taste and sensory experiences (Michie et al., 2011).

Emotions. Emotions have also been reviewed in the meat reduction field, specifically cognitive dissonance. First proposed by Festinger in 1957, cognitive dissonance is a barrier to meat reduction, as meat-eaters tend to avoid negative information about eating meat to reduce distressing emotions (Beardsworth & Bryman, 2004; Joy, 2005; Piazza et al., 2015). This dissonance often results in the ‘meat paradox’, whereby meat eaters are reminded of the gap between their meat eating behaviours and their animal welfare values. To resolve this conflict, people either stop eating meat or engage in psychological tactics to reduce their distress. The 4Ns (i.e., beliefs that eating meat is natural, normal, necessary, and nice) are examples of how people justify their choice of eating meat and therefore reduce their feelings of guilt (Piazza et al., 2015). Potentially emphasising the effects of this dissonance is an Australian study that found that ‘committed meat eaters’ were the least likely to believe the link between livestock production and climate change (Malek et al., 2019).

Disgust has also been associated with reduced meat eating, specifically for people who abstain from meat such as vegans and vegetarians. Persuasive communication that evokes negative (such as disgust and guilt) or positive (such as satisfaction from reducing meat levels) emotions might be effective, specifically for people who have never considered reducing their meat consumption (Weibel et al., 2018). However, this method should be used cautiously, as these initiatives may trigger greater defences *towards* meat eating, especially for people attached to meat (Graça et al., 2015). One study also found that meat eaters who reduced their meat eating for one month, had greater meat disgust afterwards (Becker et al., 2022).

Reflective Motivation. The reflective aspect of motivation refers to a more conscious and evaluative decision-making process that can be linked to several factors as outlined below (Mitchie et al., 2011). Intervention functions aimed at increasing reflective motivation include education, training, and persuasion.

Values. Values relate to a person's sense of right and wrong and are used to help people judge situations (Darnton & Evans, 2013). A review of the literature highlights that most people who abstain from meat, such as vegans and vegetarians, do so for moral and ethical reasons (i.e., animal welfare and environmental sustainability); in contrast, meat reducers are more motivated by health factors (Penny et al., 2015). Age also appears to have an impact, with younger people being more open to reducing their meat consumption (i.e., flexitarian diet) for moral (i.e., animal welfare and environment) reasons (van den Berg et al., 2022), while older people are more motivated by health factors (Pribis et al., 2010). Thus, activating these different values using tailored persuasive messaging may be an effective intervention to reduce meat eating (Dibb & Fritzpatrick, 2014; Garnett et al., 2015; Joyce et al., 2012). Critically though, as food choices are strongly influenced by habits, interventions aimed only at changing values are unlikely to be effective for sustained change.

Self-identity. Food consumption has long been considered as a marker for social identities and lifestyles (e.g., meat consumption and its association with affluence). Thus, the abstinence and/or avoidance of meat can be regarded as a choice due to lifestyle decisions (Grunert et al., 2001). While people choose to eat meat (or abstain from it) for multiple reasons, one reason may be to manage their public image (Higgs, 2015). More people choosing to eat a vegetarian and flexitarian diet (in Western countries) may relate to a satisfying identity and lifestyle (Verain et al., 2015). For example, being a flexitarian eater may allow a person to form a satisfying identity and lifestyle (i.e., in line with moral and health values) and the opportunity to 'fit in' to social settings (i.e., avoid embarrassment

when dining with a meat eater and/or if vegetarian options are limited) (Beardsworth & Keil, 1991; Kondrup et al., 2023).

Perceived Behavioural Control. According to Ajzen (1991), perceived behaviour control is defined as the ‘*perceived ease or difficulty of performing the behaviour.*’ As such, people are more likely to perform a behaviour if they think they can complete it. In the context of low skill level as highlighted above, perceived behaviour control may act as a barrier to meat reduction. Building one’s skills (via training) to cook tasty and cost-effective meat-free meals is one way to increase perceived behaviour control (Darnton & Evans, 2013). An example of this is Meatless Monday (Laestadius et al., 2013), an initiative focused on increasing plant-rich eating using small shifts, which may provide a sense of control. Furthermore, increasing the variability, availability, and familiarity of vegetarian foods may help increase perceived behavioural control (Zur & Klöckner, 2014).

Intentions. As highlighted above, eating behaviours are habitual. When a behaviour becomes habitual, it is performed unintentionally and outside of awareness (Aarts & Dijksterhuis, 2000; Bargh, 1994), making it difficult to shift. To overcome high meat-eating habits, there needs to be a conscious change intention. Self-monitoring (a form of enablement) is one mechanism that can increase intention implementation to reduce meat levels (Rees et al., 2018), but again this needs to be considered in the context of habit, skill level, and cultural/social norms. These factors are summarised in the table below:

Table 2.2

Summary of the Literature According to the COM-B Model

Sources of Behaviour		Variables
Capability	Physical	Skills; Financial Capacity; Technology
	Psychological	Knowledge; Awareness
Opportunity	Physical	Food environment; Convenience
	Social	Social norms; Household influences; Culture
Motivation	Automatic	Habits; Taste; Emotions
	Reflective	Values; Self-identity; Perceived Behavioural Control; Intentions

Interventions

Intervention studies aimed at reducing meat consumption are slowly growing but currently remain limited and focused on personal factors such as knowledge and emotions (Kwasny et al., 2022). Below is a brief review of interventions conducted as they relate to the COM-B intervention schedule.

Education. Several studies have assessed the impact of providing environmental, human health, and animal welfare information to reduce meat consumption (Brunner et al., 2018; Campbell-Arvai & Arvai, 2015; Campbell-Arvai et al., 2014; Loy et al., 2016; Monroe et al., 2015), with mixed results. Brunner and colleagues (2018) found that adding the level of GHG emissions to different meals in a student cafeteria resulted in people selecting the lower emission dishes when red meat was offered. In another study (Monroe et al., 2015), participants engaged in more ‘green eating’ behaviours (i.e., buying local food, reducing food waste, and eating plant-based proteins) when provided information about green eating compared to a control group. Providing information about environmental, ethical, health, and social implications of meat eating also reduced meat consumption, and this was present four weeks after the information was provided (Loy et al., 2016). While these results are promising, other studies have shown limited impact from education-based strategies. Across two studies, Campbell-Arvai et al. (2015) found no impact on meal choices when environmental information and a leaf symbol was added to meat-free meals on a menu. Additionally, adding CO² information to dishes (via colour coding) did not reduce meat purchases at a university restaurant, indicating that taste preferences are often prioritised over environmental concerns (Brunner et al., 2018).

Persuasion. Persuasion uses communication to induce a positive or negative feeling or stimulate action (Michie et al., 2011). In one study, Stea and Pickering (2019) assessed several persuasive messages to increase people’s intention to reduce their meat consumption.

The messages ranged from meat social norms to the importance of eating meat as a cultural (Canadian) identity. Results indicated that incorporating social norms with information-based messages produced the strongest effect. Another study also confirmed the power of social norms, with participants more likely to choose a meatless lunch meal at a restaurant when social norms were integrated into the messages (e.g., *“in the last 5 years, 30% of Americans have made an effort to reduce their meat consumption”*) (Sparkman & Walton, 2017).

Emotionally framed messages are usually more effective in reducing intentions to eat meat and meat eating behaviours than information-framed messages (Berndsen & van Der Pligt, 2005; Carfora et al., 2019). Combined health and environmental messages were also effective in increasing meat reduction intentions (Verain et al., 2017), with health appeals often stronger than environmental ones (Cordts et al., 2014), though animal welfare messages presented with mixed results (Cordts et al., 2014; Whitley et al., 2017).

Enablement. Enablement includes increasing means or reducing barriers to increase capability or opportunity (Michie et al., 2011). Self-monitoring is an enablement technique that has reduced red meat consumption when participants were provided with daily text messages (over a 7-day period) and education (i.e., recommended red meat guidelines) (Carfora et al., 2017). Goal-setting also presented as an effective intervention to change meat eating habits when paired with educational material (e.g., healthy meals, recipes), though participants were often motivated to change their diets for health reasons (Carfora et al., 2017; Carfora et al., 2019; Grimmett et al., 2015). Rees et al. (2018) found that both goal-setting and forming intentions also helped people eat less meat, though these strategies may be more effective for individuals who already intend to reduce their meat levels (Carfora et al., 2017; Loy et al., 2016, Rees et al., 2018).

Training. Training or imparting skills is another intervention that has been assessed with reducing meat consumption. Providing education and training on how to shop for and

cook vegetarian meals has been effective at increasing plant consumption and reducing meat. Though again, these interventions tend to be intensive and long-term, and aimed at people with illness or who wish to prevent disease (Carmody et al., 2008; Flynn et al., 2013).

Environmental Restructuring. Environmental restructuring includes changing the physical or social context, with several studies showing positive results for meat reduction. For example, increasing the visibility and variety of vegetarian foods has resulted in higher sales in restaurants (Garnett et al., 2019; Kurz, 2018; Wansink & Love, 2014). Similarly, making meat substitutes more visible in supermarkets (i.e., by placing them next to meat products) resulted in more sales, while meat sales remained stable (Vandenbroele et al., 2018). Modifying portion sizes (i.e., larger plants, smaller meat) also led to an increase in vegetables and reduced meat eating in restaurants and canteens (Reinders et al., 2017; Rolls et al., 2010), and offering smaller meat portions in supermarkets reduced overall meat sales (Vandenbroele et al., 2018). Making meat-free meals the default option (Campbell-Arvai & Arvai, 2015; Campbell-Arvai et al., 2014) was also successful in increasing meat-free meal sales in a student cafeteria. These strategies are promising, though are unlikely to change meat consumption in other contexts where there is less external ability to enact environmental restructuring (e.g., at home).

Finally, some studies have assessed multiple factors. Amiot et al. (2018) assessed the effectiveness of a 4-week multicomponent intervention designed to reduce red meat eating in 32 young men. The intervention incorporated a social norm component, an informational/educational component, an appeal to fear, a mind attribution induction, and a goal setting/self-monitoring component. Measures of meat intake were assessed using food diaries at three points in time (baseline, two weeks, and four weeks). Significant reductions were found in overall meat consumption, with reduced positive emotions towards meat eating a major driver.

Despite the range of research conducted, more is needed with specific reference to targeting habits and social influences, such as household members (Godfray et al., 2018). Additionally, meat reduction interventions would benefit from incorporating a behaviour change model to support intervention design and assess adoption and maintenance of actual meat reduction behaviours rather than simply intentions. Lastly, as these studies were mostly conducted in Europe and Canada, it is difficult to determine whether these interventions would produce similar results within an Australian context.

Rationale for the Current Research

Our global food system is at breaking point, with our food decisions continuing to drive environmental destruction, human disease, and animal suffering. We are at a crucial juncture to reduce these pressures by shifting people to eating a plant-rich diet (IPCC, 2019, 2022; Poore & Nemecek, 2018), particularly in high-income countries where meat-overconsumption continues to be the norm. Given the urgency of this crisis, we need to develop interventions that work. As some of the highest meat eaters in the world (Whitton et al., 2021), Australians are best placed to change their eating habits to support a sustainable food system, but as a nation of (mostly) high meat eaters, we need tailored, evidence-based approaches to achieve this. To that end, we designed a series of studies using two prominent behaviour change models—community-based social marketing (CBSM) (McKenzie-Mohr, 2011) and the behaviour change wheel (BCW) (Michie et al., 2011) to conduct a thorough, methodologically sound investigation into which plant-rich diet we should promote and how to achieve the necessary dietary changes.

In Study 1, we identified which plant-rich diet to target in an intervention. Using the CBSM (McKenzie-Mohr, 2011) within the holistic ‘One Health’ framework (Zinsstag et al., 2011) we assessed the environmental, human health, and animal welfare metrics of five plant-rich diets (Mediterranean, flexitarian/semi-vegetarian, pescatarian, vegetarian, and

vegan), followed by measuring the probability of people adopting each diet and current penetration levels.

After identifying the target diet (which ended up being the Mediterranean diet), the second step of the CBSM was applied to identify the barriers and drivers to adopting this diet. The COM-B from the BCW (Michie et al., 2011) was used to assess a range of individual and environmental factors relevant to the Mediterranean diet, particularly habits and household influences. A deep dive qualitative analysis (Study 2) was initially conducted to gain a thorough understanding of these barriers and drivers. To quantify these results, we then developed a COM-B Mediterranean diet survey in Study 3, using the results from the qualitative deep-dive analysis (and the literature) (Lacroix & Gifford, 2019; Malek et al., 2019; McEvoy et al., 2018; Stoll-Kleemann & Schmidt, 2017). Using a specific COM-B survey and hierarchical regression enabled us to identify which barriers *predicted* Mediterranean diet adoption the most.

Armed with the above information, we then implemented Step 3 (developing interventional strategies), and Step 4 (conducting a pilot study) of the CBSM (McKenzie-Mohr, 2011). Using the above results, we developed a messaging intervention study (Study 4) aimed at increasing legume consumption intentions. Legumes are a core Mediterranean diet food and were targeted based on our findings. The COM-B intervention functions (Michie et al., 2011) were used to design the messages. These messages were then assessed in a pilot study to determine if messages (and which message attributes) increase people's intentions to eat legumes (and the Mediterranean diet).

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Chapter 3

Study 1

What should we eat? Realistic solutions for reducing our food footprint

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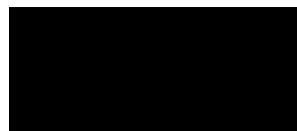
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Abstract

Livestock production systems are associated with climate change, land degradation, and animal welfare concerns, while overconsumption of animal-sourced foods is a major driver of human disease. Thus, shifting towards plant rich diets is expected to deliver benefits for human health, the environment, and animal welfare. Nevertheless, diets high in animal products are flourishing, especially in high-income countries. Here, we take a novel interdisciplinary approach to evaluating sustainability of diets by assessing five common plant-rich diets (Mediterranean, flexitarian/semi-vegetarian, vegan, vegetarian, and pescatarian) on two metrics. First, we established each diet's environmental, human health, and animal welfare impacts, using quantitative data sourced from a review of the literature, including life cycle assessments. Second, we evaluated the human factor by surveying current consumer dietary preferences (i.e., which diet participants had followed over the past week) and the likelihood of adopting each plant-rich diet in the future, among a sample of Australian adults ($N = 253$). Combining the results from the review and the survey in a behavior prioritization matrix (BPM), the Mediterranean diet was shown to have the greatest projected positive impact, followed by the vegetarian diet. This study is the first to combine assessments of sustainable diets on the three dimensions of environment, human health, and animal welfare *with* probability of adoption. Our findings highlight the necessity of assessing plant-rich diets through a holistic lens when identifying target diets to promote, in order to support sustainable food systems in high-income countries.

Keywords: sustainable diets, meat consumption, behaviour change, behaviour prioritization matrix, life cycle assessment

Introduction

Our current food systems are a significant contributor to global greenhouse gas (GHG) emissions, making them a prime area of focus in tackling the climate crisis (Poore & Nemecek, 2018). With our growing global population, the demand for food is increasing, with certain foods being in greater demand (e.g., meat and dairy) in response to rising urbanisation and individual wealth (Food and Agriculture Organization [FAO] of the United Nations, 2017a). Given the many elements of a sustainable food system (e.g., water, biodiversity, energy use, and food security), a holistic approach is clearly needed to achieve sustainability (Béné et al., 2019). While change is urgently needed in agricultural practices, population and social trends reveal that consumer dietary choices also need to be examined given these choices create “demand pull” that in turn influences agricultural systems. Identifying which diets are environmentally sustainable is an important starting point to support consumers in making sustainable dietary choices. Further to the environmental benefits are the equally important human health and animal welfare credentials of specific diets. It is also a waste of precious time and resources to promote diets that most people are not willing to adopt, making population preferences a key factor in sustainable diet change. Combining these key elements enables the development of future behaviour change interventions to support sustainable consumption.

Literature Review

Food systems account for 26% of global greenhouse gas (GHG) emissions, of which most (59%) comes from livestock production (including meat, dairy, seafood, and eggs) (Poore & Nemecek, 2018), making the livestock production sector the third largest emitter, following the energy (35%) and transport (23%) sectors (Gerber et al., 2013; Intergovernmental Panel on Climate Change [IPCC], 2014). The major contributor to GHG emissions from red meat production is methane emitted from the digestive system of

ruminants, while other significant sources include methane and ammonia from manure management, and nitrous oxide from feed production (Opio et al., 2013). Further, livestock production uses extensive amounts of land and water resources, and contributes to biodiversity loss, land degradation, and pollution of waterways (FAO, 2017b; Westhoek et al., 2011).

Global meat production is predicted to increase by 76% between 2007 and 2050, associated with increasing adoption of diets high in animal-sourced products in developing countries (Alexandratos & Bruinsma, 2012; Organisation for Economic Co-operation and Development [OECD] & FAO, 2019). Such ‘affluent diets’ are common in developed Western countries, where meat is traditionally the central component of a meal (Beardsworth & Bryman, 2004).

In response to this urgent need, several initiatives have emerged, ranging from agricultural innovations (Beach et al., 2015; IPCC, 2019) to food technology developments including plant-based meat substitutes and cultured meat (i.e., grown artificially from animal cells) (Apostolidis & McLeay, 2016; Bryant & Barnett, 2019). In their report on Climate Change and Land, the IPCC (2019) emphasised that demand management encouraging shifts to sustainable diets rich in plant-based foods could reduce GHG emissions by 0.7 to 8.0 GtCO₂ eq yr⁻¹, along with parallel benefits for human health and biodiversity conservation. The potential climate change benefits from supplementing animal protein with plant protein (e.g., tofu, fava beans) are highlighted by Sadhukhan et al. (2020).

While several definitions have been offered, the Food and Agriculture Organization of the United Nations (2010, p. ix), states that a sustainable diet is one “...with low environmental impacts which contribute to food and nutrition security and to healthy life for present and future generations.” Recent studies based on life cycle assessment have evaluated the sustainability of various foods and alternative diets (e.g., GHG emissions, water use, and

land use) (Aleksandrowicz et al., 2016; Battle-Bayer et al., 2020). Overall, plant-based foods typically have less environmental impact than the lowest-impact animal products (Poore & Nemecek, 2018). So, plant-rich diets—vegan, vegetarian, pescatarian, Mediterranean, or flexitarian/semi-vegetarian—are expected to have reduced impacts on the environment, as these diets reduce or eliminate reliance on livestock. Dietary shift will have the greatest environmental benefits in countries with a high intake of meat and other animal-sourced products (Nelson et al., 2016; Springmann et al., 2018).

It is imperative that a sustainable diet is also nutritious and healthy. Dietary guidelines provide recommendations for food consumption, including portion sizes for meat and other animal-sourced products. Most guidelines promote high intake of fruit, vegetables, and whole grain foods, with moderate levels of protein (e.g., meat, eggs, and beans) and dairy (National Health and Medical Research Council, 2013; Public Health England, 2018). Specifically, guidelines generally recommend limited consumption of red meat and avoidance of processed meat due to their association with cardiovascular diseases, several cancers, type 2 diabetes, and, for processed meat, higher mortality rates (Demeyer et al., 2016; Li et al., 2018; Micha et al., 2010; Pan et al., 2011). In contrast, a diet high in plant-based food and low in meat (particularly red and processed meat), such as traditional Mediterranean diets, has been associated with reduced all-cause mortality and lower incidence of heart failure, stroke, cognitive decline, and some cancers (Martinez-Gonzalez & Martín-Calvo, 2016; Trichopoulou & Vasilopoulou, 2000). The flexitarian, pescatarian, vegetarian, and vegan diets have also been found to be nutritionally adequate, with the exclusionary diets (vegetarian and vegan) requiring a small number of nutrients to be supplemented (Springmann et al., 2018).

Beyond environmental and human health concerns are the less-discussed animal welfare impacts associated with livestock production. Growing demand generated by higher

per capita consumption of animal-sourced products, combined with the increasing human population, has led to intensified livestock farming systems (Gregory and Grandin, 2007; Harrison, 1964; Thompson, 2015). The high stocking densities typical of such systems have been linked to a series of negative welfare effects (Bessei, 2006; Dawkins et al., 2004; Park et al., 2020; Peden et al., 2018), as well as dependence on antibiotics to combat increased disease prevalence and boost food conversion rates—promoting both antibiotic resistance and antibiotic spread through the environment (Kivitis et al., 2018). Intensive farming practices also amplify the risk of zoonoses, such as coronaviruses (Allen et al., 2017). Reducing the global consumption of meat and other animal-sourced products could moderate these risks as well as alleviating animal suffering.

Thus, shifting to plant-rich diets brings many environmental, health, and animal welfare benefits and can support a sustainable food system. Clearly, the appeal and the harmful impacts of various diets differ, and some consumers have little choice; however, in high-income countries, education and the availability of alternatives facilitate food footprint reduction. To date, efforts to reduce meat consumption (e.g., Meatless Monday) (Laestadius et al., 2013) have not delivered significant behavioural change (Tapsell, 2017). Many people in Western countries continue to over-consume animal-sourced products and under-consume plant-based products (Australian Bureau of Statistics [ABS], 2018; World Health Organization [WHO], 2019). The impact of dietary shifts is therefore determined both by the sustainability benefits of the target diet, and its level of adoption; both must be aligned to promote the most beneficial, sustainable outcome.

Changing dietary patterns is challenging, and research into reducing consumption of animal-sourced products has identified an extensive list of barriers, including strong cultural and social norms, perception that vegetarian meals are bland, and lack of skill in cooking meat-free meals (Dibb & Fitzpatrick, 2014; Joy, 2011; Malek et al., 2019; Stoll-Kleemann &

Schmidt, 2017). Overcoming these barriers will require effective interventions to encourage behaviour change. In the health sector, behaviour models have been effective in changing specific behaviour patterns (e.g., smoking cessation programs, enhancing healthy eating) (Michie et al., 2011). Given that pro-environmental behaviours (i.e., behaviours that minimise harm to the environment) also depend on human behaviour patterns, it is appropriate to apply behaviour models in this context to identify which diet(s) to target for maximal environmental benefit (Steg & Vlek, 2009).

Community-based social marketing (CBSM) is one model that has been widely used to identify and promote pro-environmental behaviours that support behaviour change (McKenzie-Mohr, 2011). Using a 5-step strategy, CBSM identifies and assesses target behaviours (Step 1), followed by identifying barriers to and benefits of these target behaviours (Step 2), developing interventional strategies (Step 3), conducting a pilot study (Step 4), and broad-scale implementation and evaluation of the strategy (Step 5). This model has been used across various contexts, including pro-environmental palm oil behaviours (Sundaraja et al., 2020), energy behaviour (Frantz et al., 2016), and wild dog management (Hine et al., 2020; Please et al., 2017).

The current study aims to apply the first step of CBSM to evaluate the impact associated with five plant-rich diets (flexitarian/semi-vegetarian, vegetarian, vegan, Mediterranean, and pescatarian) to identify which diet can be promoted in future intervention(s) to deliver the greatest net benefit.

Methods

Community-based Social Marketing (CBSM)

To determine which behaviours to target, CBSM uses a Behavior Prioritization Matrix (BPM) with three components: 1) calculating how effective each proposed behaviour will be in solving the problem; 2) determining the proportion of the target population already

engaged in each behaviour (i.e., penetration); and 3) calculating the likelihood that the target population will adopt the behaviour (i.e., probability). One of two methods can reveal the effectiveness of possible behaviours, with the first and preferred method being to rate behaviours based on available quantitative information (e.g., emissions reductions associated with washing clothes in cold, rather than hot, water). If reliable information is unavailable, experts can be enlisted to rate the estimated effectiveness of behaviours (as used in Sundaraja, et al., 2020). The next two steps—assessing penetration and probability—are critical to ensure the behaviour is not already widely practiced (and thus any efforts to increase the target behaviour would have little net benefit due to ceiling effects) and that people are willing to engage in the behaviour. To rank the behaviours, a total weighted impact score is calculated for each target behaviour by multiplying the effectiveness score by inversed penetration by the probability score, where inversed penetration is the maximum possible penetration minus observed penetration (McKenzie-Mohr, 2011).

Using this BPM formula, the current study evaluated the flexitarian/semi-vegetarian, vegetarian, vegan, Mediterranean, and pescatarian diets (see Table 3.1). The BPM incorporated the environmental, health, and animal welfare impacts, as well as penetration and probability (as described above). To obtain quantitative data on ‘effectiveness’, a review of the peer-reviewed literature was conducted to determine the impact of each plant-rich diet on the environment, health, and animal welfare. This was followed by an assessment of penetration and probability among survey participants who were representative of the Australian population. Results from the review and survey were included in the BPM to calculate a total weighted impact score for each diet. The process undertaken is outlined below.

Table 3.1*Diet Definitions and Common Food Types*

Diet	Definition	Common Food Types	
Omnivore (Goldstein et al., 2016; Springmann et al., 2018; Turner-McGrievy et al., 2017)	Meat (beef, pork, lamb, poultry, fish, seafood) and other animal-based foods (dairy, eggs) one or more times per day; plant-based foods (fruits, vegetables, cereals, legumes, and nuts)	Red meat (beef, pork, lamb) Poultry Fish Seafood	Milk Cheese Potato Eggs Wheat flour Rice
Mediterranean (Bach-Faig et al., 2011; Ulaszewska et al., 2017)	No processed meat; small amounts of red meat (beef, lamb, pork; one serving per week); moderate amounts of fish, seafood, poultry, eggs and dairy (2 - 3 servings per week); plant-based foods (fruits, vegetables, whole grains, legumes, nuts, and olive oil)	Poultry Fish Seafood Eggs Cheese	Milk Rice Wheat flour Potato Legumes
Flexitarian/semi-vegetarian (Derbyshire, 2017; Hudders & de backer, 2014; Springmann et al., 2018)	At least three meat-free days per week; no processed meat; small amounts of red meat (beef, lamb, pork; one serving per week); moderate amounts of fish, seafood, poultry, eggs and dairy (2 - 3 servings per week); plant-based foods (fruits, vegetables, cereals, legumes, and nuts)	Poultry Fish Wheat flour Rice Cheese	Eggs Milk Potato Legumes
Pescatarian (Chen et al., 2019; Springmann et al., 2018)	No red meat (beef, pork, lamb) or poultry; fish, seafood, other animal-based foods (dairy, eggs); plant-based foods (fruits, vegetables, cereals, legumes, and nuts)	Fish Seafood Wheat flour Rice Cheese	Eggs Milk Potato Legumes
Vegetarian (Craig et al., 2009; Springmann et al., 2018)	No meat (beef, lamb, pork, poultry, fish, seafood); animal-based foods (dairy, eggs); plant-based foods (fruits, vegetables, cereals, legumes, and nuts)	Milk Cheese Wheat flour Rice Potato	Eggs Legumes Tofu Soy Beverage
Vegan (Craig et al., 2009; Springmann et al., 2018)	No meat or other animal-based food (beef, pork, lamb, poultry, fish, seafood, dairy, eggs); plant-based foods (fruits, vegetables, cereals, legumes, and nuts)	Wheat flour Rice Potato Legumes Tofu	Soy Beverage

Environmental, Health, and Animal Welfare Impact

A review of the literature was conducted to obtain environmental, health, and animal welfare impact data for each of the five plant-rich diets, in line with CBSM methodology. Three environmental indicators (GHG emissions, water, and land use), two human health metrics (deaths averted and reduction in mortality risk), and three animal welfare measures (animal life years suffered, ALYS; animal loss, AL; and morally adjusted animal lives; MAL) were used for the impact score calculations. Selection of these indicators was based on

data available in the literature. An outline of the process undertaken for each impact category is provided below, including study selection and exclusion criteria.

Environmental Impact

Searches in Science Direct and ProQuest were conducted using the terms ‘greenhouse gas’ OR ‘land use’ OR ‘water use’ OR ‘sustainable diets’ AND ‘Mediterranean’ OR ‘vegan’ OR ‘vegetarian’ OR ‘pescatarian’ OR ‘flexitarian’ OR ‘semi-vegetarian.’ A follow-up search of Google Scholar was also conducted using the same search terms. Given the large number of search results, variability in methodology and design (i.e., life cycle assessments of dietary patterns), and that no single study assessed all target diets, a search of review articles was conducted using the terms ‘systematic review’ OR ‘review.’ Recognising the benefits of life cycle assessment (LCA) (International Organization for Standardization, 2006) (Finnveden et al., 2009) in evaluating the full environmental impacts of alternative diets, two articles that reviewed relevant LCA studies were selected as the basis of the environmental impact analyses, the first being a systematic review of environmental footprint studies of sustainable diets published from 2000 to 2016 (Aleksandrowicz et al., 2016) and the second, a review of LCA studies comparing alternative diets published between 2017 and 2019 (Batlle-Bayer et al., 2020). Together these articles reviewed an extensive range of relevant literature spanning more than 20 years, reporting quantified changes (i.e., percentage difference in the target environmental variables) between average population-level dietary intake and the five dietary patterns, providing data to distinguish between low/medium/high income countries, and assessing the three key environmental indicators. Cross-checking between the original search and articles reviewed in the two articles was also conducted.

Data from only high-income countries (based on The World Bank, 2021 classifications) were included in the impact assessment. This decision was made due to the current study being conducted in a high-income country (Australia) and because the

environmental impacts of adopting a diet lower in animal-sourced products differ between high- and low/medium-income countries, with greater benefits reported for high-income countries (Springmann et al., 2018). Diets termed ‘meat partially replaced by plant-based food’ (per Aleksandrowicz et al., 2016) were classed as flexitarian/semi-vegetarian diets. Percentage differences in the environmental variable (from the studies that met the above criteria) were used to calculate a score out of 10 on each environmental indicator for the target diets. Due to wide variation in the percentage differences among studies, the median was used to enhance internal consistency (per Aleksandrowicz et al. 2016 methodology).

Health Impact

Searches in Science Direct and ProQuest were conducted using the terms ‘health’ OR ‘nutrient’ AND ‘sustainable diets’ AND ‘Mediterranean’ OR ‘vegan’ OR ‘vegetarian’ OR ‘pescatarian’ OR ‘flexitarian’ OR ‘semi-vegetarian.’ Several articles from the environmental search also reported health assessments, and thus were also assessed for eligibility. As no single study assessed all the target diets on the basis of deaths averted and all-cause mortality, studies with quantifiable changes in deaths averted and/or all-cause mortality between average population-level dietary intake and the target diets were included in the current calculations (Aleksandrowicz et al., 2016). Total scores were calculated using the median, for internal consistency, due to variability between studies. Only high-income countries were included in the analysis, as per the environmental impact methodology. Furthermore, health impacts also differ between low-, medium-, and high-income countries, with greater benefits accruing when high-income countries adopt plant-rich diets (Springmann et al., 2018).

Animal Welfare Impact

The animal welfare assessment framework developed by Scherer et al. (2018) was used to calculate the estimated animal welfare impact scores for each target diet. Specifically, the ALYS, AL, and MAL scores from Scherer et al. (2019) were used. These scores were

adopted as this study was the only study to date to apply this framework to the dietary guidelines of 37 countries. The researchers calculated country-level per capita ALYS, AL, and MAL for seven animal-sourced food categories (milk, eggs, seafood, poultry, pork, beef, and other meat) using each country's baseline daily diet (obtained from The Food and Agriculture Organization [FAO] of the United Nations) and conditions during farm life including transport and processing stressors (obtained from EXIOBASE v.3.4, a multi-regional input-output database that incorporates a national level animal welfare component based on Scherer et al., 2018 framework). In the current study, the averages of the country level ALYS, AL, and MAL scores for the 28 high-income countries (based on The World Bank, 2021 classifications) were calculated and divided by each country's average consumption levels (of the seven animal categories reported above) to obtain the high-income country per capita ALYS, AL, and MAL scores. These results formed the omnivore ALYS, AL, and MAL scores. The decision to focus only on high-income countries was driven by the need to maintain consistency with the environmental and health impact inclusion criteria.

Furthermore, livestock production systems and regulations tend to differ substantially between high- and low-income countries (Gerber et al., 2015), so welfare issues are likely to also differ. The calculated omnivore ALYS, AL, and MAL scores (per above) were converted and then applied to the daily animal consumption levels of four target diets (excluding the vegan diet due to its complete exclusion of animal products). To determine the quantity (grams/day) of animal products in each target diet, studies that had a breakdown of diet composition, from the environmental and health assessment, were used. To support consistency and comparability, all diets were scaled to 2300 calories/day—the upper level of average daily caloric intake for individual energy requirements (Springmann et al., 2016). For internal consistency in the face of variability among studies, the median was used to compute total scores for each target diet. An overall animal welfare loss score (i.e., combined ALYS,

AL, and MAL) was calculated for each diet on a scale of 0 – 1, with 1 representing the greatest animal welfare concerns. In line with the absence of animal products, the vegan diet scored zero on this scale.

Environmental, Health, and Animal Welfare Impact Scores

The environmental and health scores (i.e., median) and overall animal welfare loss score were converted to a 10-point impact (effectiveness) scale (1 = no effect; 10 = high effectiveness) and used in the BPM calculation. As there were three environmental impact scores (GHG emissions, water, and land use), the overall environmental impact scores for each target diet were calculated using the average of the median scores for each environmental indicator.

Penetration and Probability Survey

A pilot study was conducted first to assess the diet definitions and understanding of the survey questions prior to administering the survey to a larger, more representative sample from the community. The pilot sample comprised 131 first year psychology students at a university specialising in distance education located in rural Australia (100 women, 30 men, 1 gender unspecified). Participants were first-year psychology students who self-selected to participate and received research participation credit for completing the survey. Ages ranged from 18 to 58 years, with a mean of 34.63 ($SD = 9.31$). Most respondents reported consuming an omnivore diet over the preceding week, consistent with other research on Australian dietary behaviours (Malek et al., 2019). We interpret this alignment to indicate that participants understood and were able to differentiate between the diet definitions.

Participants and Procedure

Participants ($N = 253$) for the community online survey were recruited by an online panel provider and survey administrator, QualtricsTM. Sample size was determined based on similar studies, ranging from 150 and 300 participants (Kneebone et al., 2017; Please et al.,

2017; Sundaraja et al., 2020). Quota sampling was applied for gender to enhance representation, and participants who were below 18 years of age and/or provided partial responses were screened out. A soft launch with 43 participants was conducted and the median time to complete was calculated. Participants who completed the survey in less than half the median time (less than 120 s) were automatically screened out. Participants completed the survey after providing informed consent. Ethics approval was received from the University of New England (Approval No. HE19-254). Most participants (92.5%) had completed Grade 12 and/or tertiary and trade qualifications, with 60.1% stating they earned an income less than AUD80,000 (35.2% reporting greater than \$80,000 and 4.7% preferring not to say). Gender, age, income, and education were nationally representative of the Australian population (Australian Bureau of Statistics, 2017). Couples with children (29.2%) represented the most common household type, followed by couples (26.5%), single households (17.8%), share houses (11.5%), single parents with children (8.3%), and extended family living situations (children, parents, grandparents; 6.7%).

Measures

A quantitative research design was used to assess existing penetration levels for each diet and the likelihood of adoption (i.e., probability). Specifically, participants were presented with definitions of each of the diets - omnivore, Mediterranean, pescatarian, vegan, flexitarian/semi-vegetarian, or vegetarian (see Appendix A for a copy of the survey) and asked to select which diet best represented what they had eaten over the past week. The likelihood of adopting each diet was assessed by asking participants how likely they were to follow each diet in the future, using an 11-point scale, where 0 = not at all likely, and 10 = extremely likely (Sundaraja et al., 2020). Diets were presented in a randomised order throughout the survey.

Statistics

Descriptive statistics and the average probability and penetration scores were calculated for each target diet. The effectiveness rate of each target diet (calculated in the review) and the survey results (penetration and probability) were applied in the BPM calculation, using the formula presented above.

Results

Environmental, Health, and Animal Welfare Impact Results

The environmental impact calculation (based on Aleksandrowicz et al., 2016; Battle-Bayer et al., 2020) included 31 studies for the GHG emissions impact assessment, 14 studies for the land-use impact assessment, and 13 studies for the water-use impact assessment (see supplementary data for list of individual articles). Compared with the baseline omnivore diet, all diets had lower GHG emissions (median -11% to -48%) and land-use (-10% to -44%), with the vegan diet having the greatest median reduction. All diets used less water than the baseline omnivore diet (-6% to -37%), with the exception of the vegan diet (+1.5%).

For health impacts, six studies (Biesbroek et al., 2014; Mitrou et al., 2007; Orlich et al., 2013; Sabate et al., 2015; Soret et al., 2014; Springmann et al., 2018) were included in the scores for all-cause mortality and deaths averted, with all diets reducing mortality compared with the baseline omnivore diet (median ranging from -10% to -21%), and the Mediterranean diet having the greatest change (see supplementary data for list of individual articles).

Six studies (Bryngelsson et al., 2016; Goldstein et al., 2016; Meier & Christen, 2013; Springmann et al., 2018; Ulaszewska et al., 2017; Veeramani et al., 2017) provided a breakdown of animal products (grams/day) and were included in the animal welfare scores. The Mediterranean diet was included in one study, the flexitarian/semi-vegetarian in two studies, and the pescatarian and vegetarian in two and five studies, respectively. Significant variations among studies were observed in the amount of animal products in the same diet

(e.g., dairy consumption for the vegetarian diet ranged from 170 to 827g/day). All diets scored lower (i.e., better) on the combined animal life years suffered, animal loss, and morally adjusted lives score (0–0.36) than the baseline omnivore diet, with the exception of the pescatarian diet (0.63) primarily due to a higher AL score (see supplementary data for list of individual articles and calculations). Environment, health, and animal welfare impact scores are shown in Table 3.2.

Table 3.2

Environment, Health, and Animal Welfare Impact Calculations for each Diet, with Higher Scores Equating to Greater Benefits

Metric	Impact Scores (1-10)					
	OMN	MED	PESC	FLEX /SV	VEG	VGN
GHG emissions	1.00	3.06	6.81	3.44	7.19	10.00
Land use	1.00	7.55	7.75	3.09	9.59	10.00
Water use	1.35	5.56	5.09	2.75	10.00	1.00
Total environmental effectiveness ^a	1.12	5.39	6.55	3.09	8.93	7.00
Health impact (mortality/deaths averted)	1.00	10.00	9.14	5.29	6.36	9.23
Animal welfare impact	2.12	4.86	1.00	6.64	9.14	10.00
Total effectiveness (environmental, health, animal welfare)	1.41	6.75	5.56	5.01	8.14	8.74

Notes: OMN = Omnivore; MED = Mediterranean; PESC = pescatarian; FLEX/SV = flexitarian/semi-vegetarian; VEG = vegetarian; VGN = vegan.

^aAverage of GHG emissions, land use, and water use impact scores.

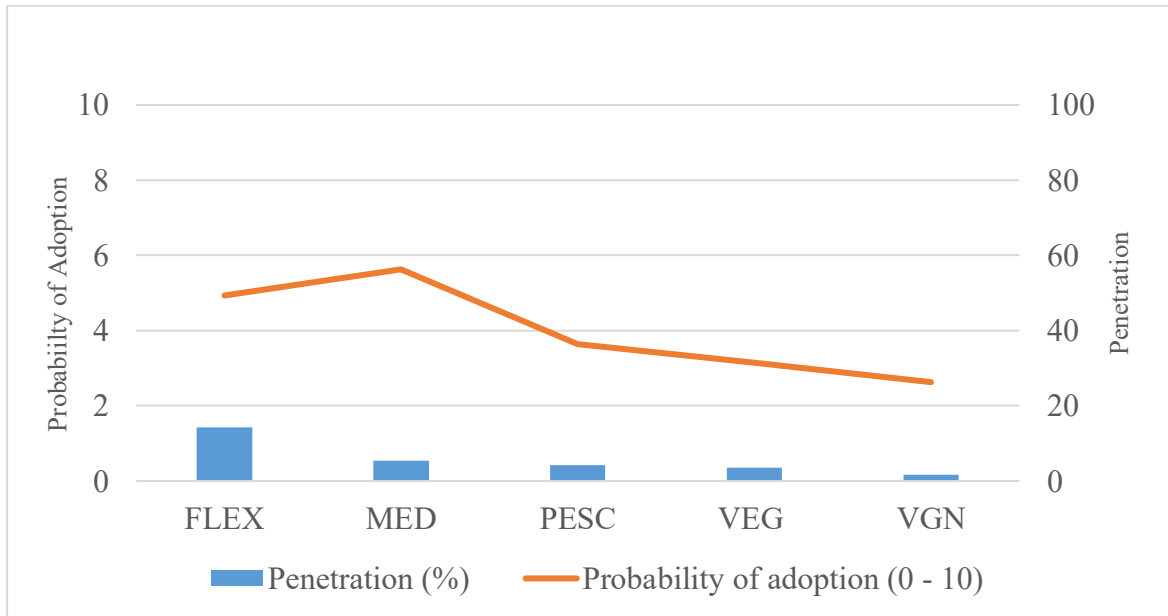
Penetration and Probability Survey

The survey revealed that 70.8% of participants reported consuming an omnivore diet over the past week, followed by flexitarian/semi-vegetarian (14.2%), Mediterranean (5.5%), pescatarian (4.3%), vegetarian (3.6%), and vegan (1.6%) diets. The Mediterranean diet had the highest probability of adoption in the future, rating 5.63 on a scale from 0-10, followed by the flexitarian/semi-vegetarian (4.93), pescatarian (3.64), vegetarian (3.14), and vegan

(2.63) diets (see Figure 3.1; see Appendix B for participant characteristics).

Figure 3.1

Penetration and Probability of Adopting Five Plant-rich Diets



Notes: MED = Mediterranean; PESC = pescatarian; FLEX = flexitarian/semi-vegetarian; VEG = vegetarian; VGN = vegan.

Behavior Prioritization Matrix (BPM)

Results from the impact assessment and survey (penetration and probability) were applied in the BPM to obtain a total weighted impact score (see Table 3.3). Based on the BPM, the Mediterranean diet emerged as the diet with most overall beneficial impact, followed by the vegetarian diet. While the Mediterranean diet had the third greatest total weighted impact score, it had the highest probability of adoption. In contrast, the vegan diet had the greatest total weighted impact score, but the lowest probability of adoption. The diet rated the least beneficial was the pescatarian diet, with both moderate effectiveness and probability scores.

Table 3.3*Behavior Prioritization Matrix (BPM)*

Plant-rich Diets	<u>Impact Scores</u>	<u>Community Online Survey</u>		Total Weighted Impact
	Environmental, Health, Animal Welfare Benefits (1-10)	Inversed Penetration (0-1)	Probability Score (0-10)	
Mediterranean	6.75	0.94	5.63	35.90
Vegetarian	8.14	0.96	3.14	24.54
Vegan	8.74	0.98	2.63	22.53
Flexitarian/Semi-vegetarian	5.01	0.86	4.93	21.24
Pescatarian	5.56	0.96	3.64	19.43

Notes: Sample size = 253; Higher total weighted impact = greater benefits.

Discussion

The overall aim of the current study was to assess common diets on three major dimensions (environmental, human health, and animal welfare), existing penetration, and probability of future adoption to rank their overall merit in anticipated behaviour change initiatives. Despite the Mediterranean diet being only moderately effective in reducing environmental/health/animal welfare impacts (relative to the standard omnivore diet), it had the highest overall weighted impact score, largely by virtue of its relatively high probability of adoption. Notably, the sustainable diets with the greatest health, environmental, and animal welfare benefits (e.g., vegan and vegetarian) had the lowest probability of adoption. This result is not surprising, given that most participants identified as meat eaters, in alignment with previous research assessing meat consumption in Australia (Malek et al., 2019). Further, only 29% of participants reported consuming one of the sustainable diets, thus confirming the need to target the reduction of meat consumption in Australia.

For most Australians, the Mediterranean diet represents a smaller shift in dietary patterns. Despite this diet having only a moderate impact assessment result, its appeal of requiring only a relatively small shift in eating habits from our participants' typical diet

suggests that it is more likely to be adopted, and therefore more likely to make a sustained difference (Park & Barker, 2020). In contrast, a vegan diet requires greater dietary shifts with the exclusion of all animal-sourced products and the addition of fortified foods and/or supplements to ensure adequate nutrition. Such a significant shift in dietary patterns in countries with a long history of eating animal-sourced products appears less feasible for most of the population and therefore less impactful from an intervention perspective (van Dooren et al., 2014).

Assessing the overall effectiveness of each sustainable diet highlights the importance of evaluating diets through a holistic lens. While the vegan diet provided the highest environmental benefits on the GHG emissions and land-use scales, it performed worse than the baseline omnivore diet on water-use. This result is due to foods common in a vegan diet (e.g., legumes, vegetables, fruit, and nuts) demanding high levels of irrigation (Meier & Christen, 2013; Springmann et al., 2018).

Large variations in water-use were found between the studies (from 107% increase to 22% decrease, with median 1.5% increase), partly due to differences in the reference diet between countries, but also due to use of different metrics to quantify the water footprint of foods (Berger & Finkbeiner, 2013). Nevertheless, the current results highlight the importance of assessing a range of environmental factors to determine the true environmental impacts of different sustainable diets and effectively support the development of behaviour change interventions.

The pescatarian diet performed the poorest on the animal welfare assessment, having a lower score than the baseline omnivore diet due to a high animal loss (AL) score. This result is consistent with Scherer et al. (2019), who reported that high seafood intake countries, such as China, Norway, and Japan, generated notably high animal welfare concerns due to high AL. While this is a new framework that has been applied to only one life cycle

assessment (Scherer et al., 2019), these results further highlight the importance of applying a holistic approach when assessing the effectiveness of sustainable diets to promote dietary change. There may not be any reasonable “one size fits all” approach in this context, given the variation in typical diets cross-culturally, and the differences in worldview between individuals and societies with respect to welfare of fish in comparison with other livestock (Röcklinsberg, 2014).

The Mediterranean diet had the greatest human health benefits (i.e., deaths averted and reduction in mortality risk), followed closely by the vegan and pescatarian diets. These results are generally consistent with past research showing the Mediterranean diet to have better health outcomes than the other sustainable diets (e.g., van Dooren et al., 2014). Furthermore, the Mediterranean diet is often recommended by health professionals (e.g., British Heart Foundation, 2022; The Royal Australian College of General Practitioners, 2014).

Implications for Interventions

To the authors’ knowledge, this is the first study to assess the impact of a variety of sustainable diets on all three major relevant dimensions - environment, human health, and animal welfare *together with* existing human behaviour assessments of current (penetration) and future (likelihood of adoption) consumption patterns. Assessing impacts and adoption together enables policymakers and researchers to make informed decisions on which sustainable diets to target for interventions aimed at reducing the consumption of animal-sourced products. Further, using a behaviour model enhances the likelihood of successfully shifting peoples’ dietary behaviours. Clearly, less restrictive diets, such as the Mediterranean diet, are more agreeable to people in high-income countries and should be the focus of interventions in Australia and other similarly high-income, high meat consumption countries. Despite this, life cycle assessments have often focused on elimination diets such as vegan and

vegetarian diets, though the inclusion of other sustainable diets in life cycle assessments is increasing (e.g., Chen et al., 2019; Kim et al., 2020; Springmann et al., 2018; van Dooren et al., 2014). The flexitarian/semi-vegetarian diet is one that may benefit from additional life cycle assessment research, given its high probability of adoption as revealed in the current study. While it was the least effective of the sustainable diets, this in part may have been due to the varied definitions and therefore dietary compositions in the literature, resulting in a range of effectiveness results.

Given the urgent changes needed to our food systems to address agriculture's contributions to climate change and environmental degradation, it is important that these shifts occur sooner rather than later, particularly in high-income countries (IPCC, 2019). Thus, the focus should be not only on the effectiveness of different diets, but on the willingness of consumers to shift and maintain these dietary changes, particularly given the challenges learned from the health field around changing eating habits (van't Riet et al., 2011). Despite the rapid need for shifts in diet preferences, as highlighted above, we recognise that any diet changes will have follow-on effects on local agricultural production, economic, and social systems (Springmann et al., 2018). While beyond the purview of the current study, these factors also need to be considered and addressed to support sustainable food systems.

Limitations and Future Directions

It is important to note that extensive variability existed in the literature assessing the effectiveness of each sustainable diet. To minimise the risk of over- or under-reporting, only peer-reviewed review articles were used. The recent publications of these articles and extensive nature of their reviews indicate they present a comprehensive overview of the published literature. Limited health information was available for comparison across all the sustainable diets, which was due, in part, to a range of scales in the literature used to assess

health. Specifically, only one health study was used for the Mediterranean health calculation, which contrasts with three or four studies available for the other sustainable diets. Despite limited data, the Mediterranean health benefits in the current study are consistent with past research using other health measures (Chen et al., 2019; Clarys et al., 2014; Rosi et al., 2017; van Dooren et al., 2014).

A further consideration is that farming practices, and their associated environmental and animal welfare impacts, vary between countries. For example, the greenhouse gas emissions from beef and milk production are substantially higher in low- to middle-income regions than in high-income regions (Harrison et al., 2021). While some of the studies used in our literature review incorporated varied farming practices in their assessments, the studies assessing only one country were specific to that country's farming practices (Rosi et al., 2017; Springmann et al., 2018; Veeramani et al., 2017). To improve consistency, only high-income countries were included in the effectiveness calculations. As such, the environmental, health, and animal welfare impact calculations reported in this study could be applied to other high-income countries. Meat consumption patterns in Australian are also similar to many other high-income countries (FAOSTAT, 2021), so the probability and penetration results reported here may be consistent with, and therefore applied to, other high-income countries.

Given the Mediterranean diet was identified as the most beneficial sustainable diet to target, it is recommended that future research further assess drivers and barriers to consuming this diet, through a behaviour model lens. To date, most research in this area has been conducted without the use of an empirically-driven behaviour change model, which is considered essential for developing successful interventions (Michie et al., 2011).

Furthermore, research assessing the Mediterranean diet is limited and often focused on 'at-risk' populations (e.g., older adults, high cardiovascular risk) (Davis et al., 2015; McEvoy et al., 2018; Zacharia et al., 2020) as distinct from all population groups. The behaviour change

wheel (BCW) is a comprehensive behaviour model that could be used to assess the Mediterranean diet in this manner. This model assesses behaviours in terms of capability, opportunity, and motivation, otherwise known as the COM-B, which then informs which of the nine identified intervention functions to apply. The BCW has also been utilised within health and environmental fields to shift behaviours and inform policy makers (McEvoy et al., 2018; Sundaraja et al., 2021).

Conclusions

The urgent need to shift to plant-rich diets is now considered a vital strategy in achieving a global sustainable food system and in combating an important driver of climate change. Our findings indicate that, from the diets assessed, the Mediterranean diet has the greatest potential for improving sustainability of high-income country diets, specifically those with high meat intake patterns, based on: (1) its effectiveness in reducing negative environmental, human health, and animal welfare impacts; (2) its relatively low current adoption rates in the population; and (3) its relatively high probability of being adopted by the target population. Our evidence demonstrates the importance of assessing diet effectiveness within a human context to determine not only which diets people should eat, but which diets people are willing to eat. Without these crucial elements, any attempt to change people's dietary patterns is at risk of failure. By using a behaviour prioritisation model that combines social, environmental, human health, and animal sciences, a more complete picture emerges, whereby pitfalls and realistic solutions can be identified. Given the urgent need to shift our eating habits, this research delivers the much-needed starting point on the demand-side road map to building a more sustainable food system

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Appendix A

Penetration and Probably of Adoption Questionnaire

Please select the answer that best represents your current situation.

What is your age?

_____ (Scroll down bar to select age)

What is your gender?

- ☐ Female
- ☐ Male
- ☐ Other, please specify _____
- ☐ Prefer not to say

What is the highest education you have completed?

- ☐ Less than High School
- ☐ High School
- ☐ TAFE
- ☐ Bachelor's degree
- ☐ Master's degree
- ☐ Doctorate degree, Professional degree (PhD, MD, JD)
- ☐ Other, please specify _____

What is your ancestry? Select as many as apply.

- ☐ Australian and the Pacific: Includes Australian and New Zealand Peoples, Melanesian and Papuan Micronesian, Polynesian
- ☐ North-West European: Includes British, Irish, Western European, Northern European
- ☐ Southern and Eastern European: Includes Southern European, South Eastern European, Eastern European
- ☐ North African and Middle Eastern: Includes Arab, Jewish, Peoples of the Sudan, other North African and Middle Eastern
- ☐ South-East Asian: Includes Mainland South-East Asian, Maritime South-East Asian
- ☐ North East Asian: Includes Chinese Asian, other North-East Asian
- ☐ Southern and Central Asian: Includes Southern Asian, Central Asian
- ☐ People of the Americas: Includes North American, South American, Central American, Caribbean Islander
- ☐ Sub-Saharan Africa: Includes Central and West African, Southern and East African

What is your household type?

- ☐ Single person
- ☐ Share-house
- ☐ Couple
- ☐ Couple with children
- ☐ Single parent with children
- ☐ Extended family (children, parents, grandparents)

What is your current combined household income (previous year) before taxes, in Australian dollars? Please provide your best guess.

- Less than \$10,000
- \$10,000 - \$19,999
- \$20,000 - \$29,999
- \$30,000 - \$39,999
- \$40,000 - \$49,999
- \$50,000 - \$59,999
- \$60,000 - \$69,999
- \$70,000 - \$79,999
- \$80,000 - \$89,999
- \$90,000 - \$99,999
- \$100,000 - \$109,999
- \$110,000 - \$119,999
- \$120,000 - \$129,999
- \$130,000 - \$139,999
- \$140,000 - \$149,999
- \$150,000 - \$159,999
- \$160,000 - \$169,999
- \$170,000 - \$179,999
- Over \$180,000
- Rather not say

In this study, we are interested in a number of diets. The following are definitions of diets we are interested in:

Omnivore diet consumes:

- Meat (beef, pork, lamb, poultry, fish, seafood) and other animal-based foods (dairy, eggs) one or more times per day
- Plant-based foods (fruits, vegetables, cereals, legumes, and nuts)

Mediterranean diet consumes:

- No processed meat
- Small amounts of red meat (beef, lamb, pork; one serving per week)
- Moderate amounts of fish, seafood, poultry, eggs and dairy (2-3 servings per week)
- Plant-based foods (fruits, vegetables, whole grains, legumes, nuts, and olive oil)

Vegan diet consumes:

- No meat or other animal-based food (beef, pork, lamb, poultry, fish, seafood, dairy, eggs)
- Plant-based foods (fruits, vegetables, cereals, legumes, and nuts)

Vegetarian diet consumes:

- No meat (beef, lamb, pork, poultry, fish, seafood)
- Animal-based foods (dairy, eggs)
- Plant-based foods (fruits, vegetables, cereals, legumes, and nuts)

Flexitarian/semi-vegetarian diet consumes:

- At least three meat-free days per week
- No processed meat
- Small amounts of red meat (beef, lamb, pork; one serving per week),
- Moderate amounts of fish, seafood, poultry, eggs and dairy (2-3 servings per week)
- Plant-based foods (fruits, vegetables, cereals, legumes, and nuts)

Pescatarian diet consumes:

- No red meat (beef, pork, lamb) or poultry
- Fish, seafood, other animal-based foods (dairy, eggs)
- Plant-based foods (fruits, vegetables, cereals, legumes, and nuts)

	Fruits & Vegetables 	Legumes / Nuts 	Dairy 	Eggs 	Fish/ Seafood 	Poultry 	Red Meat (beef, lamb, pork) 
Omnivore	✓	✓	✓	✓	✓	✓	✓
Mediterranean	✓	✓	MODERATE ⁺	MODERATE ⁺	MODERATE ⁺	MODERATE ⁺	LOW*
Pescatarian	✓	✓	✓	✓	✓	✗	✗
Flexitarian / Semi-Vegetarian	✓	✓	MODERATE ⁺	MODERATE ⁺	MODERATE ⁺	MODERATE ⁺	LOW*
Vegetarian	✓	✓	✓	✓	✗	✗	✗
Vegan	✓	✓	✗	✗	✗	✗	✗

*Low = one serving per week

+ Moderate = 2 to 3 servings per week

Click on which diet is *the closest to describing* what you have eaten over the last week. Choose one only.

Omnivore diet consumes:

- Meat (beef, pork, lamb, poultry, fish, seafood) and other animal-based foods (dairy, eggs) one or more times per day
- Plant-based foods (fruits, vegetables, cereals, legumes, and nuts)

Mediterranean diet consumes:

- No processed meat
- Small amounts of red meat (beef, lamb, pork; one serving per week)
- Moderate amounts of fish, seafood, poultry, eggs and dairy (2-3 servings per week)
- Plant-based foods (fruits, vegetables, whole grains, legumes, nuts and olive oil)

Vegan diet consumes:

- No meat or other animal-based food (beef, pork, lamb, poultry, fish, seafood, dairy, eggs)
- Plant-based foods (fruits, vegetables, cereals, legumes, and nuts)

Vegetarian diet consumes:

- No meat (beef, lamb, pork, poultry, fish, seafood)
- Animal-based foods (dairy, eggs)
- Plant-based foods (fruits, vegetables, cereals, legumes, and nuts)

Flexitarian / Semi-Vegetarian diet consumes:

- At least three meat-free days per week
- No processed meat
- Small amounts of red meat (beef, lamb, pork; one serving per week)
- Moderate amounts of fish, seafood, poultry, eggs and dairy (2-3 servings per week)
- Plant-based foods (fruits, vegetables, cereals, legumes, and nuts)

Pescatarian diet consumes:

- No red meat (beef, pork, lamb) or poultry
- Fish, seafood, other animal-based foods (dairy, eggs)
- Plant-based foods (fruits, vegetables, cereals, legumes, and nuts)

Did the rest of the household eat the same diet?

- ☐ Yes
- ☐ No
- ☐ N/A

If No, directed to:

Click on which diet is *the closest to describing* what the rest of the household have eaten over the last week. Choose one only.

Omnivore diet consumes:

- Meat (beef, pork, lamb, poultry, fish, seafood) and other animal-based foods (dairy, eggs) one or more times per day
- Plant-based foods (fruits, vegetables, cereals, legumes, and nuts)

Mediterranean diet consumes:

- No processed meat
- Small amounts of red meat (beef, lamb, pork; one serving per week)
- Moderate amounts of fish, seafood, poultry, eggs and dairy (2-3 servings per week)
- Plant-based foods (fruits, vegetables, whole grains, legumes, nuts and olive oil)

Vegan diet consumes:

- No meat or other animal-based food (beef, pork, lamb, poultry, fish, seafood, dairy, eggs)
- Plant-based foods (fruits, vegetables, cereals, legumes, and nuts)

Vegetarian diet consumes:

- No meat (beef, lamb, pork, poultry, fish, seafood)
- Animal-based foods (dairy, eggs)
- Plant-based foods (fruits, vegetables, cereals, legumes, and nuts)

Flexitarian / Semi-Vegetarian diet consumes:

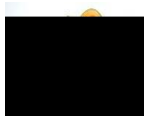
- At least three meat-free days per week
- No processed meat
- Small amounts of red meat (beef, lamb, pork; one serving per week)
- Moderate amounts of fish, seafood, poultry, eggs and dairy (2-3 servings per week)
- Plant-based foods (fruits, vegetables, cereals, legumes, and nuts)

Pescatarian diet consumes:

- No red meat (beef, pork, lamb) or poultry
- Fish, seafood, other animal-based foods (dairy, eggs)
- Plant-based foods (fruits, vegetables, cereals, legumes, and nuts)

The following questions are about the Mediterranean diet which includes:

- No processed meat
- Small amounts of red meat (beef, lamb, pork; one serving per week)
- Moderate amounts of fish, seafood, poultry, eggs and dairy (2-3 servings per week)
- Plant-based foods (fruits, vegetables, whole grains, legumes, nuts and olive oil)

	Fruits & Vegetables 	Legumes / Nuts 	Dairy 	Eggs 	Fish/ Seafood 	Poultry 	Red Meat (beef, lamb, pork) 
Mediterranean	✓	✓	MODERATE⁺	MODERATE⁺	MODERATE⁺	MODERATE⁺	LOW[*]

*Low = one serving per week

+ Moderate = 2 to 3 servings per week

On a scale from 0 – 10, how appealing is the Mediterranean diet for you personally?

Not at all appealing					Extremely appealing					
0	1	2	3	4	5	6	7	8	9	10

On a scale from 0 – 10, how appealing do you think the Mediterranean diet would be for your household to follow?

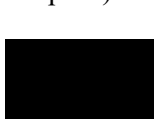
Not at all appealing					Extremely appealing					
0	1	2	3	4	5	6	7	8	9	10

On a scale from 0 – 10, how likely are you to follow a Mediterranean diet in the future?

Not at all likely					Extremely likely					
0	1	2	3	4	5	6	7	8	9	10

The following questions are about the Flexitarian / Semi-Vegetarian diet which includes:

- At least three meat-free days per week
- No processed meat
- Small amounts of red meat (beef, lamb, pork; one serving per week),
- Moderate amounts of fish, seafood, poultry, eggs and dairy (2-3 servings per week)
- Plant-based foods (fruits, vegetables, cereals, legumes, and nuts)

	Fruits & Vegetables	Legumes / Nuts	Dairy	Eggs	Fish/ Seafood	Poultry	Red Meat (beef, lamb, pork)
							
Flexitarian / Semi-Vegetarian	✓	✓	MODERATE ⁺	MODERATE ⁺	MODERATE ⁺	MODERATE ⁺	LOW*

*Low = one serving per week

⁺Moderate = 2 to 3 servings per week

How appealing is the Flexitarian / Semi-Vegetarian diet for you personally?

Not at all appealing					Extremely appealing					
0	1	2	3	4	5	6	7	8	9	10

How appealing do you think the Flexitarian / Semi-Vegetarian diet would be for your household to follow?

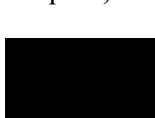
Not at all appealing					Extremely appealing					
0	1	2	3	4	5	6	7	8	9	10

On a scale of from 0 – 10, how likely are you to follow a Flexitarian / Semi-Vegetarian diet in the future?

Not at all likely					Extremely likely					
0	1	2	3	4	5	6	7	8	9	10

The following questions are about the Omnivore diet which includes:

- Meat (beef, pork, lamb, poultry, fish, seafood) and other animal-based foods (dairy, eggs) one or more times per day
- Plant-based foods (fruits, vegetables, cereals, legumes, and nuts)

	Fruits & Vegetables	Legumes / Nuts	Dairy	Eggs	Fish/ Seafood	Poultry	Red Meat (beef, lamb, pork)
							
Omnivore	✓	✓	✓	✓	✓	✓	✓

On a scale from 0 – 10, how appealing is the Omnivore diet for you personally?

Not at all appealing					Extremely appealing					
0	1	2	3	4	5	6	7	8	9	10

On a scale from 0 – 10, how appealing is the Omnivore diet for your household to follow?

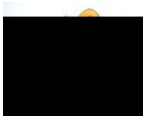
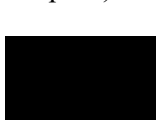
Not at all appealing					Extremely appealing					
0	1	2	3	4	5	6	7	8	9	10

On a scale from 0 – 10, how likely are you to follow an Omnivore diet in the future?

Not at all likely					Extremely likely					
0	1	2	3	4	5	6	7	8	9	10

The following questions are about the Vegan diet which includes:

- No meat or other animal-based food (beef, pork, lamb, poultry, fish, seafood, dairy, eggs)
- Plant-based foods (fruits, vegetables, cereals, legumes, and nuts)

	Fruits & Vegetables	Legumes / Nuts	Dairy	Eggs	Fish/ Seafood	Poultry	Red Meat (beef, lamb, pork)
							
Vegan	✓	✓	✗	✗	✗	✗	✗

On a scale from 0 – 10, how appealing is the Vegan diet for you personally?

Not at all appealing					Extremely appealing					
0	1	2	3	4	5	6	7	8	9	10

On a scale from 0 – 10, how appealing do you think the Vegan diet would be for your household to follow?

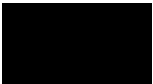
Not at all appealing					Extremely appealing					
0	1	2	3	4	5	6	7	8	9	10

On a scale from 0 – 10, how likely are you to follow a Vegan diet in the future?

Not at all likely					Extremely likely					
0	1	2	3	4	5	6	7	8	9	10

The following questions are about the Pescatarian diet which includes:

- No red meat (beef, pork, lamb) or poultry
- Fish, seafood, other animal-based foods (dairy, eggs)
- Plant-based foods (fruits, vegetables, cereals, legumes, and nuts)

	Fruits & Vegetables	Legumes / Nuts	Dairy	Eggs	Fish/ Seafood	Poultry	Red Meat (beef, lamb, pork)
							
Pescatarian	✓	✓	✓	✓	✓	✗	✗

How appealing is the Pescatarian diet for you personally?

Not at all appealing					Extremely appealing					
0	1	2	3	4	5	6	7	8	9	10

How appealing do you think the Pescatarian diet would be for your household to follow?

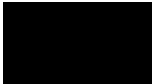
Not at all appealing					Extremely appealing					
0	1	2	3	4	5	6	7	8	9	10

On a scale of from 0 – 10, how likely are you to follow a Pescatarian diet in the future?

Not at all likely					Extremely likely					
0	1	2	3	4	5	6	7	8	9	10

The following questions are about the Vegetarian diet which includes:

- No meat (beef, lamb, pork, poultry, fish, seafood)
- Animal-based foods (dairy, eggs)
- Plant-based foods (fruits, vegetables, cereals, legumes, and nuts)

	Fruits & Vegetables	Legumes / Nuts	Dairy	Eggs	Fish/ Seafood	Poultry	Red Meat (beef, lamb, pork)
							
Vegetarian	✓	✓	✓	✓	✗	✗	✗

On a scale from 0 – 10, how appealing is the Vegetarian diet for you personally?

Not at all appealing Extremely appealing										
0	1	2	3	4	5	6	7	8	9	10

On a scale from 0 – 10, how appealing do you think the Vegetarian diet would be for your household to follow?

Not at all appealing Extremely appealing										
0	1	2	3	4	5	6	7	8	9	10

On a scale from 0 – 10, how likely are you to follow a Vegetarian diet in the future?

Not at all likely Extremely likely										
0	1	2	3	4	5	6	7	8	9	10

Appendix B

Participant Characteristics and Current Dietary Patterns

	OMN (%)	MED (%)	FLEX/SV (%)	PESC (%)	VEG (%)	VGN (%)
Gender						
Male	75.2	7.4	11.6	2.5	2.5	0.8
Female	66.2	3.8	16.9	6.2	4.6	2.3
Other	100.0	0.0	0.0	0.0	0.0	0.0
Age (years)						
18-30	63.3	1.7	21.7	3.3	10.0	0.0
30-44	64.9	6.5	16.9	3.9	2.6	5.2
45-59	82.0	3.3	8.2	6.6	0.0	0.0
≥ 60	74.5	10.9	9.1	3.6	1.8	0.0
Income '000 (AUD)						
<40k	73.0	8.1	10.8	5.4	2.7	0.0
40k-<80k	70.5	2.6	19.2	3.8	2.6	1.3
80k-<120k	59.1	9.1	15.9	0.0	11.4	4.5
120k+	80.0	2.2	11.1	4.4	0.0	2.2
Prefer not to say	66.7	8.3	8.3	16.7	0.0	0.0
Educational attainment						
≤ Secondary	85.0	2.5	6.3	3.8	2.5	0.0
Post-secondary, not tertiary	79.7	4.7	10.9	1.6	1.6	1.6
Bachelors degree	61.3	10.7	13.3	5.3	8.0	1.3
Post-graduate	34.6	3.8	50.0	3.8	0.0	7.7
Other	62.5	0.0	12.5	25.0	0.0	0.0
Household type						
Single	64.4	6.7	13.3	13.3	2.2	0.0
Share-house	75.9	0.0	24.1	0.0	0.0	0.0
Couple	68.7	9.0	13.4	3.0	4.5	1.5
Couple with children	73.0	4.1	16.2	2.7	1.4	2.7
Single parent with children	76.2	4.8	4.8	4.8	4.8	4.8
Extended family	70.6	5.9	5.9	0.0	17.6	0.0

Note. OMN = omnivore, MED = Mediterranean, FLEX/SV = flexitarian/semi-vegetarian, PESC = pescatarian, VEG = vegetarian, VGN = vegan.

**Higher Degree Research Thesis by Publication
University of New England**

Statement of Originality

(To appear at the end of each thesis chapter submitted as an article/paper)

We, the Research Master/PhD candidate and the candidate's Principal Supervisor, certify that the following text, figures and diagrams are the candidate's original work.

Type of work	Page number/s
Text (inclusive of tables)	75 - 122

Name of Candidate: NICOLE ALLENDEN

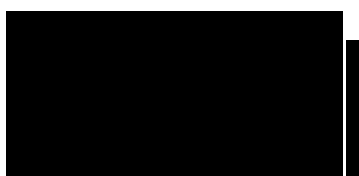
Name/title of Principal Supervisor: ASSOCIATE PROFESSOR AMY LYKINS



Candidate

3 December, 2024

Date



Principal Supervisor

3 December, 2024

Date

**Higher Degree Research Thesis by Publication
University of New England**

Statement of Authors' Contribution

(To appear at the end of each thesis chapter submitted as an article/paper)

We, the PhD candidate and the candidate's Principal Supervisor, certify that all co-authors have consented to their work being included in the thesis and they have accepted the candidate's contribution as indicated in the *Statement of Originality*.

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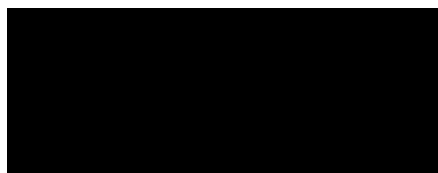
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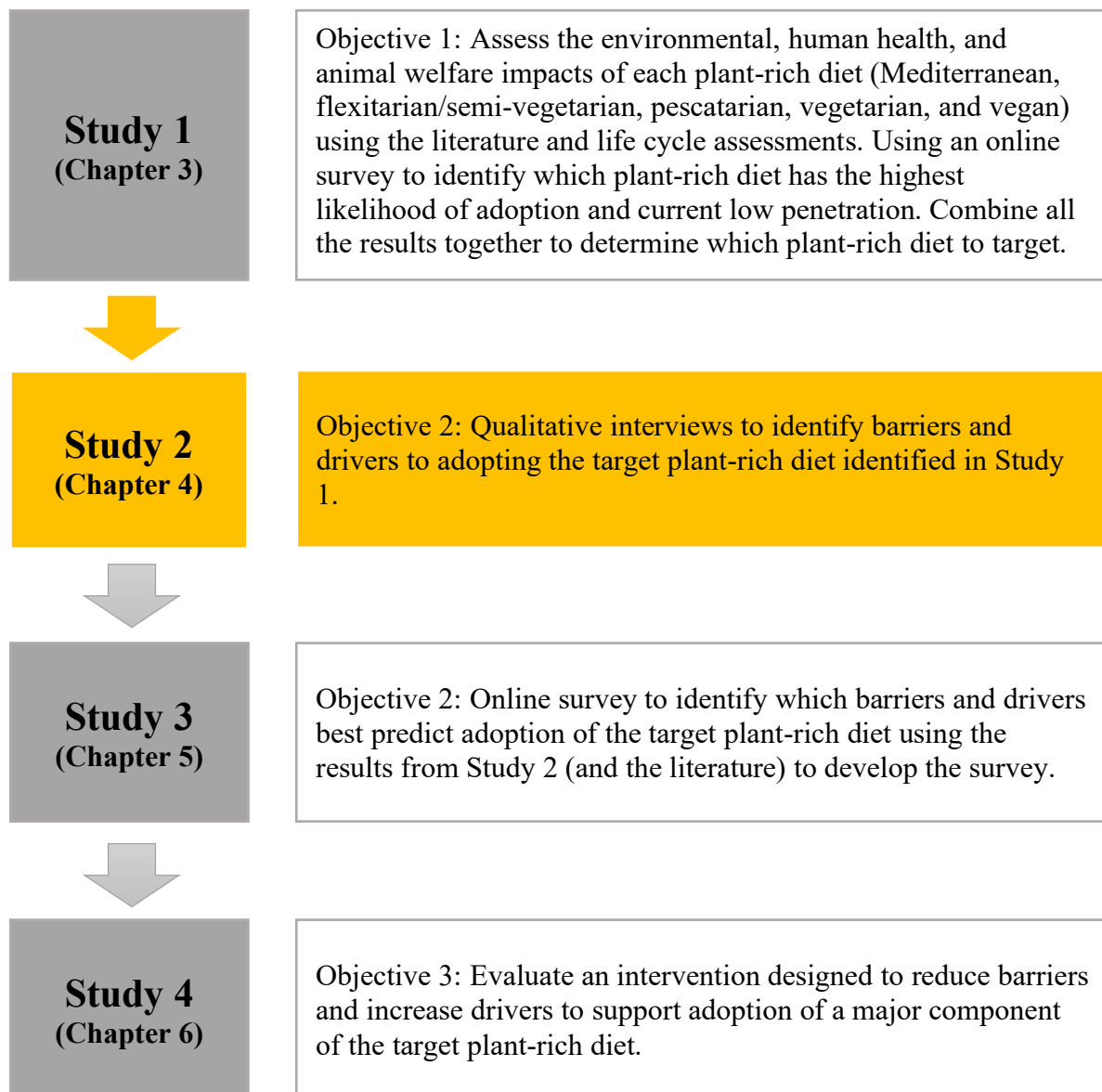


3 December, 2024

Principal Supervisor

Date

Research Progression to Study 2

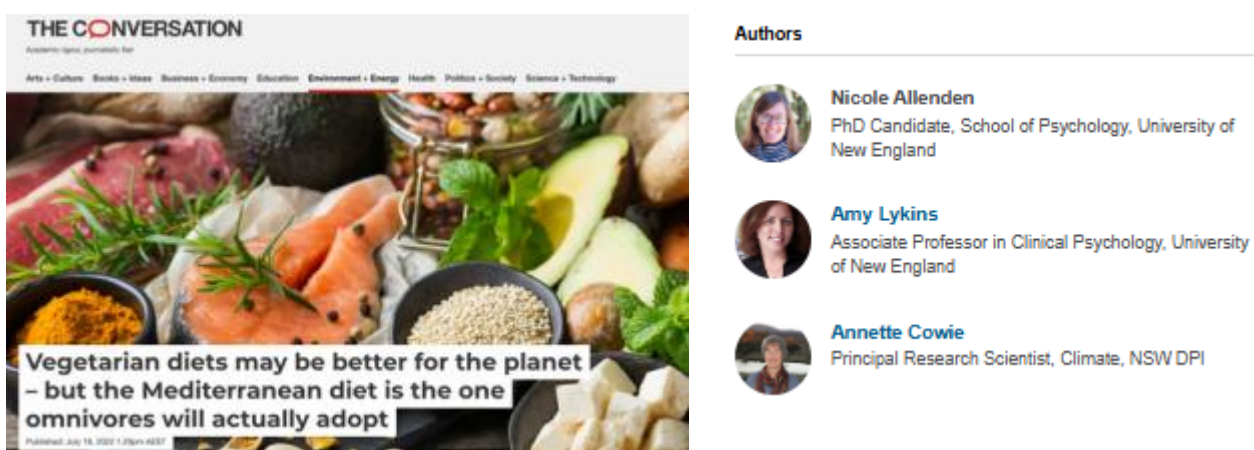


Study 1 is the first to combine life cycle assessments and behavioural measures (i.e., CBSM) to determine which plant-rich diet to target in an intervention. Using this interdisciplinary approach, the effectiveness of five plant-rich diets was first assessed on three metrics (environmental, human health, and animal welfare). A survey was then used to assess the ‘human’ component—current penetration (i.e., proportion of people currently eating each plant-rich diet and the high-meat omnivore diet), and likelihood of people adopting each of

the plant-rich diets. Scores from all three measures were then entered into a behavior prioritization matrix (BPM), to determine which plant-rich diet had the highest projected positive impact, and thus was the diet to target. The Mediterranean diet ranked the highest overall and was therefore the plant-rich diet we elected to target over the following studies. It is not surprising that a meat-reduced diet ranked higher than meat-exclusionary diets (i.e., vegan and vegetarian) on adoption levels, given most participants ate a high-meat, omnivore diet. That said, which meat-reduced diet would claim the top spot (i.e., Mediterranean or flexitarian/semi-vegetarian) was unknown. Additionally, from an environmental science perspective, the meat-exclusionary diets present as the ones to promote (as expected) (Aleksandrowicz et al., 2016; Allenden et al., 2022; Battle-Bayer et al., 2020); but when the ‘people’ component is added (i.e., likelihood of adoption) they are clearly not. Using this unique and inter-disciplinary approach gives policymakers (and individuals) a clear starting point, with the Mediterranean diet presenting as an effective and realistic plant-rich diet to promote to high-meat eaters. Furthermore, people seem keen to receive some guidance, with our article in The Conversation (below) attracting 159 442 views (July 2022).

Figure 3.2

Article in The Conversation, “Vegetarian Diets may be Better for the Planet – But the Mediterranean Diet is the one Omnivores will Actually Adopt.”



Before designing an intervention to increase adoption, however, it is vital that the barriers and drivers are understood. So far, Mediterranean diet research has focused on aging participants or those with (or at risk of developing) health problems (McEvoy et al., 2018; Moore et al., 2018; Zacharia et al., 2020). Limited research has also been conducted in non-Mediterranean, high-meat eating countries such as Australia (Scannell et al., 2020). Study 2 aimed to overcome these limitations by exploring the barriers and drivers to Australians eating a Mediterranean diet using in-depth qualitative interviews. To achieve this, the capability-motivation-opportunity of behaviour (COM-B) framework from the behaviour change wheel (BCW) was applied. The application of behaviour change models is limited in the sustainable eating field (Tsofliou et al., 2022), despite being considered best practice for intervention design (Michie et al., 2011). As such, findings from Study 2 will enable the design of more robust (and potentially more effective) interventions aimed at increasing Mediterranean diet adoption levels.

Chapter 4

Study 2

Barriers and drivers to adopting a plant-rich Mediterranean diet in a high-income country: A qualitative study

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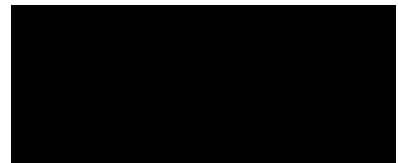
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Abstract

Eating a plant-rich diet is considered essential for human and planetary health and the Mediterranean diet offers a realistic way to increase this. Gaining greater knowledge of the barriers and drivers to consuming the Mediterranean diet in residents of high-income countries was the aim of the current study. Semi-structured interviews were conducted with 16 adults residing in Australia who ate either an omnivore or plant-rich diet. Using reflexive thematic analysis (RTA) and the behaviour change wheel (BCW), an in-depth exploration of these barriers and drivers was conducted. Key barriers were: (1) changing ingrained meat habits, (2) lack of physical and mental availability, (3) household influences, (4) meat perceived as tasty and Mediterranean diet foods as bland, and (5) minimal knowledge of the nutritional benefits of Mediterranean diet foods. Our findings emphasise the need to consider multiple individual and environmental barriers when designing behaviour change interventions to increase Mediterranean diet adoption.

Key words: Mediterranean diet, meat consumption, behavior change, behavior change wheel, sustainability

Introduction

High meat consumption – particularly red and processed meat – is linked to a range of chronic health problems (Demeyer et al., 2016; Li et al., 2018; Micha et al., 2010; Pan et al., 2011), and livestock husbandry produces 16.5 to 30% of total global greenhouse gas (GHG) emissions (Twine, 2021), prompting concerns about human *and* planetary health. With meat consumption continuing to rise globally (FAO, 2017), these risks are ever-increasing. To fully understand the scale of this crisis, meat consumption is best viewed through the holistic ‘One Health’ model (Zinsstag et al., 2011). This model emphasises the inter-connections between human, animal, and planetary health, and posits that human health is reliant on the health of our eco-system. High meat consumption clearly threatens human health directly, but also threatens our eco-system, prompting an urgent review of our dietary behaviours. Promoting plant-rich eating is now considered a vital strategy to support human health and a sustainable food system (e.g., low environmental impacts, nutritiously adequate) (IPCC, 2022, 2023) and aligns with the ‘One Health’ model. Greater health and environmental gains can be achieved if people in high-income countries adopt plant-rich eating, as their meat consumption, on average, is above expert-recommended targets (Willet et al., 2019). Developing interventions to increase plant-rich eating is therefore vital if we are to support human health and achieve a sustainable food system.

The Mediterranean diet (MD) is a plant-rich diet that has positive health and environmental outcomes (Aleksandrowicz et al., 2016; Yacoub Bach et al., 2023). It is comprised of high levels of plants (fruit, vegetables, whole grains, legumes, and olive oil) and moderate (chicken, fish) to low (red meat) levels of meat (Bach-Faig et al., 2011). It is associated with reduced risk of developing heart disease, type 2 diabetes, dementia, and some cancers (Demeyer et al., 2016; Li et al., 2018; Micha et al., 2010; Pan et al., 2011; Shannon et al., 2023), and emits fewer GHG emissions and uses less land and water than an omnivore

diet (Aleksandrowicz et al., 2016; Batlle-Bayer et al., 2020). These health and environmental credentials reveal the MD as a worthwhile plant-rich diet to promote, however adoption remains low (Allenden et al., 2022). To that end, exploring the drivers and barriers to people adopting the MD in high-income countries with high occurrence of ‘lifestyle’ diseases is crucial to guide development of interventions to enhance their likelihood of success in changing dietary patterns.

To harness the health benefits of the MD, health researchers have assessed the barriers and drivers of MD adoption in populations at risk of developing health conditions (McEvoy et al., 2018; Moore et al., 2018). The barriers ranged from a lack of knowledge of the MD and negative attitudes towards MD foods (e.g., olive oil, nuts, fish), limited cooking skills for MD dishes, resistance to changing current eating habits, perceived financial cost increase, lack of time, and cultural food norms. In a study of Australian adults, Scannell and colleagues (2020) found that reduced perceived behaviour control (i.e., self-efficacy) had the greatest impact on MD adoption. While insights can be gained from this study, more is clearly needed with community populations to further these findings. Additionally, behaviour change models—considered best practice for developing interventions—are underutilised in this field, with the few models employed (e.g., theory of planned behaviour) not always focused on habitual behaviours, which are considered essential in food choices (Klöckner, 2013; Moore and Boldero, 2017; Scannell et al., 2020).

The behaviour change wheel (BCW) is a comprehensive behaviour change framework that may overcome this limitation.¹ Each COM-B component is assessed individually and collectively to understand both individual and environmental factors (Figure 1) (Michie et al., 2011).

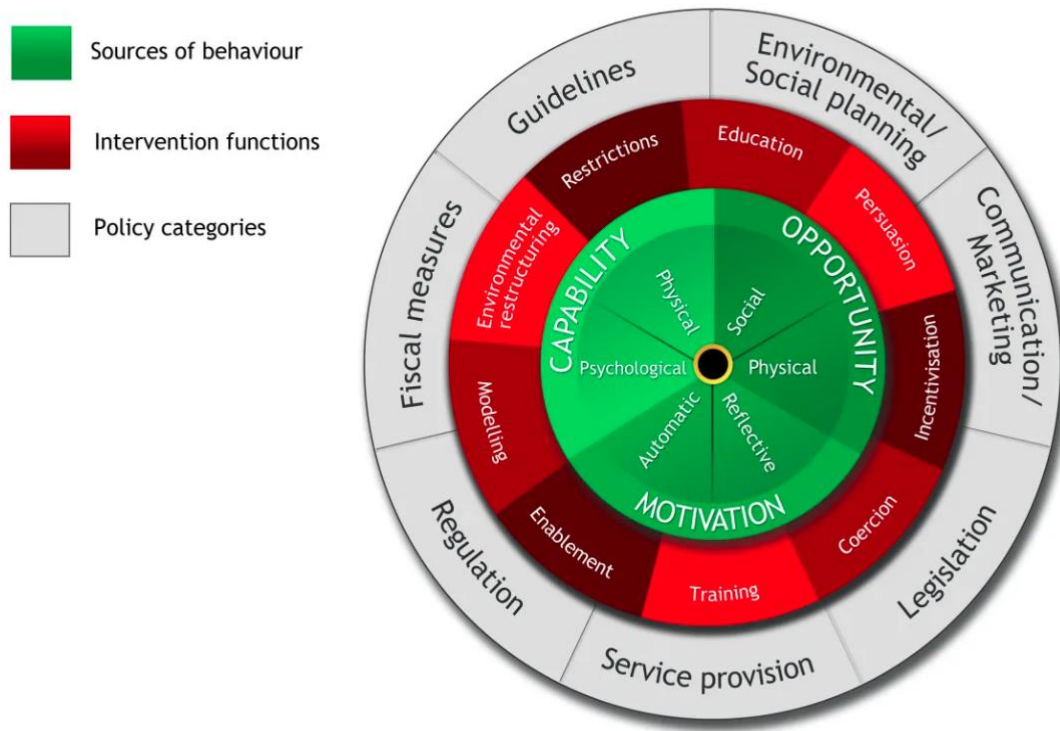


Figure 4.1

The Behaviour Change Wheel

Reprinted from “The behaviour change wheel: A new method for characterising and designing behaviour change interventions,” by S. Michie, M. M. van Stralen and R. West, 2011, *Implementation Science*, 6(42), p. 7. Copyright [2011] by Michie et al., licensee BioMed Central Ltd. Used under Creative Commons Attribution License: <http://creativecommons.org/licenses/by/2.0>.

¹ The first layer of the BCW is the capability, opportunity, and motivation model of behaviour, otherwise known as COM-B. “Capability” relates to psychological skills (e.g., knowledge, attention) and physical skills to perform the behaviour. “Opportunity” includes influences from both the physical environment, such as available resources, and the social environment, such as friends and family. “Motivation” can be either reflective (e.g., intentions, beliefs) or automatic (e.g., habits, emotions).

The COM-B model has been used previously to promote healthy (Barker et al., 2016; McEvoy et al., 2018) and pro-environmental behaviours (Allison et al., 2021; Sundaraja et al., 2021), and more recently to assess meat reduction behaviours in young people (van den Berg et al., 2022) and adoption of the MD in people at risk of developing cardiovascular disease (McEvoy et al., 2018). The current study, however, is the first to apply this model to qualitatively explore the adoption of the MD in a community sample. Given the myriad of individual and environmental factors that influence dietary behaviours, the current study aims to gain an in-depth understanding of the barriers and drivers to MD adoption using reflexive thematic analysis (RTA) and COM-B model components, to inform intervention(s) to promote a plant-rich diet that people are willing to consume.

Material and Methods

Participants

Participants were recruited via first-year psychology students, social media, and word of mouth. All participants completed an online survey to determine study eligibility. Inclusion criteria were being aged 18+ years, residing in Australia, living in a household with at least one other person, and being the main or joint cook (i.e., to assess participants' meal and preparation decisions and the possible impacts of other household members). Using purposive sampling (see Kelly, 2010), eligible participants were then selected based on their current diet and likelihood of adopting the MD in the future (see supplementary material for more detail). The researchers aimed to interview a broad cross section of participants in each group to obtain a wide range of perspectives on potential barriers and drivers.

From 100 people who completed the screening survey, 30 respondents who met eligibility criteria were invited to take part in interviews. Sixteen interviews were conducted, at which point data saturation was deemed to have been met. Data saturation was determined by the first author by applying a high-order grouping of salient themes as they evolved during

the interview process (Hennink & Kaiser, 2022), and as no additional novel information or ideas emerged. All participants received a \$50 e-gift voucher for participating in the interview, and university students also received class credit. See supplementary data for descriptive and diet information for each participant.

Procedure

Ethics approval was provided by the University of New England's Human Research Ethics Committee (Approval No. HE21-014).

In-depth Interview

Interviews were conducted by the first author via Zoom between March 2021 and January 2022. Informed consent was obtained prior to commencing the interview. The MD, meat-reduction literature (Lacroix & Gifford, 2019; Malek et al., 2019; Stoll-Kleemann & Schmidt, 2017), and COM-B informed the semi-structured interview guide (see supplementary material), with questions covering capability, opportunity, and motivation (i.e., dietary habits, dinner decision-making processes, reasons for reducing [or not reducing] meat, and household influences included), with this broad approach also used to capture new insights. General questions about current dinner habits were asked first before MD and meat reduction questions to reduce social desirability bias (Althubaiti, 2016) and gather descriptions of dietary behaviour. Meat (and meat reduction) was a core food (behaviour) in the discussion guide given omnivores need to reduce their meat levels to align with the MD. Participants were shown the MD Pyramid (Medical News Today, n.d.) and a MD plate example (Durrer Schutz et al., 2019) (see supplementary data) to assess MD awareness. Participants were also asked questions about meat consumption, human health, and climate change to assess their awareness of the negative impacts that meat can have on human health and the environment.

Using visual research methods (Pink, 2012), participants moved to the kitchen for a video observation of their pantry/fridge. Two participants were not able to conduct the observation and were asked to describe what they thought was in their pantry/fridge and take photos and send via email, with one participant completing this request. During the observation, participants often discussed their eating and cooking habits in greater detail after receiving visual prompts. Interviews lasted between 1 and 2 hours, with an average length of 1.5 hours. All interviews were video recorded and transcribed verbatim, with pseudonyms applied.

Analysis

A reflexive thematic analysis (RTA) was used to analyse the data (Braun & Clarke, 2019; Braun et al., 2022) using a combined inductive and deductive approach (Fereday & Muir-Cochran, 2006). This combined approach matched the aims of the study, as themes could be generated directly from the data (inductive coding) and the COM-B could be integrated into the analysis (deductive coding). Using the RTA approach, the first author became familiar with the data by transcribing and re-reading transcripts. Initial code development was then conducted by identifying and labelling relevant segments of the transcripts using colour coding. Initial codes were refined (e.g., expanded, joined) and modified (e.g., relabelled) by re-reviewing the transcripts and the notes.

Following inductive coding, a deductive approach was then applied by mapping the codes onto the COM-B sources of behaviour: “Capability” “Opportunity” “Motivation” and specific factors (e.g., psychological capability – knowledge). Codes with shared meaning (and COM-B factors) were then collated to generate initial themes and subsequent subthemes. Themes and subthemes were re-mapped onto the COM-B and further refined. Several differences were identified between participants consuming a plant-rich diet and those consuming an omnivore diet, although group differences were not detected between the

two omnivore groups, *Likely to Adopt* and *Unlikely to Adopt*, therefore, these two groups were joined as *Not Engaged*. Barriers and drivers are discussed under each theme. A comparative analysis was not conducted, though per the qualitative research process (Phoenix & Orr, 2017), participants discussed their unique experiences which were considered in relation to different and similar broad MD experiences across the sample.

Overall, an iterative and reflexive process was undertaken. The influence of the first author's prior knowledge of the COM-B and meat consumption literature on the analysis was considered. Codes, themes, and subthemes were initially generated by the first author. Multiple reviews and code checks (Miles & Huberman, 1994) were then conducted in collaboration with the second and last author, being psychologists, with the last author less familiar with the COM-B, specifically in the context of plant-rich diets. Inter-rater reliability was not used as this method is not generally viewed as in-line with RTA (Braun & Clarke, 2020). Instead, we used an open review procedure in line with a 'critical friends' approach (Smith & McGannon, 2017), which enabled the exploration of multiple and alternative explanations and interpretations as they emerged. This collaborative inductive and deductive process ensured a thorough and rigorous methodological approach that enhanced research outcomes by valuing participant voices and applying a theory driven assessment (Braun et al., 2022; Fereday & Muir-Cochran, 2006).

Results

Using the overarching COM-B themes of capability, opportunity, and motivation, five themes, relating to the adoption of the MD, were generated: (1) ingrained habits (repetition and culture/childhood), (2) perceived lack of time (mental and physical availability), (3) social influences (household and external), (4) taste and satiety, and (5) human health (perceptions of nutrition and food intolerances) (see themes according to the COM-B in

Figure 2). Barriers to adopting the MD were identified in each theme, with drivers also identified.

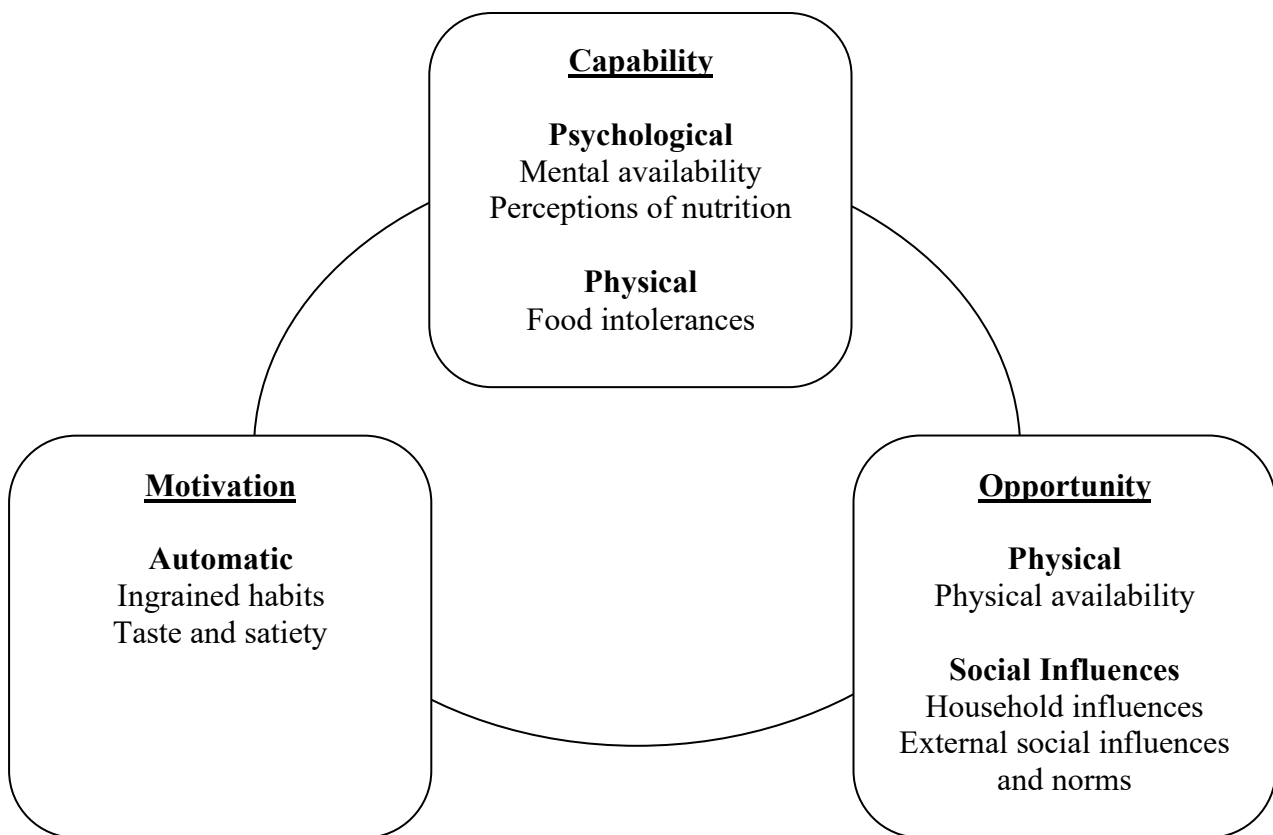


Figure 4.2

A Summary of Results for Themes Organised According to the COM-B Model

Theme One: Ingrained Habits (Automatic Motivation)

All participants reported habitual meal planning, often stating that changing these ingrained habits was a key barrier to MD adoption. Two subthemes were identified; these were ‘dinner repetition’ and ‘culture and childhood influences.’ Given the repetitive and automatic nature of habitual behaviours, this theme is best characterised by automatic motivation in the COM-B model.

Dinner Repetition

Participants across all groups cooked the same meals on a weekly or fortnightly basis, with a typical dinner repertoire ranging from five to fifteen meals. This habitual meal

planning was reportedly a barrier to dietary change in multiple ways. Participants reported minimal use of recipes, with most dinner meals being *“in my head.”* The same food purchasing, meal choice, meal preparation, and consumption behaviours were described as repeated on a regular basis.

Engaged and *Not Engaged* participants reported different meat levels in their dinner meals. *Not Engaged* participants frequently mentioned meat first, whereas *Engaged* participants reportedly consumed less or no meat for dinner. Several *Not Engaged* participants mentioned that changing these ingrained meat-focused habits was hard, representing a key barrier to consuming a MD (*“...because it’s the path of least resistance, we just keep eating what we eat now and not think about it,”* Ryan, *Not Engaged*). However, some *Not Engaged* participants had modified their meal habits to align more with the MD (e.g., reducing red meat, incorporating one meat-free meal in their weekly dinner repertoire), with health and ethical concerns identified as the main drivers, (*“...the carbon dioxide associated, and the water associated with meat production, and it’s a little bit for health reasons,”* Laura, *Not Engaged*).

Culture and Childhood Influences

The majority of *Not Engaged* participants described eating meat-focused meals in their childhood and mentioned the influence of their culture on these eating behaviours (*“...very meat and three veg kind of traditional, you know, Anglo cooking,”* Martin, *Not Engaged*). *Not Engaged* participants continued to consume these meat-focused meals, indicating that early eating experiences influenced current eating habits (*“I find meat and three veg easy...it came from my childhood I guess,”* Jessica, *Not Engaged*).

Engaged participants who identified with non-Australian cultures and/or reported early eating experiences in line with the MD also described the influence of culture and early childhood eating experiences on their current eating habits (*“...the portion size of the meat,*

would be really quite small...[came] from my childhood," Greta, Engaged). In contrast, Engaged participants who identified as Australian described the challenges associated with changing from a meat-focused diet to a plant-rich diet, ("...most of the meals...I knew how to cook...were meat-based meals so, yeah... definitely made it harder," Justin, Engaged), with participants starting with small shifts ("so one [vegetarian] meal a week regularly...and I introduced the fish meal probably once weekly as well...and I've just slowly increased it from there," Leah, Engaged) to change these ingrained habits.

Theme Two: Perceived Lack of Physical and Mental Availability (Physical Opportunity; Psychological Capability)

This key theme related to time. All participants mentioned that work, study, and childrearing commitments reduced their physical and mental availability to make dinner. In the context of these commitments, participants often described dinner as "*exhausting*" and a "*chore*," with familiar and convenient meals preferred. For *Not Engaged* participants, changing their current dinner repertoire to align with the MD was described as effortful, with perceived lack of time a key barrier. Two subthemes were identified; these were 'physical availability' and 'mental availability.' Per the COM-B, these subthemes relate to physical opportunity (i.e., less physical availability to make dinner) and psychological capability (i.e., less mental availability for dinner decision-making and less knowledge of MD and meat-free recipes).

Physical Availability

Most participants stated that their work and childrearing commitments impacted what time they got home, resulting in less physical time to make dinner ("*We both get home late...therefore [I] make a meal that is always something very easy to cook*," Martin, *Not Engaged*). Even when participants worked from home, physical availability continued to

impact dinner as the boundaries between work, study, and home time were frequently blurred.

“...like last night...there is nothing that could have made me want to cook dinner at all... I have really full days. I knew I had more to do into the evening and...don't have the emotional bandwidth to do anything other than just get some of this, you know churn through the work...,” (Laura, Not Engaged)

Given these time barriers, all participants prepared quick and easy dinner meals. To save time, participants described and showed a range of convenience foods (e.g., frozen peas, tinned chickpeas, taco kit) during the pantry and fridge observation.

Mental Availability

These commitments also reduced mental availability, with most participants describing last minute dinner decisions due to attending to other tasks first.

“...finish work at five or four thirty, I jump in the car and I go get the baby from day care ...if I haven't thought about it, it's really hard, you know, to just snap into that mode. I get home and I just get straight into the kitchen and start.” (Rebecca, Not Engaged)

The mental demands of attending to these other tasks made it hard for participants to decide what to cook for dinner (*“...should I cook this, I don't really feel like it, oh, we don't have enough of this and, like, just more decision making,” Jessica, Not Engaged*) with the “effort of changing” often described as a key barrier to adopting the MD. Most *Not Engaged* participants described meat meals as quicker and easier than meat-free meals, (*“It's so easy to like throw a steak on the fry pan and like dinner's done...I don't want to have to be making a new vegetarian meal every day,” Kelly, Not Engaged*), as they had less knowledge of MD and meat-free recipes. Both *Engaged* and *Not Engaged* participants (who had reduced some of their meat consumption) explained that they had saved time and mental

effort by modifying current meals (i.e., replacing meat with tofu, plant-based meat alternatives [PBMA], or lentils), rather than learning new recipes.

Theme Three: Social Influences (Social Opportunity)

The third theme related to social influences, that is, other household members and people outside of the home. All participants were influenced by other household members' eating habits, with some *Not Engaged* participants describing these influences as a barrier to adopting the MD. Children appeared to be the greatest barrier to adopting the MD, with their parents highlighting their preference for meat and carbohydrates over core MD foods such as vegetables and legumes. All participants were influenced by people outside of the home (e.g., friends, family), however, to a lesser extent than household members. Two subthemes were identified; these were 'household influences' and 'external social influences.' Both subthemes relate to social opportunity in the COM-B model as they are factors outside of the individual.

Household Influences

Most participants reported eating dinner with other household members, with everyone usually eating the same meal ("*you know, probably 90% of the time we eat the same thing,*" *Justin, Engaged*). Given household members usually ate the same dinner meal, some *Not Engaged* participants reported that the MD would be difficult to adopt if other household members were not interested ("*I quite like most of the aspects of the Mediterranean diet...the only issue...I'm living in a household that not everybody shares that opinion,*" *Laura, Not Engaged*). Making multiple dinner meals to suit individuals needs was considered inconvenient given the perceived time barriers reported above.

When exploring why other household members may not prefer the MD, *Not Engaged* participants described a dislike of legumes and/or a resistance to reducing meat consumption levels, specifically red meat. One participant increased her beef consumption due to her

partner's cultural background, despite eating a MD in her childhood, (*"I was never a big red meat eater, my partner's predominant meat of choice is always going to beef, it's just what he grew up on in [South America],"* Kelly, *Not Engaged*), highlighting the influence of other household members. While household members acted as a barrier to reducing meat to be in line with the MD, some *Not Engaged* participants reported their influences on other household members, (*"...[my partner's] definitely cut down [on red meat] because the rest of us is not eating as much red meat in general,"* Laura, *Not Engaged*). Thus, household influences can be multidirectional, acting as both a driver and a barrier to meat reduction.

Children also presented as barriers to consuming a MD. Participants who were parents stated that dinner was often determined by what their children would eat. Both *Engaged* and *Not Engaged* participants described their children as "fussy" eaters who prefer meat and carbohydrates (*"...[my children] are very interested in having say, pasta or rice or mashed potato...they definitely like things like sausages or, um, chicken...,"* Greta, *Engaged*) with other MD foods, such as vegetables and legumes, less preferred or disliked. Parents also mentioned that their children responded with strong emotions when offered less preferred or less familiar food. Dinner choice was therefore determined by what children will eat *and* how they may respond, (*"...if they're actually going to eat [dinner]...how much push will I get, versus how much energy do I have to enforce this tonight,"* Rebecca, *Not Engaged*). Thus, participants reported cooking meat and carbohydrate-focused meals as they knew their children would eat them.

External Social Influences

Participants' eating habits were also influenced by people outside of the household. Several *Not Engaged* participants described interacting with friends and family who ate a similar omnivore diet, with fewer interactions with people who ate a MD or other plant-rich diet. This lack of exposure may act as a barrier to adopting the MD. Moreover, some *Not*

Engaged participants described how they changed their eating habits to match the social norm of the group. Laura (*Not Engaged*), for example, ate a plant-rich meal when eating out with her vegetarian and pescatarian friends, but consumed an omnivore diet when eating with her extended family (“...to say I’m only going to eat a Mediterranean diet, that would actually be quite constraining...[they] may kind of find it a bit weird if I was trying to put constraints on them.”), highlighting the challenges associated with deviating from the social eating norms of a peer or family group.

Theme Four: Taste And Satiety (Automatic Motivation)

Another theme identified was the sensory experiences of eating, specifically taste and satiety (or fullness)—an automatic motivation per the COM-B. Most *Engaged* and *Not Engaged* participants reported that meat was tasty, to some extent, with meat preferences less in line with the MD (e.g., dislike of fish and preference for red meat). Most *Engaged* participants also described meat as tasty, (“...mincemeat is done in a way and...put on a skewer and...cooked over a fire which is really delicious,” *Shahen, Engaged*).

Compared to meat, *Not Engaged* participants often described vegetables and legumes as less appealing on taste and texture, (“I could just slap up some more veggies, so why don't I? ...well that's boring or it doesn't taste good,” *Jessica, Not Engaged*; “I am bit ambivalent about beans in salad, I don't particularly like the texture,” *Brian, Not Engaged*). In addition to taste, some *Not Engaged* participants found meat to be filling and vegetables less satisfying from a satiety perspective, (“...[meat-free meals] might not be quite as satisfying after a meal, and then you need to make another meal before you know it,” *Ryan, Not Engaged*). Given these perceptions around vegetables and legumes, most *Not Engaged* participants reported that meat was easy to make tasty, (“I mean salmon’s really tasty, you don’t need to do much to it at all, a bit of salt and pepper and you’re good,” *Martin, Not Engaged*) compared to vegetable-based dishes (“...like with veggies... what do I do to make

this taste good enough,” Kelly, Not Engaged). One way people had overcome these taste barriers was by learning new recipes and having greater exposure to MD foods (“...since [becoming] vegetarian... I’ve been liking veggies more and more... I’ve just sort of acquired more of a liking to the taste,” Justin, Engaged).

Theme Five: Human Health (Psychological Capability; Physical Capability)

The final barrier related to human health. Two subthemes were identified; these were ‘perceptions of nutrition’ and ‘food intolerances.’ Meat was perceived as essential for a healthy diet and not easily replaced by plant protein sources. In contrast, carbohydrates, a core food of the MD, were often perceived as less healthy. Another health factor was allergies because some participants presented with food allergies or intolerances to core MD foods (e.g., gluten and legumes). Per the COM-B, these subthemes relate to psychological capability (i.e., knowledge and awareness of food nutrients) and physical capability (i.e., reduced capability to consume certain foods due to allergies).

Perceptions of Nutrition

From a nutrient perspective, most participants described meat as important for health, specifically “protein” and “iron,” with iron perceived as more important for women (“I have exceptionally low iron so am anaemic and find that red meat works,” Kelly, Not Engaged). Meat was also described as the easy way to get nutrients, with some *Not Engaged* participants less aware of how to replace meat nutrients in a meal (“[meat]...have some really great vitamins and minerals that you'd have to eat so much veggies to get that kind of thing...I also don't have enough information to make a really informed decision about it. It's probably just a lot of that upbringing,” Katherine, Not Engaged), with this lack of nutrient knowledge a barrier. In contrast, some *Not Engaged* participants reported knowledge of nutritional ways to substitute meat protein, such as legumes (“... 'cause I mean, I know there's other things you can eat that's not meat, ah, for protein, but are [the children] gonna eat it... probably

not,” Rebecca, *Not Engaged*), with other barriers, such as household influences, impacting consumption. Further to substituting legumes for meat, some *Engaged* participants ate PBMA as a substitute; however, both *Engaged* and *Not Engaged* participants questioned the health impacts of consuming these “*processed*” foods.

Participants also varied in their perceptions of carbohydrates, another typical MD food nutrient. Several *Not Engaged* participants described carbohydrates as unhealthy, with some adopting a “*low-carb*” diet for health reasons (i.e., high blood pressure, diabetes). Gender differences were also observed, with several *Not Engaged* female participants stating that they reduced their carbohydrate consumption for health reasons (“*my husband and my daughter eat more of the carbohydrates than I do...just because I’m trying to watch what I eat...for health reasons,*” Katherine, *Not Engaged*) and due to messages received from the media (“*I guess there’s a lot of...media out there that say carbs are bad for you,*” Rebecca, *Not Engaged*) on this food type. This had been Rebecca’s own perceptions until she received nutrition education - where whole grain carbohydrates were recommended - when she developed gestational diabetes during her pregnancy. Overall, most *Engaged* participants were aware of the nutritious components of different foods including meat substitutes and carbohydrates. In contrast, nutrient knowledge and awareness was more varied in the *Not Engaged* group, and this posed a barrier to adopting the MD.

Food Intolerances

Although less common, some participants were simply allergic or intolerant to foods that form part of the MD, namely gluten and legumes, acting as the main barrier to adoption. When shown the MD pyramid, Martin (*Not Engaged*), who described himself as coeliac and intolerant to legumes, highlighted that, (“*what really trips up with the Mediterranean is yeah, pretty much that bottom layer [grains and legumes], I can only have limited amounts*

of [those foods]’). Clearly, these intolerances limit Martin’s physical capability to consume these foods and meals and are therefore a barrier to consuming the MD.

Discussion

The current study aimed to explore the barriers and drivers to adopting the MD by understanding factors that influence a participant’s capability, opportunity, and motivation. Results highlighted several key themes across the COM-B model that influenced MD adoption including ingrained eating habits, perceived lack of time, household influences, external social influences, taste and satiety, and health (perceptions of nutrition and food intolerances). Both barriers and drivers were identified within the themes, though barriers were more commonly described by participants and consequently formed more of our analysis, likely due to most participants being omnivore eaters. Inter-relationships between each of the themes and COM-B factors were found, indicating that multiple factors need to be considered when developing interventions aimed at increasing the uptake of the MD.

Omnivore participants regularly ate dinner meals focused on meat, with this automatic motivation impeding their adoption of the MD. Consistent with past research in non-Mediterranean regions (McEvoy et al., 2018), most participants ate more meat, specifically red meat, for dinner than the MD, and fewer MD foods (e.g., legumes) overall. Given most participants grew up in Australia and ate similar dinner meals in their childhood, these meat-focused eating habits were well established, as often found in high-income Western countries (Malek et al., 2019). Several omnivore participants emphasised that the unconscious day-to-day routine of eating meat-focused dinner meals made change hard, even when they were highly motivated to consume the MD for health and ethical reasons. Given these findings, *habit strength* needs to be considered when designing MD interventions (Rees et al. 2018; Van’t Riet et al., 2011). Our study highlighted that to change eating habits, all stages of the

dinner process need to be considered, including habitual dinner decision-making and purchasing practices (Rees et al., 2018).

Insights from participants who had changed their high meat-eating habits emphasised the importance of small dietary shifts, ranging from adding one weekly meat-free meal to swapping red meat for white meat. Participants may build new MD eating habits using action planning where they identify how (meal type) and when (day) they complete the new eating behaviour (Lacroix & Gifford, 2020). Repetition, particularly when performed in the same environment, helps form and maintain new habits (Lally et al., 2011), and self-monitoring techniques (e.g., calendar, app, text messages) can assist people to stay on track with their action plan (Carfora et al., 2019; Rees et al., 2018). Like our participants, these strategies may be more successful with people already motivated to adopt the MD for ethical and health reasons. Further, dietary change also needs to be supported by policies aimed at creating sustainable eating environments (Mozaffarian et al., 2018), in addition to the promotion of individual behaviour change.

Another important automatic motivation identified was taste and satiety or fullness. All participants spontaneously discussed the sensory experience of eating, often describing meat as tasty and MD foods (e.g., legumes, vegetables) as less appealing. This finding is consistent with research in other Western countries where taste preferences are skewed towards meat and vegetarian meals are considered bland (Lea & Worsley, 2001). These taste preferences may impede the adoption of the MD and need to be considered when developing interventions, though some of these taste barriers may be reduced by meat being a component of the MD (Corrin & Papadopoulos, 2017; Graça et al., 2015). Several omnivore participants were less familiar with legumes and questioned their taste and texture, indicating that a lack of exposure had formed negative sensory cues (Rees et al., 2018; Timlin et al., 2020).

To overcome these taste barriers, several participants used recipes to learn how to make tasty plant-focused meals, which indicates that education and training may be useful interventions (McEvoy et al., 2018). Using existing familiar food experiences (savoury, flavoursome, and satisfying) can also help initiate and sustain new eating habits by activating parts of the brain that signify how a food is likely to taste and how rewarding it may be (de Boer and Aiking, 2017). Likewise, showing visually appealing pictures of MD meals can build new sensory cues that are perceived as rewarding (Michie et al., 2011; Simmons et al., 2005). Making tasty and visually rewarding MD meals also increases the chances of the meal being repeatedly cooked, supporting the formation of new eating habits.

Lack of time was another key theme influencing physical opportunity and psychological capability. Lack of time is a common barrier to dietary change, with people engaging in more habitual responses when stressed (Schwabe and Wolf, 2010). Changing to a MD requires conscious goal-directed intentions (Carfora et al., 2017). In the context of already limited physical time and decision-making capabilities, it is not surprising that omnivore participants perceived MD and meat-free meals as inconvenient (Malek et al., 2019). The increased availability of pre-prepared or ready meals (e.g., frozen, chilled, shelf-stable) in supermarkets (Wooldridge et al., 2021) indicates that many people seek convenient food, and this was prominent among our participants. Educating people on how to use convenient MD foods (e.g., tinned lentils) combined with quick MD recipes may help overcome these time barriers. Small shifts may also help reduce the physical and mental demands of changing dinner meals (Lacroix and Gifford, 2020), with some of our participants overcoming these time barriers by adding meat replacements (e.g., tofu, PBMA) to familiar meals.

Household members also impacted participants' social opportunity to adopt the MD, with a lack of support from family members a key barrier (Kretowicz et al., 2018). Past

research in Australia found that 68% of families were too busy to find meals that the whole household would enjoy, with over half of parents indicating that their dependent children were the most difficult to cook for (McCrindle, 2017). While not specific to the MD, these findings are consistent with our study where children were mentioned as a key barrier, often responding negatively to MD foods (e.g., legumes). As a result, these foods did not become habitual as they were not offered again (Moore and Boldero, 2017). Despite the influence of household structure on eating, this area has received limited attention in relation to meat reduction (Kretowicz et al., 2018; Stoll-Kleemann and Schmidt, 2017). Given our findings, household influences need to be considered, with *environmental restructuring* and *enablement* being common intervention strategies used to target social opportunity (Michie et al., 2011).

The final theme related to psychological capability as participants' nutrient knowledge could be a driver or a barrier. Several omnivore participants considered meat an essential component of a healthy diet, with some having less knowledge of the nutritional benefits of legumes and whole grain foods. In fact, participants were divided on the health benefits of carbohydrates, with several participants adopting a 'low-carb' diet. Participants already eating a plant-rich diet generally had greater knowledge of the associated health benefits of consuming legumes and whole grain foods and the health risks of meat overconsumption (Lea et al., 2006). These findings correspond to nutrition literacy research, with higher literacy levels found to predict healthy eating patterns, including greater adherence to MD foods (Taylor et al., 2019). Education is therefore a possible intervention, though this needs to be considered in the context of the habitual and routine nature of eating rather than a stand-alone strategy (Van't Riet et al., 2011). Furthermore, several omnivore participants who had high nutrient knowledge mentioned that other household members were the greatest barrier, emphasising the importance of developing tailored interventions.

Nevertheless, health can be a strong driver for dietary change including meat reduction (Penny et al., 2015), so promoting the nutritional benefits of MD foods (and the health risks associated with red meat) can support adoption through increased knowledge. However, such approaches need to consider broader family influences and may incorporate education of the entire family unit. Additionally, MD adoption would extend to greater health benefits (i.e., reduced stroke and cardiovascular disease) (Micha et al., 2010) and consequently, reduced healthcare costs (Australian Institute of Health and Welfare, 2024).

Implications

To our knowledge, this is the first study to qualitatively assess the adoption of the MD using in-depth interviews in a community sample. This contrasts with past research that has mostly focused on at-risk participants where health conditions required diet change and thus acted as a major driver for behaviour change (Davis et al., 2014; McEvoy et al., 2018; Zacharia et al., 2020). Furthermore, our findings highlighted that household influences, an often-overlooked environmental factor, was a major barrier for many of our participants and needs to be considered when designing interventions.

An advantage of the current study is its naturalistic generalisability; that is, where the results resonate with one's personal experience (i.e., barriers and drivers to MD adoption for omnivore eaters, in an Australian community sample) (Smith, 2018). Given the limited MD research (including interventions) in the Australian (and other high-income countries) community, future research would benefit from assessing these findings with a larger sample using quantitative research measures. Due to this limited research, the current study took a broad approach to understanding barriers and drivers to MD adoption; thus, future research could assess specific MD behaviours (e.g., red meat consumption) individually, incorporating frameworks that specify behaviours (e.g., AACTT) (Presseau et al., 2019).

Nevertheless, our study provides vital data to inform the design and evaluation of a community-focused MD adoption intervention, which are limited in non-Mediterranean and high-income countries, using the intervention functions that form the second layer of the COM-B. For example, to change ingrained meat eating habits and support MD habit formation, training could be used to teach people how to make an ‘easy’ Mediterranean dinner meal that they schedule in once a week (on the same day) for multiple weeks. This intervention could be trialled with specific groups, such as households with children and/or couples with no children, and modified for the general population. To then support widespread MD adoption in Australia, the third layer of the COM-B (policy categories) can inform marketing campaigns and policy-level initiatives.

Limitations

A range of recruitment methods were employed in this study; however, people more interested in the MD and plant-rich diets may have been more motivated to participate. Offering incentives in the form of money and course credits (for university students) contributed to the inclusion of a range of eating patterns. University students were also from a regional university that is known for having varied adult age groups, further adding to the inclusion of varied diet experiences and attitudes toward plant-rich diets. Another possible limitation is that a small number of participants were mostly confined to their homes for the interview due to COVID-19-related restrictions. This may have impacted their current eating habits (i.e., fewer dinner meals at restaurants and external social engagements), and in these instances participants discussed their past eating behaviours. A benefit was the collection of additional information about how dinner was impacted by people working from home, being a more common behaviour post-COVID (Parker et al., 2022).

Conclusions

People in high-income countries need to reduce their meat consumption to support a healthy life and a healthy planet. The MD is a realistic plant-rich diet that can be promoted to high meat eaters to achieve these goals. Our analysis provides key information on the barriers and drivers to consuming the MD in a context where meat consumption is high. In order of priority, key barriers related to: 1) ingrained meat habits, 2) lack of time to change dietary patterns, 3) meat being perceived as tasty, 4) influences of household members, and 5) lack of nutrient knowledge of MD foods, though a tailored approach is recommended given that multiple barriers are often present. Our current food system is unsustainable and practical solutions are needed urgently. The current study provides vital information about how to implement these solutions.

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Appendix C

Participant Demographics and Diet Group

Pseudonym	Gender	Age	Heritage	Household Type	Income ‘000	Education Attainment	Current Diet	Likelihood of MD adoption (0-10)
<i>Engaged</i>								
Justin	Male	24	Australian	Couple	170	Tertiary	VEG	1
Greta	Female	29	European	Single parent with children	20-29	Tertiary	FLEX/SV	8
Leah	Female	33	Australian	Couple with children	130-139	Tertiary	MD	3
William	Male	55	Australian	Couple	70-79	TAFE	FLEX/SV	6
Shahen	Female	64	Assyrian	Extended Family	60-69	Tertiary	MD	8
<i>Likely to Adopt</i>								
Rebecca	Female	35	Australian	Couple with children	170-179	Tertiary	OMN	7
Kelly	Female	37	Australian	Couple	180+	Tertiary	OMN	10
Jessica	Female	43	Australian	Couple with children	180+	Tertiary	OMN	9
Brian	Male	47	Australian	Couple	180+	< High school	OMN	8
Laura	Female	50	Australian	Couple with children	180+	High school	OMN	8
Mark	Male	65	Australian	Couple	110-120	Tertiary	OMN	9
<i>Unlikely to Adopt</i>								
Raymond	Male	28	Australian	Couple	80-89	High school	OMN	0
Alison	Female	34	Australian	Extended Family	100-109	TAFE	OMN	1
Katherine	Female	31	Australian	Couple with children	140-149	Tertiary	OMN	2
Ryan	Male	35	Australian	Couple	150-159	High school	OMN	4
Martin	Male	44	Australian	Couple	120-129	TAFE	OMN	5

OMN = Omnivore; MD = Mediterranean diet; FLEX/SV = flexitarian/semi-vegetarian; VEG = vegetarian.

Higher scores on the likelihood of adoption scale indicate greater likelihood of adoption.

To assess their current diet, participants viewed six diets—omnivore, MD, flexitarian/semi-vegetarian, pescatarian, vegetarian, and vegan—and selected the diet that most closely described what they had eaten over the last week. To assess their likelihood of adopting the MD, participants indicated this on an 11-point scale, where 0 = not at all likely, and 10 = extremely likely. Based on these responses, participants were placed into one of three groups: *Engaged* (i.e., currently consuming a MD or other plant-rich diet), *Likely to Adopt* (i.e., currently consuming an omnivore diet and a likelihood of MD adoption score of six or more), and *Unlikely to Adopt* (i.e., currently consuming an omnivore diet and a likelihood of MD adoption score of five or less).

Appendix D

Zoom Semi-structured Interview – Interested Participants

PART 1: EXPLORING DINNER HABITS (30 Minutes)	
Aim	Explore and understand dinner habits using the Behaviour Change Wheel (COM-B)
Stimulus	None
DINNER HABITS	COM-B & Observation Notes
Tell me what meals you usually have for dinner in a general week Code frame below (do not prompt). Prompt by saying ‘what else, what else etc.) Steak and salad or vegetables Fish and salad or vegetables Chicken and salad or vegetables Pork chop and salad or vegetables Lamb chop and salad or vegetables Sausages and salad or vegetables Bolognaise (Pasta) Lasagne Pizza Stir fry (meat) Noodles (meat) Curry (meat) Any vegetarian meal (e.g., no meat) Other _____ Other _____ Other _____	PHYSICAL CAPABILITY: COOKING SKILLS AUTOMATIC MOTIVATION: HABITS, TASTE, EMOTIONS • Meal repertoire (<u>unprompted</u>) • Record <u>meat</u> language • Consider where meat sits within decision making hierarchy? (e.g., steak and vegetables = meat is the main ingredient and dinner decisions are made around steak).

• Does everyone eat the same meal? If no, what are the differences? (HOUSEHOLD CONTEXT) • Does everyone eat at the same time? If no, what are the differences? (HOUSEHOLD CONTEXT) • How do you decide what to have for dinner? <u>Prompt on (as needed):</u> ✓ When do you decide what you will eat for dinner? ✓ Who decides what to cook / eat for dinner? • What do you like about making dinner? • What do you dislike about making dinner? • Who usually cooks dinner? • Do other people in the house cook (when?) • Do the children help you cook dinner (if applicable)? • Do you ever use a recipe when cooking dinner? • Do you like to try new foods/food from different countries? ✓ If yes, which types? ✓ What about the children (if applicable)? • Does anyone have any special food requirements / allergies? How does this affect the meals you choose? • What time do you usually eat dinner? • Where do you usually eat dinner (e.g., table, front of TV)	PHYSICAL CAPABILITY: COOKING SKILLS, FINANCIAL PSYCHOLOGICAL CAPABILITY: DECISION MAKING – What to cook REFLECTIVE MOTIVATION: PERCEIVED BEHAVIOUR CONTROL (CAPABILITIES), VALUES, INTENTIONS AUTOMATIC MOTIVATION: HABITS, TASTE, EMOTIONS PHYSICAL OPPORTUNITY: CONVENIENCE, HOUSEHOLD CONTEXT/ENVIRONMENT (e.g., cooking for others, availability of food)
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• Where do you get your food (own garden, Woolworth, Coles, IGA, Farmer Markets, Pre-made delivery e.g., weight watchers, light and easy - mixture) • Who does the grocery shopping? • How often do you shop for food? • What type of food do you spend the most money on? • Do you get take-away or eat out? If yes, how often, where, and what do you eat? • Are you happy with the food you eat for dinner – would you like to change anything about dinnertime (food, waste, where, when)	
• When you think of meat – what words come to mind? Over the last week/ which of the following meats have you eaten, and how many times (if applicable)? <u>Is this a typical week?</u> • Beef • Poultry • Fish/Seafood • Pork • Lamb • Meat-free main meals (specify) Prompt on <u>why</u> (i.e., cost, habit, taste, children, convenience, skill) they eat that meat and type: • Cost	AUTOMATIC MOTIVATION: HABITS, TASTE REFLECTIVE MOTIVATION: VALUES, INTENTIONS PHYSICAL CAPABILITY: FINANCIAL, SKILL PSYCHOLOGICAL CAPABILITY: KNOWLEDGE PHYSICAL OPPORTUNITY: CONVENIENCE, FOOD ENVIRONMENT

• Taste • It's what other household members (e.g., children like/will eat) • It's easy/quick to cook (convenience) • I know how to cook it (skill level) • Organic, Free-Range, No Added Hormones, Antibiotic-Free, Raised/produced in Australia, Raised/produced by local livestock farmers. • Are there any meats you could do without? • What dinner meals did you eat growing up? Did you grow up eating meat – how much? (adaptation of TEMS)	
PANTRY & FRIDGE - BEHAVIOUR Can you show me what is in your fridge and freezer? Talk me through what food you have in there. <u>PROMPT IF NECESSARY</u> What meat do you have in there? What vegetables? Can you show me what's in your pantry; again talk me through what's in there. What cooking equipment do you usually use? (equipment i.e., frying pan, microwave, slow cooker, pressure cooker, oven)	PHYSICAL CAPABILITY: SKILLS, FOOD TECHNOLOGY AUTOMATIC MOTIVATION: HABITS PHYSICAL OPPORTUNITY: FOOD ENVIRONMENT • <i>Meat / Eggs / Dairy (note: organic / free range)</i> • <i>Vegetables</i> • <i>Packaged food (including plant based – veggie burgers etc)</i> • <i>Meat / Eggs / Dairy (note: organic / free range)</i> • <i>Vegetables (tinned)</i> • <i>Packaged food (e.g., pasta)</i> • <i>Record any other foods that are aligned to a Mediterranean diet (olive oil, nuts)</i> PHYSICAL CAPABILITY: SKILL PHYSICAL OPPORTUNITY: KITCHEN ENVIRONMENT

PART 2: EXPLORE DINNER DECISION MAKING PROCESS - DESCRIBE A RECENT DINNER MEAL (TONIGHT & LAST NIGHT) 30 Minutes	
Aim	Explore and understand drivers and barriers per the COM-B, in the context of a recent dinner events to facilitate memory recall
Stimulus	None
Tonight and last nights' meal	COM-B & Observation Notes
Tonight's meal <i>Decision making:</i> • What are you cooking tonight? (check if decision has been made) • What made you decide to cook this meal/these meals? • When did you decide to cook this meal/these meals? Last nights' meal • What did you cook last night PROMPT IF NECESSARY: <i>Decision making:</i> • What made you decide to cook that meal? <i>Ingredients / Equipment</i> • What is in the meal and why did you decide on those ingredients?	PHYSICAL CAPABILITY: SKILLS, FINANCIAL PHYSICAL OPPORTUNITY: CONVENIENCE, HOUSEHOLD MEMBER COMMITMENTS, FOOD ENVIRONMENT AUTOMATIC MOTIVATION: HABITS, TASTE, EMOTIONS <i>Record language used, and non-verbals.</i> * Consider 'scratch' cooking and where are they getting 'help' (i.e., pre-packaged sauces, frozen / tinned food)

Are <u>meat, vegetables, and processed foods</u> in the meal? <i>Prompt on:</i> • Reasons for choosing those ingredients • Taste (how do the ingredients affect the taste?) • Health (how do the ingredients impact health) • Ease of using ingredient • Affordability • Availability of ingredients in freezer, pantry fridge, supermarket <i>Preparation/ Cooking process</i> • How long did it take to cook • Was it easy/hard to cook • What cooking equipment did you use? • Did anyone help you with cooking? • Portion sizes they are using (e.g., meat, vegetables) ✓ Why that size? ✓ Is that optimal for you and your family? ✓ What is stopping you from using more or less? <i>Eating</i> • Where did you eat dinner? • Did everyone eat the same? • Did everyone eat at the same time? • Taste / sensory experience • What do people eat first/last (including children) <i>Food waste</i> • Did everyone eat everything on their plate? • What was left (if any)? What did you do with the leftovers?	
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PART 3: UNDERSTAND DRIVERS AND BARRIERS FOR PEOPLE <u>INTERESTED</u> IN MEAT REDUCTION BEHAVIOUR (MEDITERRANEAN / VEGETARIAN DIETS) (15 MINUTES)		
Aim	To understand the drivers and barriers to engaging in meat reduction behaviours for people who are interested	
Stimulus	None	
QUESTIONS		COM-B Section & Observation notes
You said when I first contacted you that you were open to the idea of (or likely to reduce) reducing some of your meat consumption in the future. Is that correct?		PSYCHOLOGICAL CAPABILITY: KNOWLEDGE REFLECTIVE MOTIVATION: VALUES, INTENTIONS, SELF-IDENTITY AUTOMATIC MOTIVATION: HABITS, TASTE, EMOTIONS PHYSICAL CAPABILITY: SKILLS, FINANCIAL PHYSICAL OPPORTUNITY: HOUSEHOLD MEMBER COMMITMENTS SOCIAL OPPORUNITY: SOCIAL NORMS/SUPPORT <i>*Record their reasons unprompted, record order reasons recalled.</i>
Tell me the reasons why you want to do this? PROMPT on the following if necessary: • <u>Health</u> reasons ✓ What specifically? ✓ For them, for others? • <u>Environmental</u> reasons ✓ What specifically? ✓ Where did you see or hear that? ✓ What specific messages made you change? ✓ For them, for others? • <u>Animal</u> welfare reasons? ✓ What specifically? ✓ For them, for others?		
• How you previously tried to reduce your meat, what have you specifically done? ✓ What has been easy? ✓ What has been hard? • What is stopping you from reducing your meat consumption? • Do most people you know eat meat/omnivore diet? (Prompt: family, friends, childhood) • Do you know people who eat a meat reduced diet (Vegetarian / Mediterranean diet?)		

• What do you think of people who eat a Mediterranean and/or Vegetarian diet? • Would important people in your life be supportive of you eating a Mediterranean or Vegetarian diet? (If applicable) • Household Context: Does everyone in the household want to eat a Mediterranean and/or Vegetarian diet? What does that mean for you (prompt on: if you want to eat vegetarian, both vegetarian and non-vegetarian meals must be prepared).	
Take first barrier they mention: You first mentioned _____ is stopping you from changing. How would you overcome that?	
Take second barrier they mention: You then mentioned _____ is stopping you from changing. How would you overcome that?	

PART 4: EXPLORE REACTIONS TO MEDITERRANEAN/VEGETARIAN DIET (10 - 15 MINUTES)	
Aim	To provide information about the MEDITERRANEAN / VEGETARIAN diet and assess thoughts, feelings, reactions, and intervention hypotheses to participants who are <u>interested</u>
Stimulus	Show MEDITERRANEAN and VEGETARIAN DIET DESCRIPTION/VISUAL, MEDITERRANEAN PYRAMID AND PLATE PORTIONS – See PowerPoint

I've shown you the Mediterranean and Vegetarian diet when I first asked if you wanted to participate in this research. Here it is again and how it differs to the Omnivore diet (**SHOW STIMULUS**)

RESPONSE TO THE MEDITERRANEAN/VEGETARIAN DIET	COM-B Section & Observation notes
On a scale from 0 – 10, you scored X on how appealing is the Mediterranean (Vegetarian) diet for you personally. ✓ Why do you say that? On a scale from 0 – 10, you scored X on how appealing you thought the Mediterranean (Vegetarian) diet would be for your household to follow. ✓ Why do you say that? On a scale from 0 – 10, you scored X on how likely are you to follow a Mediterranean (Vegetarian) diet in the future ✓ Why do you say that? ✓ What stops you from taking up this diet? ✓ What else? ✓ Anything else?	<i>Get scores from online survey conducted in the recruitment phase.</i>
Have you heard much about meat and health?* Yes: What have you heard and what are your thoughts? No: Provide information e.g., “The overconsumption of red and processed meat has been linked to non-communicable diseases, specifically cardiovascular diseases, some cancers, and type 2 diabetes.” <u>What do you think about that information?</u>	PSYCHOLOGICAL CAPABILITY: KNOWLEDGE REFLECTIVE MOTIVATION: VALUES, INTENTIONS, SELF-IDENTITY AUTOMATIC MOTIVATION: HABITS, TASTE, EMOTIONS

“A diet high in plant-based food and low in meat (particularly red and processed meat), for example, the traditional Mediterranean diets, has been associated with reduced heart failure, stroke, total mortality, cognitive decline, and some cancers” <u>What do you think about that information?</u> Have you heard much about meat and the environment/climate change?* Yes: What have you heard and what are your thoughts? No: Provide information e.g., “Livestock contributes to 14.5% of global GHGs, making livestock production the third largest emitter, following the energy and transport sectors” <u>What do you think about that information?</u> “Significant environmental benefit comes from changing consumer diets to include fewer animal-based products including the Mediterranean and vegetarian diets” <u>What do you think about that information?</u>	
I’m going to run a few ideas past you about how people could reduce their meat consumption and get closer to the Mediterranean/vegetarian diet. For each, tell me how appealing (a little, moderately, a lot) they are? ➤ Meat Free Monday ➤ No meat for lunch ➤ Half the serving of meat in every meal ➤ Fill up with carbs ➤ A tin of beans instead of mince ➤ Better (organic) but less meat	PSYCHOLOGICAL CAPABILITY: KNOWLEDGE REFLECTIVE MOTIVATION: VALUES, INTENTIONS, SELF-IDENTITY AUTOMATIC MOTIVATION: HABITS, TASTE, EMOTIONS PHYSICAL CAPABILITY: SKILLS, FINANCIAL

PART 5: CO-CREATION OF A MEDITERRANEAN/VEGETARIAN DIET (10 MINUTES) – PARTICIPATORY COLLABORATION

Aim	Assess the meals of participants who are <u>interested</u> and compare with the MEDITERRANEAN and VEGETARIAN diets
Stimulus	Show MEDITERRANEAN/VEGETARIAN Definitions, MEDITERRANEAN PYRAMID AND PLATE PORTIONS – See PowerPoint

ASSESSMENT OF THEIR DIET TO MED/VEGETARIAN DIET	COM-B Section & Observation notes
GO BACK TO THE MEALS THEY HAVE MADE OVER THE PAST FEW DAYS ASSESS THEIR DIET VS THE MEDITERRANEAN and VEGETARIAN DIETS Think of the meals you have eaten the last few days – breakfast, lunch and dinner. GET THEM TO WRITE DOWN THE MEALS – AS MANY AS THEY CAN REMEMBER Overall diet You have your list of meals that you have eaten over the past few days there. How do the meals you have eaten match with the Mediterranean / vegetarian diets? ✓ What's different? ✓ What's the same? ✓ If you had to shift, what would you change?	PSYCHOLOGICAL CAPABILITY: PROCEDURAL KNOWLEDGE REFLECTIVE MOTIVATION: VALUES, INTENTIONS, SELF-IDENTITY AUTOMATIC MOTIVATION: HABITS, TASTE, EMOTIONS PHYSICAL CAPABILITY: SKILLS, FINANCIAL PHYSICAL OPPORTUNITY: CONVENIENCE, HOUSEHOLD MEMBER COMMITMENTS, FOOD ENVIRONMENT

<i>Prompts (as required)</i> Portion size: ✓ How does the portion size of your meat differ to these guidelines? ✓ How would you change that to be in line with the guidelines? ✓ What difficulties would you have? Red Meat: ✓ Have you eaten more or less red meat than the guidelines suggest? ✓ How would you change that? ✓ What difficulties would you have? Vegetables: ✓ Have you eaten fewer servings of vegetables than the guidelines suggest? ✓ How would you change that? ✓ What difficulties would you have doing that? Dairy: ✓ Have you eaten more or less dairy than the guidelines suggest? ✓ How would you change that? ✓ What difficulties would you have doing that?	
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PART 6: MENU (10 MINUTES)	
Aim	Show a menu of potential MEDITERRANEAN and VEGETARIAN meals to assess reactions (ALL Participants)
Stimulus	PowerPoint Slide with pictures of MEDITERRANEAN and VEGETARIAN MEALS

RESPONSE TO THE MEDITERRANEAN/VEGETARIAN DIET	COM-B Section & Observation notes
Go through each meal (what is in it) and record reactions: <u>PROMPT on if necessary:</u> • Visual senses, taste, satiety, emotions • Skill level required • Ingredients / availability • Affordability • What's good / not good • Household context – would others eat it? • Social norms See additional questions/prompts below (as required) ASK ABOUT OTHER MEAL IDEAS – consider cultural context – as collaborative approach	PSYCHOLOGICAL CAPABILITY: PROCEDURAL KNOWLEDGE REFLECTIVE MOTIVATION: VALUES, INTENTIONS, SELF-IDENTITY AUTOMATIC MOTIVATION: HABITS, TASTE, EMOTIONS PHYSICAL CAPABILITY: SKILLS, FINANCIAL PHYSICAL OPPORTUNITY: CONVENIENCE, HOUSEHOLD MEMBER COMMITMENTS, FOOD ENVIRONMENT

PART 7: TRIAL MAKING A MEDITERRANEAN or VEGETARIAN MEAL (10 MINUTES)	
Aim	Get participants to cook one of the meals (if they are willing) and take a photo (All participants)
Stimulus	PowerPoint Slide with pictures of MEDITERRANEAN and VEGETARIAN MEALS

RESPONSE TO MAKING A MEDITERRANEAN/ VEGETARIAN MEAL	COM-B Section & Observation notes
<i>Follow up phone call in 1 week</i> <i>How did you go with cooking a Mediterranean or vegetarian meal? If no, thank them for their time, if yes, continue below:</i> Which meal did you choose? How did it go? <u>PROMPT on if necessary:</u> • Affordability • Ingredients / availability • What was easy? • What was hard? • Did everyone eat it? Waste? • How did it taste/smell? • Did you feel full? • How did you feel? • Did you take a photo – can you send it to me?	PSYCHOLOGICAL CAPABILITY: PROCEDURAL KNOWLEDGE REFLECTIVE MOTIVATION: VALUES, INTENTIONS, SELF-IDENTITY AUTOMATIC MOTIVATION: HABITS, TASTE, EMOTIONS PHYSICAL CAPABILITY: SKILLS, FINANCIAL PHYSICAL OPPORTUNITY: CONVENIENCE, HOUSEHOLD MEMBER COMMITMENTS, FOOD ENVIRONMENT

Appendix E

Interview PowerPoint

Omnivore diet consumes:

Meat (beef, pork, lamb, poultry, fish, seafood) and other animal-based foods (dairy, eggs) one or more times per day

Plant-based foods (fruits, vegetables, cereals, legumes, and nuts)

Mediterranean diet consumes:

No processed meat

Small amounts of red meat (beef, lamb, pork; **one serving per week**)

Moderate amounts of fish, seafood, poultry, eggs and dairy (**2-3 servings per week**)

Plant-based foods (fruits, vegetables, whole grains, legumes, nuts, and olive oil)

	Fruits & Vegetables	Legumes / Nuts	Dairy	Eggs	Fish/ Seafood	Poultry	Red Meat (beef, lamb, pork)
Omnivore	✓	✓	✓	✓	✓	✓	✓
Mediterranean	✓	✓	MODERATE*	MODERATE*	MODERATE*	MODERATE*	LOW*

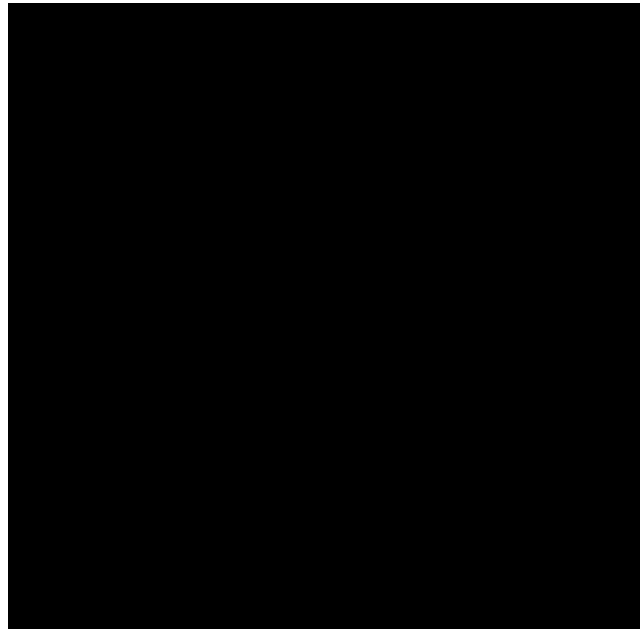
*Low = one serving per week

+ Moderate = 2 to 3 servings per week

MEDICAL NEWS TODAY

Mediterranean Diet





Mediterranean diet consumes:

No processed meat

Small amounts of red meat (beef, lamb, pork; **one serving per week**)

Moderate amounts of fish, seafood, poultry, eggs and dairy (**2-3 servings per week**)

Plant-based foods (fruits, vegetables, whole grains, legumes, nuts, and olive oil)

Vegetarian diet consumes:

No meat (beef, lamb, pork, poultry, fish, seafood),

Animal-based foods (dairy, eggs)

Plant-based foods (fruits, vegetables, cereals, legumes, and nuts)

	Fruits & Vegetables	Legumes / Nuts	Dairy	Eggs	Fish/ Seafood	Poultry	Red Meat (beef, lamb, pork)
Mediterranean	✓	✓	MODERATE ⁺	MODERATE ⁺	MODERATE ⁺	MODERATE ⁺	LOW [*]
Vegetarian	✓	✓	✓	✓	✗	✗	✗

*Low = one serving per week

+ Moderate = 2 to 3 servings per week

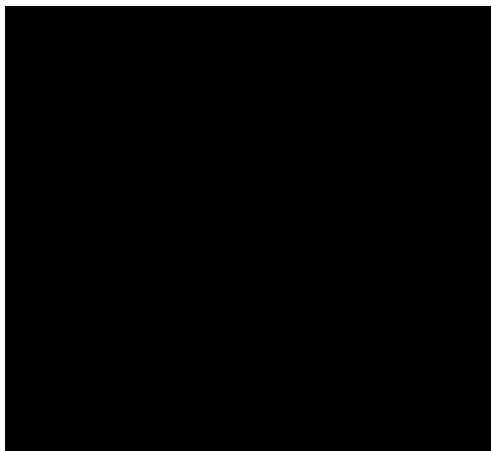
Gourmet Tomato and Mozzarella Pizza



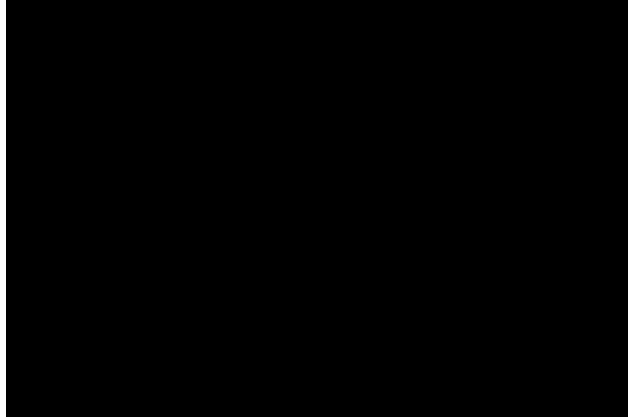
Tuna and White Bean Salad



Pesto Pasta Salad



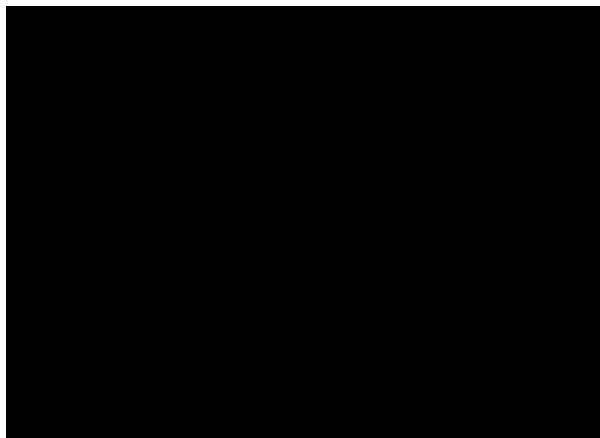
Creamy Chickpea & Vegetable Curry



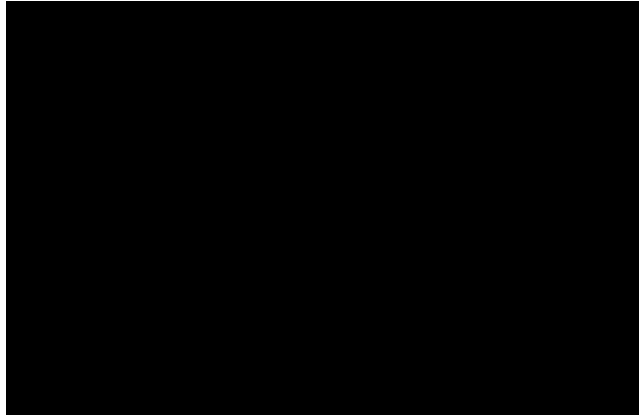
Easy Vegetable Bolognese



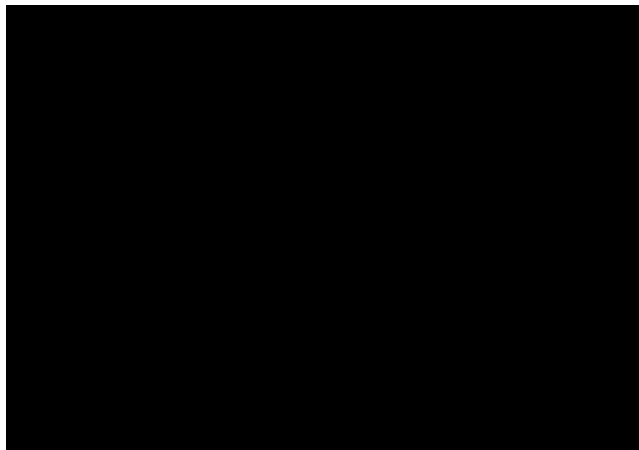
Veggie Patty Burgers



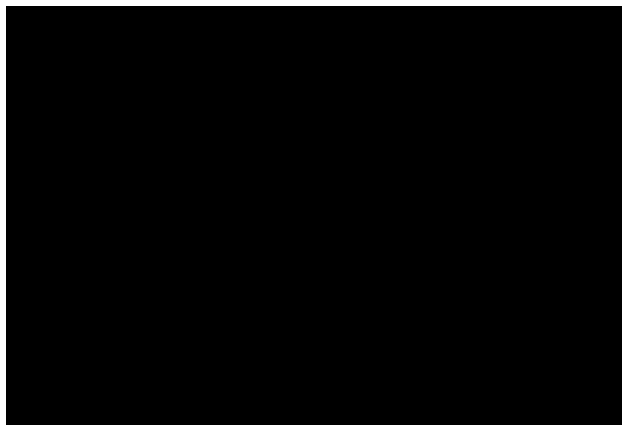
Honey, Soy and Garlic Veggie Stir Fry



Tuscan Style White Bean Stew



Classic Macaroni & Cheese



Higher Degree Research Thesis by Publication
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Statement of Originality

(To appear at the end of each thesis chapter submitted as an article/paper)

We, the Research Master/PhD candidate and the candidate's Principal Supervisor, certify that the following text, figures and diagrams are the candidate's original work.

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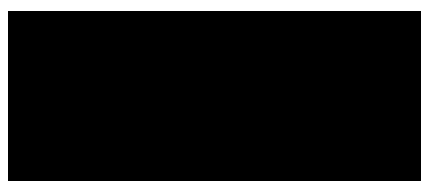
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Candidate

3 December, 2024

Date



Principal Supervisor

3 December, 2024

Date

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Statement of Authors' Contribution

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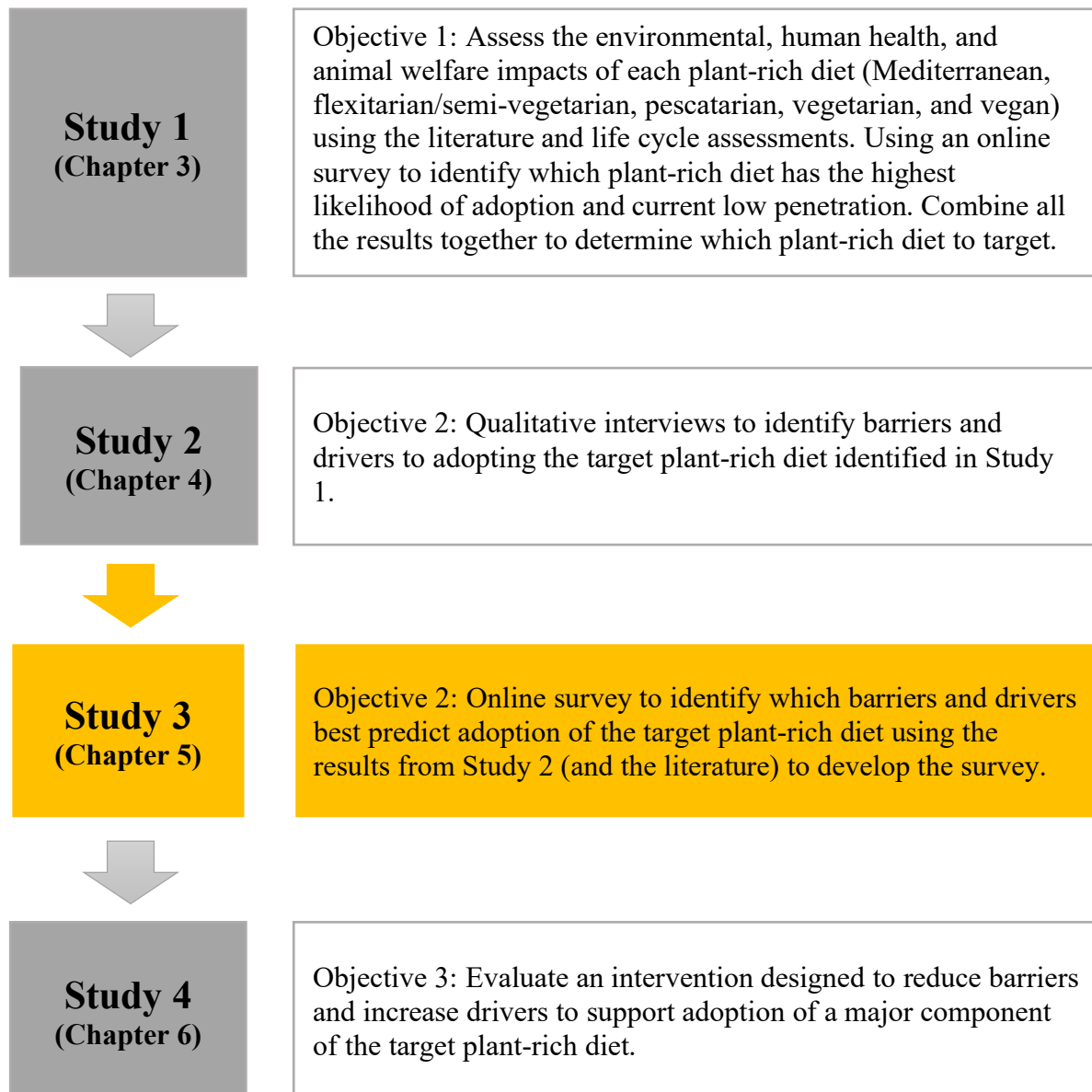


Principal Supervisor

3 December, 2024

Date

Research Progression to Study 3



In line with Step 2 of the CBSM (McKenzie-Mohr, 2011), Study 2 explored the barriers and drivers to Mediterranean diet adoption in an Australian sample using semi-structured interviews. This is the first study to conduct this assessment using both inductive (reflexive thematic analysis) (Braun & Clarke, 2019; Braun et al., 2022) and deductive (COM-B) (Michie et al., 2011) analyses. Employing this approach enabled an in-depth analysis of both individual and environmental influences and how they impacted behaviour as both separate and interrelated factors. Another key and unique feature of this study was the

inclusion of visual observations (i.e., pantry and fridge), allowing behavioural data to be collected, providing a more accurate picture of people's current eating behaviours (i.e., habits). This process contrasts with the more common reliance on only attitudinal surveys and interview data, which can be more prone to social desirability bias (Althubaiti, 2016).

Findings highlight several key themes according to the COM-B—ingrained eating habits (automatic motivation), perceived lack of time (physical opportunity and psychological capability), household influences (social opportunity), external social influences (social opportunity), taste and satiety (automatic motivation), and health (perceptions of nutrition and food intolerances; psychological capability). It is not surprising that habits featured as a main barrier, given this is reported in both health and sustainable eating literature (Malek et al., 2019; McEvoy et al., 2018). Our findings, however, highlight how significant a barrier this is and that habitual behaviours are wide-ranging, extending to the decision making and grocery shopping stages (Rees et al., 2018; Stoll-Kleemann et al., 2017).

The other main barrier identified, perceived lack of time, is also consistent with past Mediterranean diet and meat-reduction research, though this factor has received less research attention (Malek et al., 2019; McEvoy et al., 2018). The benefits of using the comprehensive COM-B model was evident with this barrier manifesting across *two* domains, one related to individual factors (i.e., lack of mental availability), and the other to external factors (i.e., lack of physical time). This provides a greater understanding on how lack of time influences Mediterranean diet adoption and importantly, what needs to be considered to reduce it. The influence of other household members was consistent with past research with at-risk patients (McEvoy et al., 2018) and using open-ended survey questions (Scannell et al., 2020), though our study enabled a more in-depth assessment of how these influences (specifically children) can impact adoption in the community. For some families,

household influences were *the* main barrier, highlighting how vital household structure is for intervention design.

Finally, taste was another key factor, with people perceiving meat as tasty and vegetables/legumes as less appealing. This was most prominent when participants were shown several Mediterranean and meat-free meals, whereby the meals with legumes generally generated less favourable responses.

Interviewing people who have reduced their high meat-eating habits also provided vital (and practical) information on how some Australians had overcome these key barriers, providing context specific results. This, in turn, provided detailed information on possible strategies to target these barriers in an intervention design. Using these in-depth results and findings from the meat reduction and Mediterranean diet literature (Lacroix et al., 2019; Malek et al., 2019; Stoll-Kleemann & Schmidt, 2017; Zacharia et al., 2020), Study 3 aimed to develop a COMB survey to assess which barriers most likely *predict* Mediterranean diet adoption. Studies assessing the predictive nature of these barriers are limited (Zacharia et al., 2020), so conducting this analysis enabled the design of more tailored and, therefore more robust, interventions. This is a key element of the next CBSM stages, developing interventional strategies (Step 3) and conducting a pilot study (Step 4).

Chapter 5

Study 3

A quantitative assessment of barriers to adopting the sustainable Mediterranean diet

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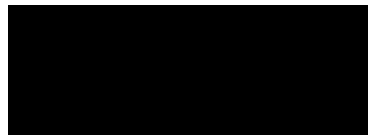
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Abstract

High-meat consumption negatively impacts our planet and our health, especially in high-income countries where this eating pattern is the norm. The plant-rich Mediterranean diet reduces these negative environmental and human health effects and omnivore eaters are more likely to adopt it than a meat-exclusionary diet. Knowing the barriers to Mediterranean diet adoption is critical to designing effective interventions to promote behaviour change.

Therefore, using the comprehensive capability-opportunity-motivation (COM-B) behaviour change model, this study identified which COM-B components predicted the likelihood of Mediterranean diet adoption in an Australian sample ($N = 443$). In terms of existing diet, omnivores in the sample, on average, consumed meat more often than their meat-reducing counterparts, and they also consumed legumes less often and were less familiar with the Mediterranean diet. In terms of barriers to adopting the Mediterranean diet in the future, exploratory factor analysis revealed four main factors covering all three components of the COM-B model: *Meat Dependence*, *Lack of Time and Knowledge*, *Household Dietary Preferences*, and *Food Allergies and Clean Eating*. Hierarchical regression analysis revealed that *Mediterranean Diet Familiarity*, the four factors from the factor analysis, and an additional standalone question, *Not Having to Cook for Others*, together explained 44% of the variability in adopting the Mediterranean diet. *Mediterranean Diet Familiarity* accounted for 21.2% of the unique variance in step one. These findings signify key components (e.g., diet familiarity and convenience) to consider when designing interventions focused on shifting people to a Mediterranean diet in a high-income, high-meat consuming country such as Australia.

Keywords: Mediterranean diet, meat consumption, behavior change, behavior change wheel

Introduction

Livestock production is a major contributor to global greenhouse gas emissions (GHGs), with estimates ranging from 16% to as high as 37% of total emissions (Twine, 2021). Eating a plant-rich diet is now considered a vital strategy to reduce these GHGs and the associated environmental destruction caused by animal agriculture (Intergovernmental Panel on Climate Change [IPCC], 2022). Despite the urgent need to increase plant-rich diet consumption, meat demand continues to rise in response to increased urbanisation and personal incomes, specifically in developing countries, and also due to increasing global population (Alexandratos & Bruinsma, 2012; Food and Agriculture Organization [FAO] of the United Nations, 2017; OECD & FAO, 2019). The high-meat 'Western' diet is becoming the global diet and some high-income countries, such as Australia, continue to consume more meat (~100kg per capita per year) (Whitton et al., 2021) than is recommended by experts (Hendri et al., 2022). These dietary trends are alarming given emissions from animal agriculture are already dangerously high.

High levels of meat consumption have broader impacts beyond higher emissions, degradation of lands and water, and reduced biodiversity. Meat-heavy diets impact human health and are linked to increased risk of cardiovascular diseases, some cancers, and type 2 diabetes (Demeyer et al., 2016; Li et al., 2018; Micha et al., 2010; Pan et al., 2011). Greater demand for meat also leads to more intensive farming practices that increase the scale of animal suffering (Bessei, 2006; Dawkins et al., 2004; Gregory & Grandin, 2007; Harrison, 1964; Park et al., 2020; Peden et al., 2018; Thompson, 2015). Eating a plant-rich diet can alleviate these negative impacts, particularly in high-income countries where high-meat diets are well-established and normalised (Aleksandrowicz et al., 2016; Batlle-Bayer et al., 2020; Springmann et al., 2018).

Encouraging omnivore eaters to eat a plant-rich diet is difficult (Stoll-Kleemann & Schmidt, 2017), especially in high-income countries where meat is usually central to a meal (Beardsworth & Bryman, 2004). Hence, meat-reduced plant-rich diets (e.g., Mediterranean and flexitarian/semi-vegetarian) are more appealing to high-meat eaters than meat exclusionary diets (e.g., vegetarian and vegan) (Allenden et al., 2022). Even though vegetarian and vegan diets are generally better for the environment, human health, and animal welfare (Aleksandrowicz et al., 2016; Batlle-Bayer et al., 2020; Scherer et al., 2019), people are reluctant to adopt them at the level required to significantly impact the many negative effects of animal agriculture (Allenden et al., 2022). Therefore, meat-reduced diets could offer a more realistic and potentially faster way to reduce meat demand in high-meat-eating countries.

The Mediterranean diet is a meat-reduced diet that has high potential for adoption. It generally consists of high amounts of plants (vegetables and legumes), moderate levels of meat (chicken, fish, and other seafoods) and dairy, and low quantities of red meat (Bach-Faig et al., 2011). There are many potential benefits of broader population adoption of the Mediterranean diet, both to the individual and beyond. The Mediterranean diet has consistently been linked to fewer health risks (i.e., heart disease, type 2 diabetes, some cancers, and dementia) (Demeyer et al., 2016; Li et al., 2018; Micha et al., 2010; Pan et al., 2011; Shannon et al., 2023) and is significantly better for animal welfare and the environment than the omnivore diet (Aleksandrowicz et al., 2016; Allenden et al., 2022; Batlle-Bayer et al., 2020). In terms of environmental benefits, a recent study found that by substituting red meat (higher carbon food) with white meat (lower carbon food), per the Mediterranean diet, the United States could reduce their total dietary carbon footprint by more than 35% (Grummon et al., 2023). As such, promoting the Mediterranean diet in a high-income country such as Australia could reap substantial environmental benefits. Moreover, such a campaign

could be favourably received because, out of five plant-rich diet options, an Australian population sample selected the Mediterranean diet as the most likely diet that they would adopt (Allenden et al., 2022). Given adoption of the Mediterranean diet remains low, identifying key barriers is crucial to the development of successful interventions.

To date, observational and qualitative studies have assessed the barriers of adopting the Mediterranean diet in several non-Mediterranean countries (Tsofliou et al., 2022). Common barriers were perceived lack of knowledge about the Mediterranean diet (including specific foods), affordability, lack of time to change diets, limited knowledge of Mediterranean diet recipes and how to use legumes in meals, a dislike of Mediterranean diet foods (e.g., fish, nuts, legumes), difficulties changing current eating habits to align with the Mediterranean diet (e.g., reducing red meat), and lack of family support (Tsofliou et al., 2022). Living in a non-Mediterranean country was also a barrier due to cold climate impacts, the seasonal availability of Mediterranean diet foods, and distinct cultural food norms (Moore et al., 2018; Scannell et al., 2020). While this research is informative, more quantitative research is needed to better understand whether or not these barriers significantly predict Mediterranean diet adoption. It will also provide a better understanding of the relative magnitudes of the potential impacts these barriers may pose for broad scale adoption of the diet. Knowing this will enable the design of more tailored interventions.

Changing dietary behaviours, however, is difficult due to their habitual nature (Rees et al., 2018; Stoll-Kleemann et al., 2017). Behaviour change models comprehensively assess behaviours and are considered best practice when designing behaviour change interventions (Michie et al., 2011), but few studies promoting change to the Mediterranean diet have used them (Tsofliou et al., 2022). Michie et al.'s (2011) behaviour change wheel (BCW; Figure 5.1) is a framework that incorporates both internal and external factors by assessing a

person's capability, opportunity, and motivation (COM-B) to perform a target behaviour.

These three interacting components form the inner layer of the BCW:

- Capability is an individuals' psychological and/or physical capability to engage in the behaviour. Psychological capability includes the knowledge and mental processes to perform the behaviour, whereas physical capability refers to the physical skills or stamina to do so (Michie et al., 2011). With the Mediterranean diet, capability may include diet awareness and knowledge (e.g., meat portion sizes, Mediterranean diet foods and recipes), and the mental capacity and perceived affordability to change diets (Tsofliou et al., 2022).
- Opportunity refers to external physical and/or social factors that make a behaviour possible or prompt it to occur (Michie et al., 2011). For example, a person's opportunity to adopt the Mediterranean diet can be influenced by less time available to prepare meals, other household members' dietary preferences, and cultural food norms (Tsofliou et al., 2022).
- Motivation is defined as brain processes that direct behaviour. It can be reflective (e.g., intentions, beliefs, and perceived behavioural control) or automatic (e.g., habitual processes, emotions, and impulses) (Michie, et al., 2011). A person's motivation to eat the Mediterranean diet may be impacted by their pro-environmental worldviews, health concerns, general attitudes towards eating meat, current dietary habits, and taste preferences (Tsofliou et al., 2022).

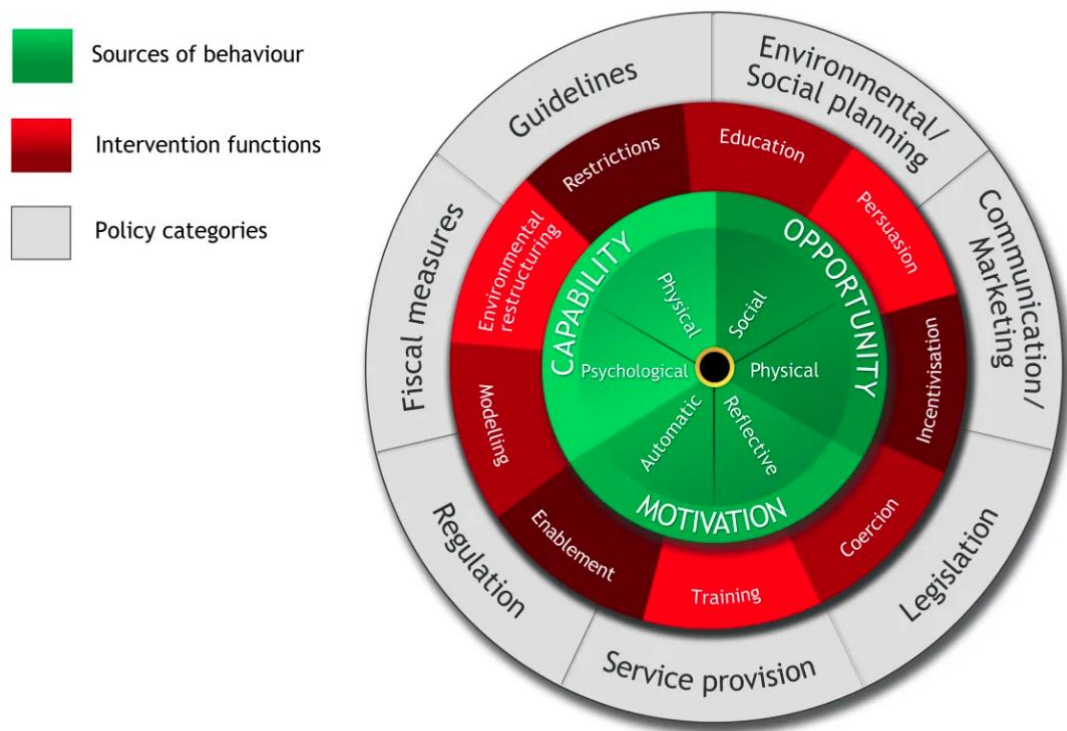


Figure 5.1

The Behaviour Change Wheel

Reprinted from “The behaviour change wheel: A new method for characterising and designing behaviour change interventions,” by S. Michie, M. M. van Stralen and R. West, 2011, *Implementation Science*, 6(42), p. 7. Copyright [2011] by Michie et al., licensee BioMed Central Ltd. Used under Creative Commons Attribution License: <http://creativecommons.org/licenses/by/2.0>. (In colour)

The BCW framework was initially developed in the health psychology field (Michie et al., 2011), and later extended to the pro-environmental sector (Allison et al., 2021; Sundaraja et al., 2021), including meat-reduction (van den Berg et al., 2022). The COM-B was also used to qualitatively assess and design a peer-support intervention to increase Mediterranean diet adoption for patients at high cardiovascular risk (McEvoy et al., 2018). Adding to this research, the authors used this model to qualitatively assess barriers and drivers to Mediterranean diet adoption in an Australian community sample ($N = 16$) (Allenden et al., 2025). Themes identified in this research were organised according to the

COM-B model (see Figure 5.2). Specifically, changing ingrained meat-eating habits, a lack of physical and mental availability to change diets, and household influences (i.e., cooking for others, including children, who do not want to change their high-meat consumption) were key barriers to adoption.

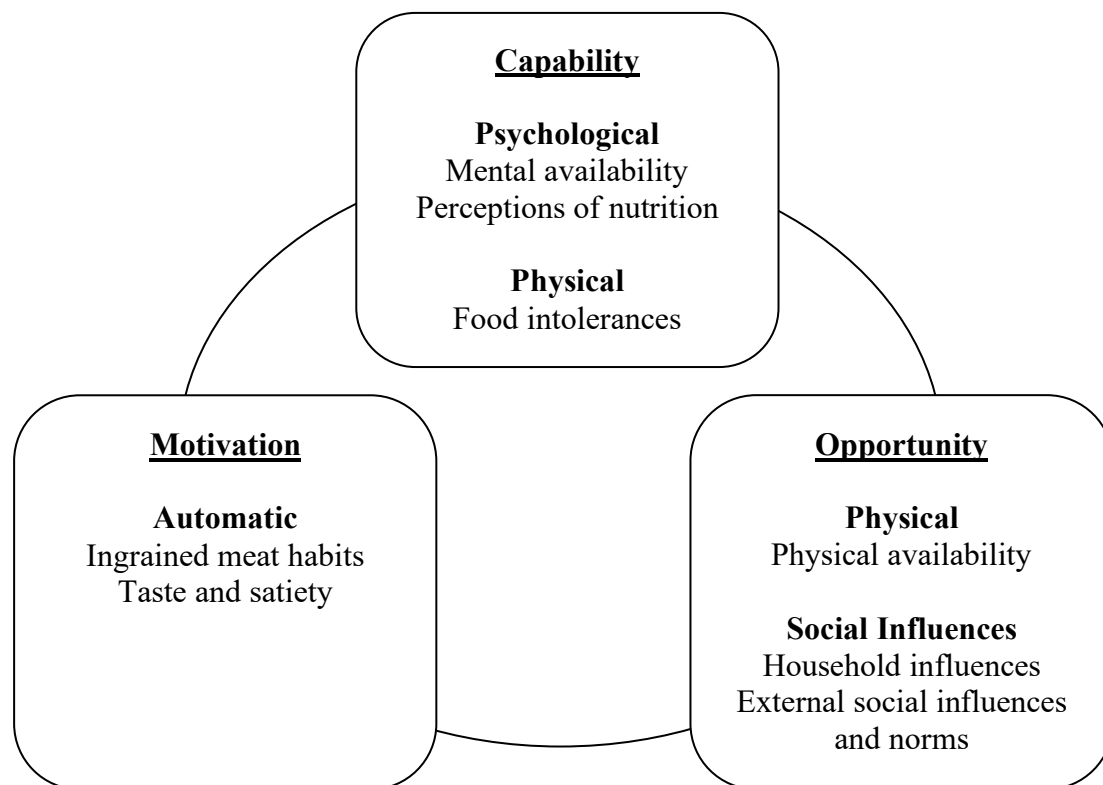


Figure 5.2

A Summary of Results for Themes Organised According to the COM-B Model.

The current study aims to extend this research with a quantitative assessment of the barriers to Mediterranean diet adoption in Australian meat eaters using the COM-B model. The authors developed a Mediterranean diet COM-B survey to assess barriers based on a person's capability, opportunity, and motivation to adopt the Mediterranean diet. The survey was developed using the above research (Allenden et al., 2025; Papadaki et al., 2016; Scannell et al., 2020; Tsofliou et al., 2022). In light of past research examining barriers to dietary change, we expect that: 1) participants who self-identify as omnivores report eating meat (particularly red meat) more frequently and meat-replacement foods (particularly

legumes) less frequently than those who identify as eating a meat-reduced Mediterranean or flexitarian/semi-vegetarian diet; 2) participants who self-identify as omnivore eaters are less familiar with the Mediterranean diet than people who identify as eating a meat-reduced diet; 3) a range of factors based on participants' capability, opportunity, and motivation to adopt a Mediterranean diet are household influences, lack of physical and mental availability to change diets, lack of knowledge, and taste preferences for meat; and 4) participants' scores on the identified factors predict their reported likelihood that they would adopt the Mediterranean diet. Taken together, these findings will help develop Mediterranean diet adoption interventions in a high meat-eating, high-income country such as Australia through identifying the most important barriers to target.

Methods

Participants and Recruitment

Adults from the general population in Australia were recruited via QualtricsTM, an online database and survey administrator. After excluding meat avoiders ($n = 21$), 443 meat-eating respondents were included in the analysis. A study that used the COM-B model to assess the drivers to adopting a plant-rich diet found medium effect sizes (Graça et al., 2019). Based on this research, the current study predicted a medium effect size of $f^2 = .15$. Using G*Power (Faul et al., 2009) and assuming a target power of .95, 10 predictors, and an α level of .01, a minimum sample size of 190 participants was recommended.

All participants provided informed consent prior to commencing the survey. Participants who were younger than 18 years old and/or not the main or joint cook in the household were screened out of the survey. The 'main/joint cook' criterion was applied to limit the sample to people who have more control over the cooking process, given 'someone else cooking for me' has been identified as a barrier in the meat reduction literature (Lacriox & Gifford, 2019; Mullee et al., 2017). A soft launch was conducted with 47 participants and

the median completion time was calculated. Participants who completed the survey in less than half the median time (4.18 minutes) were screened out for data quality. Two questions were included in the survey as attention checks, with Qualtrics™ screening out participants who failed either question. All survey questions required a response, though participants could select ‘I prefer not to say’ for gender, income, employment, and ethnicity.

Gender was subjected to quota sampling for representation (224 men, 218 women, and 1 non-binary/third gender), and to overcome possible bias from the main/joint cook criterion above, since men contribute to a significant portion of cooking duties (though less than women) in Australia (Australian Bureau of Statistics [ABS], 2021). Participants had a mean age of 55.3 years ($SD = 16.5$, range = 18 to 86 years), which is slightly higher than the national representative census data (ABS, 2021). Most participants had 12 years or more of formal education and were employed (33.0% full time, 14.7% less than 30 hours per week, and 1.4% self-employed). Consistent with the older mean age reported above, 35.9% of participants were retired, which is higher than the national representative census data (ABS, 2020-2021). Most participants identified as Australian, with 56.9% reporting an annual household income of less than 75,000AUD (the median Australian household income for 2019 to 2020 was approximately 52,338AUD) (ABS, 2022a). Almost a quarter (23.9%) of participants lived in a single household, with couples (28.9%) the most common multi-household type. Household types were nationally representative of the Australian population (ABS, 2021). See Table 5.1.

Table 5.1*Select Characteristics of Participants*

		%
Sex	Male	50.6
	Female	49.2
	Non-binary/third gender	0.2
Age	Mean	55.3
Education	Post high school (trade, tertiary)	70.6
Employment	Employed	49.1
Ethnicity*	Australian	72.7
	European	16.5
Income	≥ \$75,000AUD	40.4
Household type	Single	23.9
	Couple	28.9
	Couple with dependent children	16.3
	Couple with adult children	13.5

*Multiple responses provided

Measures

The online survey included items to assess a participant's sociodemographic characteristics, current meat and meat-replacement food consumption frequency, diet group, Mediterranean diet awareness, and COM-B barriers statements to assess capability, opportunity, and motivation for Mediterranean diet adoption.

Socio-demographic Characteristics

Six items assessed participants' gender, age, ethnicity, education, employment status, household type, and annual household income (see Appendix F).

Current Food Consumption

To evaluate current eating habits as potential automatic motivation barriers, a single item assessed how often participants had eaten meat (red, poultry, and fish/seafood), and common Mediterranean diet (legumes) and non-Mediterranean diet (tofu, plant-based meat alternatives [PBMA]) meat-replacement foods. Australia is a multi-ethnic (George et al., 2018) and non-Mediterranean diet country (Scannell et al., 2020). Therefore, tofu and PBMA were included to assess cultural and food environment influences (ABS, 2022b),

respectively. Participants indicated their consumption frequencies on a 5-point scale ('never,' '1 day per week,' '2 to 4 days per week,' 'most days [5 to 6 days per week],' and 'every day;' as per Malek et al., 2019). A specific timeframe (i.e., last week) was used to reduce recall bias (Althubaiti, 2016). To limit social desirability selection bias (Althubaiti, 2016), this item preceded the following diet group self-identity item.

Self-identified Diet Groups

A single item assessed which diet most closely described what participants had eaten over the last week (Malek et al., 2019; Tsofliou et al., 2022). Options included six diets: omnivore, Mediterranean, flexitarian/semi-vegetarian, pescatarian, vegetarian, or vegan. A description of each diet was also provided to aid selection (see Appendix F). As highlighted above, those who identified as pescatarian, vegetarian, or vegan diet eaters were screened out. A second item assessed whether or not participants' other household members ate the same diet to evaluate household influences as a possible social opportunity barrier. If the response was 'no,' they indicated which diet most closely described what other household members had eaten.

Mediterranean Diet Awareness

Two items assessed Mediterranean diet awareness (i.e., psychological capability), as the current study was conducted in a non-Mediterranean diet country (Tsofliou et al., 2022). Participants indicated how familiar they were with the Mediterranean diet on a 5-point scale (1 = 'not at all familiar' to 5 = 'extremely familiar'). Participants then selected which statements (i.e., all that applied) they perceived described the Mediterranean diet (e.g., 'it is healthy,' 'it is expensive,' 'it includes a lot of red meat'). Statements included five accurate and six inaccurate options to assess participant knowledge of the diet, with 'other' also provided as an option to gather additional information (see Appendix F).

Mediterranean Diet Information

To aid responses to the likelihood of adoption and COM-B measure questions, participants received information about the Mediterranean diet. This information included a figure displaying the Mediterranean diet pyramid (Medical News Today, n.d.), a plate example (Durrer Schutz et al., 2019), and written (Bach-Faig et al., 2011; Goldstein et al., 2016) and graphical comparisons between the Mediterranean and omnivore diets.

Likelihood of adopting the Mediterranean diet.

In a single item, participants indicated how likely they were to adopt the Mediterranean diet in the next month on a 5-point scale (1 = ‘extremely unlikely,’ 5 = ‘extremely likely’).

Mediterranean Diet COM-B Measure

The authors developed a Mediterranean diet COM-B measure to assess a range of potential capability, opportunity, and motivation barriers to Mediterranean diet adoption. The 74 items were informed by the qualitative study conducted by the authors (see above), and barriers identified in the Mediterranean diet and meat reduction literatures (Lacroix et al., 2019; Malek et al., 2019; Stoll-Kleemann & Schmidt, 2017). Some items (e.g., ‘*I always like to eat the same food*’) (Lacroix et al., 2019) were taken directly from the literature while others (‘*I would have to go food shopping more often if I made a Mediterranean meal*’) (Lea et al., 2006) were adapted to the Mediterranean diet, and others were developed by the authors (e.g., ‘*If I only had to cook for myself, I would easily eat a Mediterranean diet*’). Specific items about meat and meat-free meals were included because meat reduction is a key feature of the Mediterranean diet (Bach-Faig et al., 2011; Goldstein et al., 2016). This measure included items related to: (1) *capability* (e.g., knowledge, in relation to meat-free and Mediterranean diet recipes, Mediterranean diet food items [including meat] and health, and meat and the environment; affordability; and food allergies), (2) *opportunity* (e.g.,

household influences, external social influences, and physical availability to change diets), and (3) *motivation* (e.g., eating habits, taste preferences, and meat dependence/attachment). All items were randomised and rated on a 5-point scale (1 = ‘not at all like me,’ to 5 = ‘just like me’).

Statistical Analysis

Descriptive statistics were calculated for sociodemographic, food consumption, self-identified diet group, and Mediterranean diet awareness and familiarity variables. Diet group comparisons were conducted using multivariate analysis of variance (MANOVA) and analysis of variance (ANOVA) analyses. The Mediterranean diet COM-B survey was subjected to exploratory factor analysis (EFA), using the maximum likelihood extraction method, to determine the underlying structure of the variables and to reduce the data into more manageable units. Hierarchical multiple regression was then conducted to determine which variables (i.e., Mediterranean diet familiarity and factors from the EFA) best predicted likelihood of Mediterranean diet adoption. All statistical analyses were conducted using Jamovi, version 2.3.21 and IBM SPSS Statistics 28 (IBM corp., Armonk, NY, USA).

Ethics

The Human Research Ethics Committee of the University of New England provided ethics approval (Approval No. HE22-180).

Results

Descriptives Statistics and Diet Group Comparisons

Current Food Consumption

Respondents reported consuming poultry ($M = 1.77$, $SD = 0.67$) and red meat ($M = 1.7$, $SD = 0.79$) between 1 and 4 times a week. Fish ($M = 1.1$, $SD = 0.76$) and legumes ($M = 1.02$, $SD = 1.03$), on average, were consumed just over once a week, and tofu ($M = 0.31$, SD

= 0.75) and PBMAAs ($M = 0.26$, $SD = 0.7$) were consumed less than once per week. See Table 5.2.

Self-identified Diet Groups

Most participants identified as omnivore eaters (71.8%). Fewer participants selected the Mediterranean diet (16%) or the flexitarian/semi-vegetarian diet (12.2%) as best describing what they had eaten in the last week. Most households (78.8%) ate the same diet. To test the first hypothesis that omnivores eat meat (particularly red meat) more often and meat replacements (particularly legumes) less often than flexitarian/semi-vegetarian and Mediterranean diet eaters, a MANOVA explored current food consumption across the three diets. Using Pillai's trace, a statistically significant variance was found between the three self-identified diet groups for the six food consumption frequency variables taken together ($V = 0.127$, $F(12, 872) = 4.928$, $p < .001$, $n^2 = .064$). For post-hoc analyses, an alpha level of .05 was adopted for consumption frequency variables with equal variance (red meat, fish, and legumes) whereas a conservative alpha level of .001 was applied for three variables (poultry, tofu, and PBMAAs) where homogeneity of variance was violated. Overall, significant differences were found for the consumption frequencies of red meat, fish, and legumes across the three self-identified diet groups. Planned contrasts (using Dunnett, 1-tailed with omnivores as the contrast group) revealed that omnivores ate red meat significantly more often ($p < .001$) and legumes significantly less often ($p < .05$) than Mediterranean diet and flexitarian/semi-vegetarian eaters. No significant differences in how often participants ate fish were identified between omnivores and the meat-reduced groups. See Table 5.2. Overall, Hypothesis 1 is generally supported.

Table 5.2

Multivariate Analysis of Variance (MANOVA) of Average Consumption Frequency of Meat and Meat-Replacement Foods for Total Sample and Per Diet Group

Meat and meat-replacement foods	Mean and Standard Deviation Scores (<i>M</i> , <i>SD</i>)				<i>F</i> (2, 440)	<i>p</i> -value	<i>n</i> ²
	Total sample (<i>N</i> = 443)	Omnivore (<i>n</i> = 318)	Mediterranean diet (<i>n</i> = 71)	Flexitarian/semi-vegetarian (<i>n</i> = 54)			
Red meat	1.7 (0.8)	1.8 (0.8) ^a	1.5 (0.8) ^b	1.3 (0.7) ^b	15.8	<.001 ¹	.067
Poultry	1.8 (0.7)	1.8 (0.6)	1.7 (0.8)	1.7 (0.8)	1.74	.177 ²	.008
Fish	1.1 (0.8)	1.0 (0.8)	1.3 (0.6)	1.2 (0.8)	3.26	.039 ¹	.015
Legumes	1.0 (1.0)	0.9 (1.0) ^a	1.2 (1.0) ^b	1.3 (1.0) ^b	4.68	.010 ¹	.021
Tofu	0.3 (0.7)	0.3 (0.7)	0.3 (0.9)	0.5 (0.8)	3.33	.037 ²	.015
PBMAs	0.3 (0.7)	0.2 (0.7)	0.3 (0.6)	0.5 (0.9)	5.29	.005 ²	.023

Six food categories scored 0=4: 0 = Never, 1=1 day/wk, 2=2-4 days/wk, 3=5-6 days/wk, 4=every day.

Values with different superscripts in rows differ significantly at $p < .05$, one-tailed, with omnivores as the contrast group.

¹ Significance assessed at $p < .05$.

² Significance assessed at $p < .001$ due to violation of homogeneity of variance.

Mediterranean Diet Awareness

Participants indicated low to moderate familiarity with the Mediterranean diet ($M = 2.48$, $SD = 1.28$), with 77.7% of participants either ‘not at all familiar,’ ‘slightly familiar,’ or ‘somewhat familiar.’ An ANOVA revealed that participants’ familiarity with the Mediterranean diet differed significantly across the diet groups ($F(2, 440) = 22.3$, $p < .001$) with a medium effect size ($\eta^2 = .092$). Tukey’s post-hoc tests showed that Mediterranean diet ($p < .001$) and flexitarian/semi-vegetarian ($p < .001$) eaters were significantly more familiar with the Mediterranean diet than omnivore eaters. These results support Hypothesis 2.

Results from the other Mediterranean diet awareness measures found that most participants thought the Mediterranean diet was healthy (62.1%), with less than 1% reporting it as unhealthy. Over half (58.2%) of participants believed that the Mediterranean diet included lots of nuts and olive oil, whereas less than half of the participants thought the Mediterranean diet included lots of fish and seafood (49.7%), had limited red meat (40.9%), and had small meat portions (39.1%). Conversely, few people thought it was expensive (8.4%), included a lot of red meat (5.4%), or was not good for the environment (2.9%).

Likelihood of Adopting the Mediterranean Diet

Participants' likelihood of adopting the Mediterranean diet was moderate ($M = 3.02$, $SD = 1.23$), with 39.7% of participants selecting 'extremely likely' and 'likely,' and 25.7% selecting 'neutral.'

Exploratory Factor Analysis

The Mediterranean diet COM-B measure consisted of 74 items, with all questions phrased as barriers. The Kaiser-Meyer-Olkin measure of sampling adequacy was 0.95, and Bartlett's test of sphericity had a p -value of less than .001, indicating strong linear relationships within the data set. The number of factors to retain was based on Cattell's (1966) scree plot and parallel analysis (Horn, 2000; O'Connor, 1964). Using an oblimin rotation, the scree plot indicated that five factors be retained, while the raw parallel analysis indicated seven factors. However, these five and seven-factor solutions conveyed some conceptual overlap (e.g., in the factor seven solution, household influences and child-household influences were identified as separate factors). On close examination, a four-factor solution (*Lack of Time and Knowledge, Meat Dependence, Food Allergies and Clean Eating, and Household Influences*) appeared more defined and interpretable, with identified factors supporting Hypothesis 3. Furthermore, the four factors exhibited high internal reliability, with Cronbach Alphas ranging .71 to .95, and together accounted for 42.2% of the overall response variance.

To define each factor, items with a loading of more than .45 and cross loadings of .35 or less were used. Scaled scores were then calculated for each retained factor by averaging the selected items for each factor. These scaled scores were used in subsequent analyses. Table 5.3 conveys the mean, standard deviation, and internal reliability score for each factor, and the items that it comprises.

Table 5.3

Exploratory Factor Analysis Pattern Matrix Loadings

Mediterranean diet COM-B items	<i>M (SD)</i>	Factor loading			
		1	2	3	4
Factor 1: Lack of Time and Knowledge (Opportunity, Capability; $\alpha = .94$)					
I lack the cooking skills to prepare meat-free meals	1.87 (1.25)	.76			
I never try out new recipes	1.76 (1.17)	.54			
I think it would cost too much to eat a Mediterranean diet	2.29 (1.38)	.51			
I have no time to plan a Mediterranean / meat-free meal	2.05 (1.30)	.65			
I don't know any meat-free recipes	2.14 (1.38)	.77			
I don't know any Mediterranean diet recipes	2.42 (1.43)	.68			
I don't know what to eat instead of meat	1.98 (1.24)	.69			
I don't know what the recommended meat portion size are	2.11 (1.27)	.49			
I am too rushed at dinnertime to change what I cook	1.97 (1.28)	.52			
It would take too long to make a Mediterranean meal	1.98 (1.23)	.76			
It would take too long to make a meat-free meal	1.92 (1.20)	.75			
I would not have the ingredients to make a Mediterranean meal	2.13 (1.34)	.73			
I would not have the ingredients to make a meat-free meal	2.14 (1.36)	.72			
I would have to go food shopping more often if I made a meat-free meal	2.16 (1.33)	.58			
I would have to go food shopping more often if I made a Mediterranean meal	2.23 (1.30)	.61			
I never try new recipes on the weekend	1.88 (1.24)	.55			
I find it hard to prepare a meat-free meal	2.21 (1.38)	.75			
Factor 2: Meat Dependence (Capability, Motivation; $\alpha = .95$)					
I believe that meat is essential for protein	3.31 (1.37)		.75		
I believe that eating meat is necessary to be healthy	3.09 (1.43)		.80		
It is not possible to have an adequate diet without eating meat	2.58 (1.44)		.65		
I don't think legumes are a good replacement for meat	2.43 (1.44)		.47		
I don't think reducing meat consumption prevents disease (e.g., heart disease, cancer)	2.42 (1.39)		.67		
I think it is healthy to eat red meat on a regular basis	3.01 (1.37)		.77		
I don't think reducing red meat is better for the environment	2.46 (1.45)		.77		
I will not prevent animal suffering by reducing my meat	2.45 (1.42)		.65		
I think plant-based meat alternatives are unhealthy	2.21 (1.36)		.49		
Meat is quick and easy to cook for dinner	3.35 (1.32)		.55		
There are no good alternatives to meat	2.65 (1.52)		.60		
I rarely have interactions with people who have reduced or are interested in reducing their meat consumption	2.71 (1.45)		.49		
I never feel guilty when eating meat	3.40 (1.51)		.74		
If I was forced to stop eating meat I would feel sad	2.91 (1.56)		.68		
I feel light and good after eating red meat	2.58 (1.32)		.65		
I think meat is delicious	3.82 (1.25)		.72		
I think a meal without meat is not satisfying (filling)	2.63 (1.49)	.32	.56		
I think to eat meat is an unquestionable right of every person	3.01 (1.50)		.77		
I would not eat plant-based meat alternatives because it seems unnatural	2.75 (1.57)		.60		

Factor 3: Food Allergies and Clean Eating (Capability, Motivation; $\alpha = .71$)

I am allergic / intolerant to legumes (e.g., beans, lentils, chickpeas)	1.30 (0.82)	.60
I am allergic / intolerant to gluten (e.g., pasta, wheat)	1.39 (0.98)	.54
I think fish is unhealthy	1.30 (0.90)	.53
I don't like the taste of white meat (e.g., chicken, turkey)	1.32 (0.82)	.64

Factor 4: Household Dietary Preferences (Opportunity; $\alpha = .83$)

People I live with would not eat a Mediterranean diet	2.18 (1.41)	.59
People I live with would not reduce their meat consumption	2.51 (1.52)	.62
People I live with would not eat legumes (e.g., beans, lentils, chickpeas)	2.21 (1.49)	.73
People I live with would not eat tofu	2.93 (1.73)	.71
People I live with would not be supportive of me reducing my meat consumption	2.12 (1.40)	.59

COM-B Factors and Familiarity as Barriers to Mediterranean Diet Adoption

A three-step hierarchical multiple regression was conducted to explore the extent to which several variables would function as barriers to adopting the Mediterranean diet.

Mediterranean Diet Familiarity was added to the model in the first step as it a key adoption barrier in non-Mediterranean countries (Tsofliou et al., 2022). The second step included the four COM-B factors identified in the EFA. The third step included one individual item that did not load onto any of the factors, '*If I only had to cook for myself, I would easily eat a Mediterranean diet*' (renamed as '*Not Having to Cook for Others*'). This individual item was included in the model because it was identified as a key barrier in the authors' qualitative study highlighted above and moderately positively correlated with Mediterranean diet adoption in initial correlation analyses, $r(441) = .48, p < .001$.

In step one of the hierarchical multiple regression, *Mediterranean Diet Familiarity* explained a significant 21.2% of the variance of the likelihood of adopting the Mediterranean diet, $\text{adj. } R^2 = .43, F(1,441) = 118.4, p < .001$. In step two, the four COM-B factors were added to the regression equation and explained an additional 14.5% of the variance in adoption likelihood, $\Delta R^2 = 0.15, \Delta F(4,437) = 24.7, p < .001$. In step three, with the significant individual question '*Not Having to Cook for Others*' added, the regression

equation explained an additional 8.3% of the variance in adoption likelihood ($\Delta R^2 = 0.083$, $\Delta F(1,436) = 64.7$, $p < .001$). Combined, the variables in model three explained 44% of the variance of Mediterranean diet adoption, $\text{adj. } R^2 = .43$, $F(6,436) = 57.1$, $p < .001$. Examining beta-coefficients highlights that *Familiarity*, *Meat Dependence*, *Lack of Time and Knowledge*, *Food Allergies and Clean Food*, *Household Dietary Preferences*, and *Not Having to Cook for Others* all explained significant amounts of variance in the likelihood of adopting the Mediterranean diet. Participants' scores on these factors predicted whether or not they were likely to adopt the Mediterranean diet, and therefore support Hypothesis 4. A summary of the regression analysis is presented in Table 5.4.

Table 5.4

Hierarchical Multiple Regression Results for the Prediction of Barriers to Mediterranean Diet Adoption

	95% CI for β			B	p -value	sr^2
	β	LB	UB			
Step 1						
Familiarity	0.46	0.38	0.54	0.44	<.001	.212
Step 2						
Familiarity	0.32	0.24	0.41	0.31	<.001	.089
Meat Dependence	-0.13	-0.21	-0.05	-0.16	<.001	.016
Lack of Time and Knowledge	-0.29	-0.36	-0.21	-0.35	<.001	.081
Food Allergies and Clean Food	0.24	0.16	0.32	0.30	<.001	.054
Household Dietary Preferences	-0.07	-0.15	0.00	-0.09	0.060	.005
Step 3						
Familiarity	0.26	0.179	0.34	0.25	<.001	.053
Meat Dependence	-0.11	-0.18	-0.03	-0.13	0.004	.011
Lack of Time and Knowledge	-0.24	-0.31	-0.16	-0.29	<.001	.052
Food Allergies and Clean Food	0.17	0.098	0.25	0.21	<.001	.026
Household Dietary Preferences	-0.14	-0.21	-0.07	-0.18	<.001	.019
Not Having to Cook for Others	0.32	0.24	0.40	0.27	<.001	.083

B = unstandardised beta, CI = confidence interval, LB = lower bound, UB = upper bound, r = correlation coefficient, sr^2 = squared semipartial correlation coefficient.

Step 3 model: $R = .66$, $R^2 = .44$, $\text{Adj } R^2 = .43$

Discussion

The aim of the current study was to quantitatively identify key barriers to adopting the Mediterranean diet in adults living in a high-meat consumption and high-income country (Australia) using the capability-opportunity-motivation (COM-B) framework. Consistent with past research in non-Mediterranean countries (Allenden et al., 2022; Scannell et al., 2020), more than two-thirds of our sample ate a high-meat omnivore diet, with only 16% identifying as Mediterranean diet eaters. These findings emphasise the immense scope to increase uptake of the Mediterranean diet in Australia with all the attendant positive consequences for GHG emissions reduction, human health, and animal welfare.

In our Australian sample, we found that meat and meat replacement consumption significantly differed across the three diet groups, with omnivore eaters consuming red meat significantly more often and legumes significantly less often than those who ate a Mediterranean or flexitarian/semi-vegetarian diet, generally supporting Hypothesis 1. Qualitative studies have found that reducing red meat and increasing legume consumption are common barriers to Mediterranean diet adoption in non-Mediterranean countries (Moore et al., 2018; Tsofliou et al., 2022). The Mediterranean diet consists of limited red meat (i.e., once a week) and moderate (i.e., 2 to 3 days a week) to daily consumption of legumes (Bach-Faig et al., 2011; Serra-Majem et al., 2020), so changing these eating habits (i.e., automatic motivation per the COM-B), is essential for omnivores to adopt a Mediterranean diet.

Omnivore eaters were also less familiar with the Mediterranean diet than people who ate a Mediterranean or flexitarian/semi-vegetarian diet (supporting Hypothesis 2). Consistent with past research (Kretowicz et al., 2018; Scannell et al., 2020), most people had some high-level awareness about the Mediterranean diet (e.g., it is healthy), but were less familiar with the specifics (e.g., reduced meat portions, limited red meat). Interestingly, people considered

the Mediterranean diet to be environmentally friendly, which is promising given the recent focus on sustainable food consumption (IPCC, 2022).

Exploratory factor analysis identified four underlying factors in the Mediterranean diet COM-B measure. Identified factors include *Lack of Time and Knowledge*, *Household Dietary Preferences*, *Meat Dependence*, and *Food Allergies and Clean Eating*. These were consistent with past research, as highlighted below (Allenden et al., 2025; Papadaki et al., 2016; Scannell et al., 2020; Tsofliou et al., 2022) and supported our third hypothesis (Hypothesis 3).

The hierarchical regression analysis in step one revealed that participants' familiarity with the Mediterranean diet explained 21.2% of the variance in Mediterranean diet adoption. Low familiarity is a common barrier in non-Mediterranean countries (Moore et al., 2018; Scannell et al., 2020; Tsofliou et al., 2022), which may reduce people's psychological capability to adopt this diet. That is, people would be less likely to adopt the Mediterranean diet if they do not know what it entails, thus posing a vital barrier to address when designing interventions.

Results revealed that the four factors explained an additional 14.5% of the variance in people adopting the Mediterranean diet in step two of the hierarchical regression analysis (supporting Hypothesis 4). *Lack of Time and Knowledge* explained 8.1% of the variance for people to adopt the Mediterranean diet, indicating a reduction in people's physical opportunity and psychological capability, respectively. Specifically, participants perceived Mediterranean diet meals as inconvenient, increasing both cooking and shopping time. People's psychological capability was also reduced by their limited knowledge of Mediterranean diet recipes, recommended meat portion sizes, and the use of legumes as a meat-replacement food. Lack of time and knowledge are common barriers in the meat-reduction and Mediterranean diet research (Allenden et al., 2025; Malek et al., 2019,

Middleton et al., 2015; Scannell et al., 2020), thus indicating that people have less physical availability to make an unfamiliar Mediterranean meal and less mental availability to plan and learn new recipes. Interestingly, our participants had less knowledge of Mediterranean diet recipes than meat-free recipes. A lack of knowledge of meat-free recipes is a common hinderance to adopting the vegan or vegetarian diet (de Boer et al., 2017), and people appear to have even less knowledge of Mediterranean diet recipes. This difference may be due to the vegetarian dietary movement that has recently expanded in Western countries (Hopwood et al., 2020; Ruby, 2012), resulting in greater awareness and access to meat-free recipes. Overall, in the context of people's other commitments (work, study, and childrearing), it is understandable that people perceive changing their diets as physically and mentally effortful (Allenden et al., 2025), particularly given the strong habits formed in eating patterns (Rees et al., 2018).

Food Allergies and Clean Eating explained 5.4% of the variance in Mediterranean diet adoption, which likely reflects reduced capability (physical and psychological) and motivation (automatic) to adopt the diet. In the current study, a small portion of the sample who identified as allergic or intolerant to gluten and/or legumes reported a high likelihood of adopting the Mediterranean diet, which contrasts with our qualitative findings (Allenden et al., 2025). The availability of gluten replacement foods (Mordor Intelligence, n.d.), and legume allergies being mostly from peanuts (Sasaki et al., 2018), may partly explain why our participants in the current study were still likely to adopt the Mediterranean diet. A small percentage of participants who perceived fish as unhealthy tended to score higher on the Mediterranean diet adoption scale. This unhealthy perception of fish may relate to mercury levels reported to be observed in ocean-based fish (Foods Standards Australia New Zealand, 2020) and negative media coverage of salmon farming in Australia (Minshull & Brown, 2017). As the Mediterranean diet includes moderate consumption of fish, these results were

unexpected. Nevertheless, these findings indicate that food allergies and perceived health concerns about fish are not barriers to Mediterranean diet adoption.

Meat Dependence also appeared to impact participants' motivation (automatic and reflective) and capability (physical and psychological) to adopt the Mediterranean diet. Despite a focus on meat reduction to support Mediterranean diet uptake, this factor only explained 1.6% of the variance in adoption. Possible reasons for this finding may be due to the meat-reduced (i.e., not meat-exclusionary) features of the Mediterranean diet, particularly for red meat (Bach-Faig et al., 2011). Consistent with past research in both the Mediterranean diet and meat reduction/exclusionary literature (Lacroix & Gifford, 2020; Malek et al., 2019; Stoll-Kleemann & Schmidt, 2017), most people perceived meat as tasty and filling, easy to cook, difficult to replace in a meal, and essential for health and protein. Legumes were not viewed as a meat replacement food even despite their similarly high protein content. This finding may be due to low nutrient knowledge (Didinger et al., 2020). In contrast to past research (Allenden et al., 2025; Haigh et al., 2019), the taste and texture of legumes was not a key barrier. Legumes were eaten across all diet groups, albeit less frequently for omnivore eaters. Therefore, this consumption level may partly explain why the taste and texture of legumes was not identified as a barrier for participants in this study.

Household Dietary Preferences presented as a social opportunity barrier and explained a small amount of the variance (0.5%) in Mediterranean diet adoption. Overall, participants perceived other household members as reluctant to eat a Mediterranean diet, to reduce their current meat levels, and to consume more legumes. Like meat exclusionary (i.e., vegan and vegetarian) diets (Lea & Worsley, 2003), family members can also hinder Mediterranean diet adoption, despite it being a more flexible diet. Overall, our findings emphasise the need to consider an individual within their social context. Further to this point, most households ate the same diet, which indicates that any dietary change should consider

the whole household, particularly because eating dinner is often a shared activity in multi-person households (Allenden et al., 2025; Harrison et al., 2015).

Finally, *Not Having to Cook for Others* enhanced participants' social opportunity to adopt the Mediterranean diet and explained an additional 8.3% of the variance in step three of the regression analysis. Even if someone is personally motivated to eat the Mediterranean diet, cooking for people who are not may influence their own adoption (Allenden et al., 2025; Papadaki et al., 2016), especially if other household members' dietary preferences favour meat. All participants in this study were the main or joint cook, which implies they would have some control over the cooking process (Lacroix & Gifford, 2020). Despite this control, our results indicate that household members may hold considerable sway over what is cooked and, in turn, collectively consumed at mealtimes. Research in the meat reduction and Mediterranean diet fields has often overlooked household influences, particularly for cooking meals that children will eat (Kretowicz et al., 2018; Lacroix & Gifford, 2020; Stoll-Kleemann & Schmidt, 2017). Our study included a relatively small number of households with dependent children; future research could further assess barriers quantitatively specifically for this household type.

Intervention Implications

The current study is the first to quantitatively assess the barriers to Mediterranean diet adoption in a high-meat-eating country, which contrasts with past research that has focused on health with 'at risk' participants and/or qualitative and observational research (Davis et al., 2015; McEvoy et al., 2018; Murphy et al., 2022; Scannell et al., 2020; Zacharia et al., 2020). Assessing barriers within the COM-B framework and using hierarchical regression analysis enables the design of more robust interventions that consider both internal and external influences and quantifies the identified target barriers.

Our findings emphasise the importance of raising awareness on the attributes of the Mediterranean diet and highlights education as a key intervention function (Moore & Boldero, 2017). However, education alone is a poor predictor of dietary change (van't Riet et al., 2011) without considering the *habit strength* of eating different foods (Rees et al. 2018). In the current study, red meat (*strong habit*) and legumes (*low habit*) are key foods to target, particularly for omnivore eaters. Education and training about small dietary shifts may also support dietary change (Lacroix & Gifford, 2020) by reducing physical and mental effort and knowledge barriers. A favourable perception of the Mediterranean diet is important for it to be repeated and become habitual (Moore & Boldero, 2017) for individuals and households. It was also salient in our findings that diet change should be considered within the whole household. Cooking for other people who do not want to change their omnivore eating habits is a crucial barrier, which may reduce with *environmental restructuring* and *enablement* as social opportunity intervention strategies (Michie et al., 2011).

Limitations

The current study is not without limitations. The higher mean age may impact the generalisability of the results, though as the Australian population is aging (ABS, 2021), these results may lend themselves to current and future trends. Furthermore, age has been identified as both a driver and barrier, with older people more likely to adhere to a Mediterranean diet; however, these results are specific to Mediterranean countries or rural USA (Tsofliou et al., 2022) and may be less relevant to our Australian sample. Another potential limitation is that the Mediterranean diet COM-B survey is a new measure developed by the authors. The authors developed a new measure, rather than rely on existing validated scales, due to their greater focus on meat-reduction (rather than the Mediterranean diet, as was our focus); our analysis of the existing measures indicated that they were unsuitable for our studies' needs given the difference in focus. While past research (Allenden et al., 2025;

Papadaki et al., 2016; Scannell et al., 2020; Tsofliou et al., 2022) and aspects of validated measures were used to develop the survey, future research is recommended to further assess the validity of the measure, particularly in international populations.

Conclusions

People in high-income countries such as Australia tend to eat high-meat diets, contributing to the ever-increasing GHGs resulting from animal agriculture. The meat-reduced Mediterranean diet offers a realistic way to shift people's high-meat-eating habits to a lower emissions diet. Understanding key barriers to Mediterranean diet adoption is essential to develop robust interventions. In our Australian study, key barriers included: 1) low familiarity with the Mediterranean diet, 2) lack of time and knowledge, 3) meat dependence, and 4) household dietary preferences. Only cooking for yourself predicted greater Mediterranean diet adoption, which emphasises the influence of cooking for other household members. Mediterranean diet interventions are more likely to be successful if they target these barriers, all of which impact a person's capability, opportunity, and motivation for diet shifts. Reducing red meat and increasing legumes is also central to aligning omnivores' eating habits with the Mediterranean diet. In Australia, there is no time to delay dietary change. The current study provides clear guidance on what to include in an intervention to make these changes happen.

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Appendix F

COM-B Mediterranean diet survey

Please select the answer that best represents your current situation.

Are you the main or joint cook in the household?

- ☐ Yes
- ☐ No (discontinue, if selected)

What is your age?

(Scroll down bar to select age >18 up to 100, including prefer not to say)

**Discontinue if >18*

What is your gender?

- ☐ Male
- ☐ Female
- ☐ Non-binary / third gender
- ☐ I prefer not to say

What is the highest education you have completed?

- ☐ Less than High School
- ☐ High School
- ☐ Trade / Technical / TAFE
- ☐ Bachelor's degree
- ☐ Post-Graduate (e.g., Master's, Doctorate)
- ☐ Other, please specify _____

Which ethnic group/s do you identify? Tick all that apply to you.

- ☐ Australian Aboriginal and/or Torres Strait Islander
- ☐ Australian
- ☐ New Zealander and Pacific Islander
- ☐ Asian
- ☐ North American
- ☐ South and Central American
- ☐ African or Middle Eastern
- ☐ European
- ☐ Other, please specify _____
- ☐ I prefer not to say

What is your household type?

- ☐ Single person
- ☐ Couple
- ☐ Couple family with dependent children
- ☐ Couple family with adult children
- ☐ One-parent family with dependent children
- ☐ Extended family (e.g., children, parents, grandparents)
- ☐ Group household (not family or related)
- ☐ Other, please specify _____

If selected:

- ☐ Couple with dependent children,
- ☐ One-parent family with dependent children, or
- ☐ Extended family (children, parents, grandparents)

ASK:

What is/are the ages of your dependent child/ren?

(Scroll down bar to select ages, including N/A option for extended families)

What is your current combined household income (previous year) before taxes, in Australian dollars?

Please provide your best guess.

- ☐ Less than \$25,000
- ☐ \$25,000 - \$49,999
- ☐ \$50,000 - \$74,999
- ☐ \$75,000 - \$99,999
- ☐ \$100,000 - \$149,999
- ☐ \$150,000 - \$200,000
- ☐ More than \$200,000
- ☐ I prefer not to say

Which best describes your employment status?

- ☐ Employed - part time (less than 30 hours a week)
- ☐ Employed - full time
- ☐ Not employed
- ☐ Student
- ☐ Retired
- ☐ Other _____
- ☐ I prefer not to say

The next few questions ask about your current eating habits.

IN THE LAST WEEK, how often did you eat the following

- ☐ Red meat (beef, lamb, pork)
- ☐ Poultry (chicken, turkey)
- ☐ Fish/seafood
- ☐ Legumes (e.g., beans, lentils, chickpeas)
- ☐ Tofu, tempeh
- ☐ Plant-based meat alternatives (e.g., burger patties, sausages, mince, chicken)

Now, click on which diet is the closest to describing what you have eaten **OVER THE LAST WEEK**. Choose one only.

Omnivore diet consumes:

- Meat (beef, pork, lamb, poultry, fish, seafood) and other animal-based foods (dairy, eggs) one or more times per day
- Plant-based foods (fruits, vegetables, cereals, legumes, and nuts)

Mediterranean diet consumes:

- Very small or nil processed meat
- Small amounts of red meat (beef, lamb, pork; one serving per week)
- Moderate amounts of fish, seafood, poultry, eggs and dairy (2-3 servings per week)
- Plant-based foods (fruits, vegetables, whole grains, legumes, nuts and olive oil)

Flexitarian / semi-vegetarian diet consumes:

- Two to six meat-free days per week
- Very small or nil processed meat
- Small amounts of red meat (beef, lamb, pork; one serving per week),
- Small to Moderate amounts of fish, seafood, poultry, eggs and dairy (2-3 servings per week)
- Plant-based foods (fruits, vegetables, cereals, legumes, and nuts)

Pescatarian diet consumes:

- No red meat (beef, pork, lamb) or poultry
- Fish, seafood, other animal-based foods (dairy, eggs)
- Plant-based foods (fruits, vegetables, cereals, legumes, and nuts)

Vegetarian diet consumes:

- No meat (beef, lamb, pork, poultry, fish, seafood),
- Animal-based foods (dairy, eggs)
- Plant-based foods (fruits, vegetables, cereals, legumes, and nuts)

Vegan diet consumes:

- No meat or other animal-based food (beef, pork, lamb, poultry, fish, seafood, dairy, eggs)
- Plant-based foods (fruits, vegetables, cereals, legumes, and nuts)

	Fruits / Vegetables	Legumes / Nuts	Dairy	Eggs	Fish / Seafood	Poultry	Red Meat (beef, lamb, pork)
Omnivore	✓	✓	✓	✓	✓	✓	✓
Mediterranean	✓	✓	MODERATE*	MODERATE*	MODERATE*	MODERATE*	LOW*
Pescatarian	✓	✓	✓	✓	✓	✗	✗
Flexitarian / Semi-Vegetarian	✓	✓	LOW – MODERATE**	LOW – MODERATE**	LOW – MODERATE**	LOW – MODERATE**	LOW*
Vegetarian	✓	✓	✓	✓	✗	✗	✗
Vegan	✓	✓	✗	✗	✗	✗	✗

*Low = one serving per week

**Moderate = 2 to 3 servings per week

Does everyone in the household eat the same diet?

- ☐ Yes
- ☐ No
- ☐ N/A

If No: Click on which diet is the closest to describing what other household members have eaten **OVER THE LAST WEEK**. Choose one only (diet list as above).

IN THE LAST WEEK, which meals did you eat for dinner (tick all that apply)

- ☐ Steak and veg/salad
- ☐ Pork and veg/salad
- ☐ Lamb chops/cutlets and veg/salad
- ☐ Fish and veg/salad
- ☐ Chicken and veg/salad
- ☐ Plant-based meat and veg/salad

- ☐ Pizza **with meat**
- ☐ Stir fry/noodles **with meat**
- ☐ Pasta meal **with meat**
- ☐ Curry or stew **with meat**
- ☐ Stir fry/noodles without meat
- ☐ Pasta without meat
- ☐ Curry or stew without meat
- ☐ Soup without meat
- ☐ Pizza without meat
- ☐ Salad without meat

Have you reduced your meat consumption in the past?

- ☐ Yes
- ☐ No

If yes, when did you reduce your meat consumption

- ☐ Less than 12 months
- ☐ 1 – 2 years
- ☐ 2 – 4 years
- ☐ 5+

If yes, which meat/s did you reduce? (Tick all that apply)

- ☐ Red meat (beef, lamb, pork)
- ☐ White meat (chicken, turkey)
- ☐ Fish/Seafood

If yes, why did you reduce your meat consumption? (Tick all that apply)

- ☐ I wanted to lose weight
- ☐ I didn't like the taste
- ☐ It was too heavy
- ☐ Health concerns
- ☐ My doctor told me to
- ☐ Animal welfare concerns
- ☐ Environmental concerns
- ☐ Because of the people I live with
- ☐ To save money
- ☐ Because of people (I don't live with) in my social environment
- ☐ Other, please specify _____

If yes, how did you do it? (Tick all that apply)

- ☐ Added/increased legumes (e.g., lentils, chickpeas)
- ☐ Added/increased plant-based meat alternatives
- ☐ Added/increased tofu, tempeh
- ☐ Made meat free curry, stir fry, and/or pasta meals
- ☐ Reduced meat portion sizes
- ☐ Used meal planning
- ☐ Included 1 meat-free meal a week (e.g., Meat-free Mondays)
- ☐ Learnt new recipes
- ☐ Modified my current meals
- ☐ Other, please specify _____

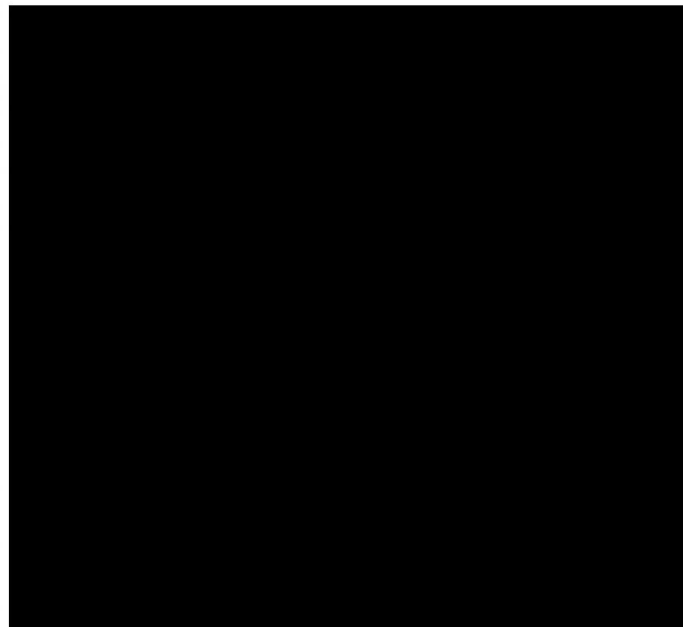
There are several meat-reduced and meat-free diets such as the vegetarian, vegan, pescatarian, and flexitarian/semi-vegetarian diets. There's another meat-reduced diet called the Mediterranean diet. How familiar are you with the Mediterranean diet?

- ☐ Not at all familiar
- ☐ Slightly familiar
- ☐ Somewhat familiar
- ☐ Moderately familiar
- ☐ Extremely familiar

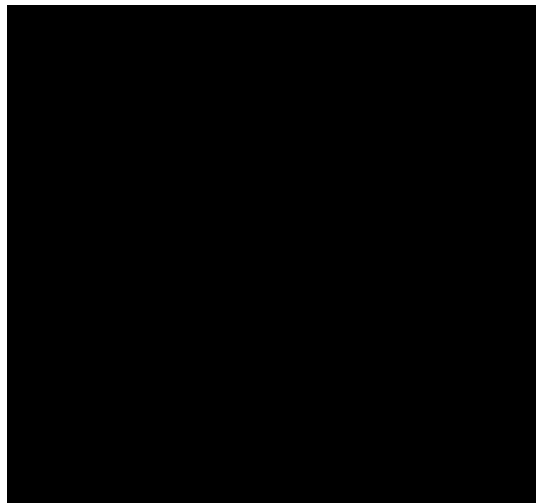
Which of the following describes the Mediterranean diet? (Tick all that apply)

- ☐ It includes a lot of pasta
- ☐ It includes a lot of fish and seafood
- ☐ It is healthy
- ☐ It has small portion sizes of meat
- ☐ It is not good for the environment
- ☐ It has limited red meat
- ☐ It is expensive
- ☐ It includes a lot of nuts and olive oil
- ☐ It is unhealthy
- ☐ It includes a lot of red meat
- ☐ It is basically Greek food

This is the Mediterranean Diet Pyramid which shows the main foods in this diet and how often each of these foods are consumed (Definition of the Mediterranean Diet: A Literature Review)



This is one example of a Mediterranean diet plate, showing portion sizes.



The difference between an omnivore diet and the Mediterranean diet is:

Omnivore diet includes:

- High frequency of meat (beef, pork, lamb, poultry, fish, seafood) and other animal-based foods (dairy, eggs) one or more times per day
- Small to moderate amounts of plant-based foods (fruits, vegetables, cereals, legumes, and nuts)

Mediterranean diet includes:

- Very small to nil processed meat
- Small amounts and low frequency of red meat (beef, lamb, pork; one serving per week)
- Moderate amounts and moderate frequency of fish, seafood, poultry, eggs, and dairy (2-3 servings per week)
- Large amounts and very high frequency of plant-based foods (fruits, vegetables, whole grains, legumes, nuts, and olive oil)

	Fruits & Vegetables	Legumes / Nuts	Dairy	Eggs	Fish/ Seafood	Poultry	Red Meat (beef, lamb, pork)
Omnivore	✓	✓	✓	✓	✓	✓	✓
Mediterranean	✓	✓	MODERATE ⁺	MODERATE ⁺	MODERATE ⁺	MODERATE ⁺	LOW*

*Low = one serving per week

+ Moderate = 2 to 3 servings per week

Now we are going to ask some questions about the Mediterranean diet. How likely are you to adopt the Mediterranean diet in the next month?

	Fruits & Vegetables 	Legumes / Nuts 	Dairy 	Eggs 	Fish/ Seafood 	Poultry 	Red Meat (beef, lamb, pork) 
Mediterranean	✓	✓	MODERATE*	MODERATE*	MODERATE*	MODERATE*	LOW*

*Low = one serving per week

*Moderate = 2 to 3 servings per week

- ☐ Extremely unlikely
- ☐ Unlikely
- ☐ Neutral
- ☐ Likely
- ☐ Extremely likely

There are many reasons that people DO NOT eat a Mediterranean diet. Please read each statement and indicate the extent to which it describes you.

- ☐ Not at all like me
- ☐ A little like me
- ☐ Somewhat like me
- ☐ Usually like me
- ☐ Always like me

I am allergic/intolerant to legumes (e.g., lentils)

I am allergic/intolerant to gluten (e.g., pasta, wheat)

I lack the cooking skills to prepare meat-free meals

I never try out new recipes

I think it would cost too much to eat a Mediterranean diet

I have no time to plan a Mediterranean / meat-free meal

I don't know any meat-free recipes

I don't know any Mediterranean diet recipes

I don't know what to eat instead of meat

I don't know what the recommended meat portion sizes are

I have difficulty understanding the health information that I read

If I ate a Mediterranean diet, I would not be able to eat other cuisines (e.g., Asian, Mexican)

I think carbohydrates are unhealthy

I believe that meat is essential for protein

I believe that eating meat is necessary to be healthy

It is not possible to have an adequate diet without eating meat

I don't think legumes (e.g., beans, lentils, chickpeas) are a good replacement for meat

I think fish is unhealthy

I don't think reducing meat consumption helps prevent disease (e.g., heart disease, cancer)

I think it is healthy to eat red meat on a regular basis

I don't think reducing red meat consumption is better for the environment

I will not prevent animal suffering by reducing my meat consumption

I think plant-based meat alternatives are unhealthy

Meat is quick and easy to cook for dinner

I am too rushed at dinnertime to change what I cook

It would take too long to make a Mediterranean meal

It would take too long to make a meat-free meal

I would not have the ingredients to make a Mediterranean meal
 I would not have the ingredients to make a meat-free meal
 I would have to go food shopping more often if I made a meat free meal
 I would have to go food shopping more often if I made a Mediterranean meal
 I never try new recipes on the weekend
 I find it hard to prepare a meat-free meal
 I don't know where to find plant-based meat alternatives in the supermarket
 I don't know where to find legumes (e.g., beans, chickpeas, lentils) in the supermarket
 The availability of meat-replacement products is insufficient where I live
 There are no good alternatives to meat
 There are no good meat-free meal options when I eat out
 I never eat Mediterranean or meat-free meals when I eat out
 I grew up eating meat every day
 People I live with would not eat a Mediterranean diet
 People I live with would not reduce their meat consumption
 People I live with would not eat legumes
 People I live with would not eat tofu
 I find it hard to get my children to eat vegetables
 My children are fussy eaters
 Dinner choice is determined by what my children will eat
 If I only had to cook for myself, I would easily eat a Mediterranean diet
 If I ate a Mediterranean diet, I would have to make multiple meals
 People I live with would be not be supportive of me reducing my meat consumption
 I rarely have interactions with people who have reduced or are interested in reducing their meat consumption
 People would make fun of me if I reduced my meat consumption
 I always like to eat the same food
 I don't like trying new foods
 If I don't know what is in a food, I won't try it
 I dislike foods from different countries
 I never feel guilty when eating meat (van der berg)
 If I was forced to stop eating meat I would feel sad
 I don't like the taste of white meat (e.g., chicken, turkey)
 I feel light and good after eating red meat
 I think meat is delicious
 I think a meal without meat is not satisfying (filling) (van der berg)
 I think vegetables are bland and boring
 I don't like the taste or texture of legumes (e.g., beans, lentils, chickpeas)
 I don't like the taste of tofu
 I don't like the taste of fish
 I don't like the taste of plant-based meat alternatives
 I think to eat meat is an unquestionable right of every person
 I would not eat plant-based meat alternatives because it seems unnatural
 What I eat is not going to affect my health
 It is not important that the food I eat is healthy
 I am not someone who is concerned about the environment
 It is not important if my food choices are harmful to the natural environment
 Animal welfare is not important to me

Higher Degree Research Thesis by Publication
University of New England

Statement of Originality

(To appear at the end of each thesis chapter submitted as an article/paper)

We, the Research Master/PhD candidate and the candidate's Principal Supervisor, certify that the following text, figures and diagrams are the candidate's original work.

Type of work	Page number/s
Text (inclusive of tables)	189 - 232

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Higher Degree Research Thesis by Publication
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Statement of Authors' Contribution

(To appear at the end of each thesis chapter submitted as an article/paper)

We, the PhD candidate and the candidate's Principal Supervisor, certify that all co-authors have consented to their work being included in the thesis and they have accepted the candidate's contribution as indicated in the *Statement of Originality*.

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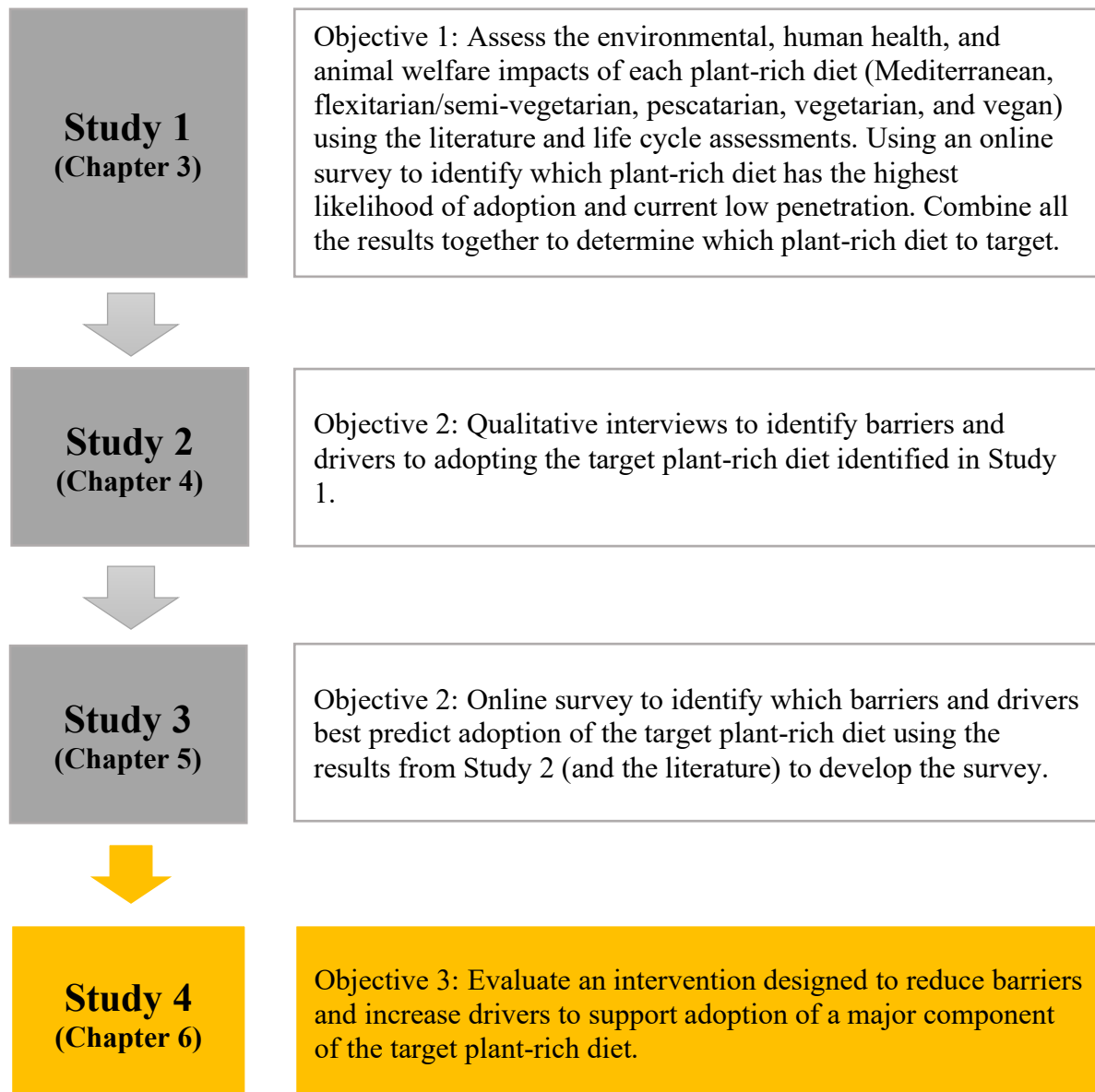


3 December, 2024

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Date

Research Progression to Study 4



Study 3 aimed to quantify the findings from Study 2 by identifying which barriers *predicted* Mediterranean diet adoption. Using hierarchical regression, results found that low Mediterranean diet familiarity was the key predictor barrier to adoption, particularly for omnivore eaters. While people had a general understanding of the Mediterranean diet (e.g., it is healthy), they were less familiar with the specifics of the diet (e.g., food types and meat portions), thus impacting adoption. Other significant factors related to people's perceived lack of time to change diets, a general dependence on eating meat - including a reduced

knowledge of other protein sources such as legumes, and household influences (specifically cooking for other people). While these results correspond to past research (Tsofliou et al., 2022), the hierarchical method provides a more targeted approach to understanding how each barrier predicts Mediterranean diet adoption, and which key barriers need to be considered in an intervention.

Another key finding related to eating habits, which were assessed by comparing food consumption behaviours with self-selected diet identities. In line with past qualitative research, our findings add to the literature by quantitatively showing that omnivores eat red meat *significantly* more frequently and legumes *significantly* less frequently than people who eat a meat-reduced diet (i.e., Mediterranean and flexitarian/semi-vegetarian). Our findings clearly emphasise that interventions need to focus on changing these food habits if people are to align with the Mediterranean diet.

As expected from Study 2 findings and research in the health literature, multiple factors need to be considered in an intervention designed to increase Mediterranean diet adoption. Study 3, however, confirms how these barriers predict Mediterranean diet adoption for people less motivated by health concerns. As past Mediterranean diet research has focused on people with health problems (Tsofliou et al., 2022), interventions tend to be more intensive (e.g., meal plans, blood tests, and dietician support), and conducted over long periods (i.e., 12 months) (Davis et al., 2015; Murphy et al., 2022). If Australians are to adopt the Mediterranean diet, interventions need to be tailored towards the general population using less intensive (and more cost effective) methods.

Findings from our study provided this information, with our next study (Study 4) aimed at designing a cost-effective intervention, by focusing on one critical Mediterranean diet food—legumes. As highlighted above, changing the meat-legume ratio is clearly needed if people in the general population are to align more with the Mediterranean diet. Using the

COM-B intervention section, several online messages (in the format of fridge magnets) were designed to determine which messages (and message attributes) increase people's intentions to eat legumes. Incorporating many of the above barriers, the objective of this study was to first identify if messages increase people's intention to eat legumes, and if so, which message attributes are most effective. Findings from this study can then be used to inform future interventions aimed at increasing legume consumption, and the Mediterranean diet, in a broader intervention study. The following study concludes the series of research studies that first identified which plant-rich diet to target, the barriers and drivers to adopting the target plant-rich diet identified (the Mediterranean diet), and designing and testing an intervention aimed at increasing Mediterranean diet adoption for Australians.

Chapter 6

Study 4

The humble bean: Finding persuasive message attributes to boost bean consumption

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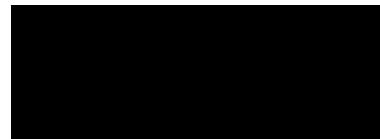
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Signature of Candidate



Signature of Principal Supervisor

Abstract

Legumes are a core food group of the sustainable and healthy Mediterranean diet, but consumption remains low in many high-income countries. If people are to adopt this plant-rich diet, legume consumption levels clearly need to increase. To support Mediterranean diet adoption, this study applied the COM-B behaviour change framework to develop 11 legume-focused message attributes and assessed their efficacy to increase legume consumption intentions within a sample of 201 Australian residents. Message attributes were assessed overall and according to participants' diet group membership—*high meat* (69.2%), *moderate meat* (20.4%), and *no meat* (10.4%), based on their red meat and legume consumption frequency levels. Multilevel modelling revealed that message attributes referencing taste and convenience significantly increased intentions to consume legumes overall. Interestingly, for members of the *high meat* diet only, message attributes referring to health and financial benefits, or those promoting enablement strategies, were detrimental to intended legume uptake, and therefore are best avoided. Implications for future research and tailoring messages are discussed.

Keywords: legumes, Mediterranean diet, behavior change, behavior change wheel

Introduction

“Could the answer to the world’s problems be the humble bean?” This question was posed in a video collaboration between Table (2023) and BBC Ideas (2023) outlining the environmental, human health, and cost benefits of eating beans compared to meat. Indeed, the answer is “no,” since no one food will solve our unsustainable food system (Table, 2023). Nonetheless, beans are crucial in reducing our global greenhouse gas (GHG) emissions—if high meat eaters in high-income countries ate more beans and less meat, emissions would reduce markedly (Aleksandrowicz et al., 2016; Allenden et al., 2022; Springmann et al., 2018; Twine et al., 2021). As global meat consumption continues to rise at alarming rates (Organisation for Economic Co-operation and Development [OECD], 2019; OECD & Food and Agriculture Organization [FAO] of the United Nations, 2023), the need to reduce meat levels through dietary change is urgently needed to slow climate change (Intergovernmental Panel on Climate Change [IPCC], 2022), placing the “humble bean” front and centre in the race to reduce livestock emissions.

The Mediterranean Diet and Beans

Promoting the plant-rich Mediterranean diet is considered a realistic (and potentially more successful) way to achieve meat-reduction dietary shifts, as high meat eaters are more likely to adopt this diet than meat-exclusionary diets (e.g., vegan and vegetarian) (Allenden et al., 2022). Beans are a core feature of the Mediterranean diet (Bach-Faig et al., 2011) and their high protein levels make them a good substitute for meat (Havemeier et al., 2017). While Western countries commonly use the term “beans” (Figueira et al., 2019), they are in fact a type of legume, the broad range of which includes dried beans, soybeans, peas, chickpeas, lentils, lupins, and peanuts (Hughes et al., 2022). This food group contains essential nutrients such as B vitamins, iron, magnesium, potassium, zinc, and protein (Calles et al., 2019; Margier et al., 2018), and legume consumption is linked to multiple health

benefits (e.g., reduced coronary heart disease risk, blood pressure, and all-cause mortality) (Bechthold et al., 2019; Darmadi-Blackberry et al., 2004; Jayalath et al., 2014; Marventano et al., 2017; Schwingshackl et al., 2017). Legumes are also environmentally sustainable, with a lower carbon footprint than animal-based products (e.g., legumes emit one-tenth of the carbon footprint of beef per unit of protein produced) (Poore & Nemecek, 2018).

Despite these health and environmental benefits, legumes are significantly under-consumed in high-income countries (Hughes et al., 2022). Australians, for example, consume fewer legumes annually (~ 2.9kg per capita) compared to world averages (~ 5kg per capita) (Gilham et al., 2018), with only 28% consuming legumes regularly (Grains & Legumes Nutrition Council, 2017). Global legume consumption is also low relative to dietary recommendations (Hughes et al., 2022; Marinangeli et al., 2017); and in contrast to rising meat consumption levels (OECD, 2019; OECD & FAO, 2023), has remained stagnant for the past 30 years (Rawal et al., 2019). Additionally, omnivore eaters consume legumes less frequently than those who eat a plant-rich diet, whilst vegetarian and vegan eaters generally consume the most (Allenden et al., 2024b; Jallinoja et al., 2016; Yurkow et al., 2017). If high meat eaters have any chance of adopting the Mediterranean diet, this legume-to-meat ratio clearly needs to increase.

Behaviour Change Wheel

In this study, we utilised the behaviour change wheel (BCW) (Michie et al., 2011) to design an intervention to promote legume consumption, and in turn possibly increase Mediterranean diet adoption. This model understands behaviour in relation to one's capability, opportunity, and motivation (known as the COM-B model, see Figure 6.1), with interventions devised to target one or more of these factors (Michie et al., 2011). Using behaviour change models to inform intervention design has gained popularity in the health field (Barker et al., 2016; Fulton et al., 2016; Gould et al., 2017; McEvoy et al., 2018) but is

less common in the sustainable eating domain (Tsofliou et al., 2022), despite being considered best practice for designing behaviour change interventions (Michie et al., 2011). A benefit of using the COM-B to assess legume consumption (and the Mediterranean diet) is its emphasis on automatic motivation (e.g., habits), an essential factor when examining eating behaviours (Klöckner, 2013; Moore & Boldero, 2017). This contrasts with other behaviour models (e.g., theory of planned behaviour) that tend to focus more on conscious-driven factors (Ajzen, 1991).

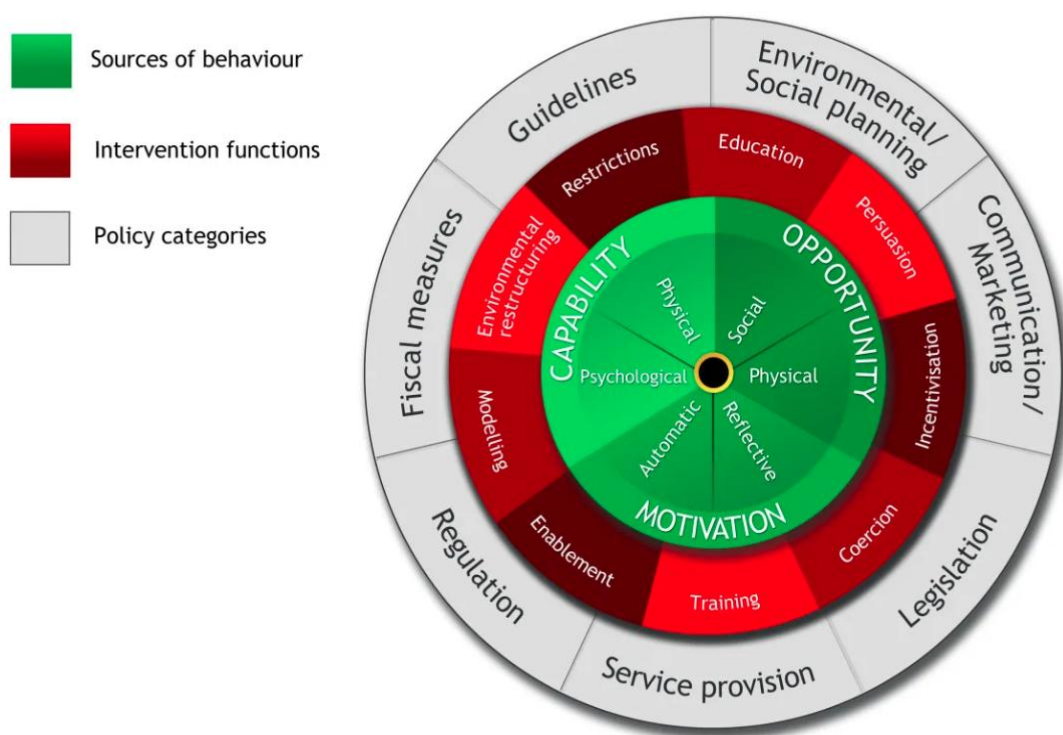


Figure 6.1

The Behaviour Change Wheel

Reprinted from “*The behaviour change wheel: A new method for characterising and designing behaviour change interventions,*” by S. Michie, M. M. van Stralen and R. West, 2011, *Implementation Science*, 6(42), p. 7. Copyright [2011] by Michie et al., licensee BioMed Central Ltd. Used under Creative Commons Attribution License: <http://creativecommons.org/licenses/by/2.0>

So far, only three studies have used the COM-B model to assess the barriers and drivers to Mediterranean diet adoption. Nevertheless, they all explored legume consumption. One focused on improving health for participants at high cardiovascular risk (McEvoy et al., 2018), and two evaluated adoption in the general population (Allenden et al., 2025; Allenden et al., 2024b). Legume-related findings revealed barriers across all COM-B factors, including ingrained meat-eating habits (e.g., high red meat, low legume eating habits), lack of time to change current dietary patterns, taste preferences skewed towards meat (and less towards legumes), reduced awareness of the protein quality of legumes, and the (unsupportive) influences of household members (Allenden et al., 2025; Allenden et al., 2024b; McEvoy et al., 2018). Legume-specific research assessing factors that impact consumption more generally supports these findings (Figueira et al., 2019; Ipsos Reid, 2010; Lea et al., 2005; Phillips et al., 2015). In sum, these findings overall point towards a multi-faceted intervention design to increase legume intake.

Interventions to promote legume consumption (and Mediterranean diet adoption in general) are scarce, specifically in the general population (McEvoy et al., 2018). We found one legume intervention study (Carfora & Catellani, 2023) that assessed the influence of persuasive (text) messages on increasing legume consumption in a healthy Italian adult population. Informed by the theory of planned behaviour model, results revealed that *addition* messages (i.e., add legumes) were more effective than *replacement* messages (i.e., replacing meat with legumes), particularly for those with a negative attitude towards a flexitarian diet. Findings from the meat-reduction literature also indicate that persuasive messages may effectively reduce red meat consumption, though results are mixed (Carfora et al., 2019; Wistar et al., 2022). Overall, these results highlight the potential for persuasive messages to reduce meat and increase legume consumption. However, more research using behaviour change models that address the habitual nature of meat consumption is required.

Current Study

The current study aimed to design and evaluate persuasive message attributes (presented within hypothetical fridge magnets) to increase legume consumption. The attributes targeted key factors previously found to hinder Mediterranean diet adoption in two past studies (see Allenden et al., 2025, 2024b). These factors include: (a) *lack of knowledge* (i.e., Mediterranean diet recipes, meat portion sizes, meat replacement foods, and perceived cost of the Mediterranean diet); (b) *lack of time* (i.e., Mediterranean diet meals take too long and there is no time available to change current meals); (c) *meat dependence* (i.e., meat is essential for protein and legumes are not an adequate replacement, meat is delicious, meat is healthy, and reducing meat affords no benefit to the environment or animal welfare); and (d) *ingrained eating habits* that do not align with the Mediterranean diet (i.e., high red meat and low legume consumption levels). These factors all relate to the COM-B components of capability (*knowledge, meat dependence*), opportunity (*perceived lack of time - physical and mental*), and motivation (*meat dependence, ingrained meat-eating habits*). The 11 message attributes were either present or not present in 12 legume messages (i.e., the proposed fridge magnets), enabling us to evaluate the influence of each attribute on peoples' intended legume consumption.

The current study also assessed self-reported consumption frequency of meat (red, poultry, and fish) and legumes within self-identified diet groups. Consistent with past research (Allenden et al., 2024b), we hypothesised that omnivores would eat meat (particularly red meat) more often, and legumes less often, than the plant-rich diet eaters (Mediterranean, flexitarian/semi-vegetarian, pescatarian, vegetarian, and vegan) (Hypothesis 1). If these self-identified diet groups were valid according to their relative food consumption frequencies, the current study also intended to assess differences in message attribute efficacy among the self-identified diet groups. Given research in this area is limited, the influence of

message attributes and diet groups on intentions to increase legume consumption was exploratory, with no specific hypotheses developed or tested.

Methods

Participants

A total of 232 first-year psychology students completed the survey. Thirty-one students failed one of two attention checks and were removed from the dataset, with a final sample of 201 participants. All survey questions required a response, though participants could select ‘I prefer not to say’ for gender, income, employment, and ethnicity. Inclusion criteria were being a first-year psychology student aged 18+. Participants had a mean age of 33.7 years ($SD = 10.3$, range = 18 to 67 years), slightly lower than the national representative census data (Australian Bureau of Statistics [ABS], 2021), though the mean age and range corresponded with participants attending a university specialising in distance education. Over three-quarters (79.6%) of participants were female (18.9% male; 1.5% non-binary/third gender). Almost all participants (99.5%) had 12 years or more formal education, and most identified as European Australian (73.1%). More than half of participants lived in a couple with dependent children (28.9%) or couple without children (23.9%) household, followed by single household (14.4%), couple with adult children (8.5%), one parent with dependent children (8.5%), one parent with adult children (5%), non-related group household (5%), multigenerational household (4%), and other (2%). Most participants (67.1%) reported a household income greater than 75,000AUD (the median Australian household income from 2019 to 2020 was approximately 52,338AUD) (ABS, 2022). Students received university credit and the chance to enter a draw to win one of five \$100 gift vouchers.

Materials and Measures

The online survey (using the QualtricsTM platform) included items to assess a participant’s sociodemographic characteristics, current meat and legume consumption

frequency, diet group, intention to eat legumes after viewing legume messages, and if they wanted to be sent the fridge magnet that was liked most overall by participants.

Socio-demographic Characteristics

Six items assessed participants' gender, age, ethnicity, education, employment status, household type, and annual household income (see Appendix G).

Current Food Consumption

Current eating habits were measured to validate diet group. A single item assessed how often participants had eaten meat (red, poultry, and fish/seafood) and legumes/beans on a 5-point scale ('never,' '1 day per week,' '2 to 4 days per week,' 'most days [5 to 6 days per week],' and 'every day') (Allenden et al., 2024b; Malek et al., 2019). This item included a specific timeframe (e.g., "how often did you eat red meat over the last week?") and was presented before the diet group item to mitigate potential recall error and social desirability selection biases (Althubaiti, 2016), respectively.

Self-identified Diet Groups

One item assessed which diet (omnivore, Mediterranean, flexitarian/semi-vegetarian, pescatarian, vegetarian, or vegan) most closely described what participants had eaten over the last week (Malek et al., 2019; Tsofliou et al., 2022). A description of each diet and pictorial table was also provided to aid selection (see Appendix G).

Mediterranean Diet Information

Next, participants viewed a brief description of the Mediterranean diet (Bach-Faig et al., 2011; Goldstein et al., 2016), pictures of the Mediterranean diet pyramid (Medical News Today, n.d.), and a plate example (Durrer Schutz et al., 2019). The description and visual depictions emphasised the inclusion of legumes/beans (see Appendix G). Given "beans" is the common term used in Australia (Figueira et al., 2019), messages referred to beans rather than legumes.

Legume Messages

Twelve legume messages were developed/sourced from the Internet and presented in the form of fridge magnets. Three messages were sourced from the Internet (Food Insight, 2017; Grain and Legumes Nutrition Council, n.d.; Table, 2023) with some design modifications (e.g., adding the term ‘beans,’ reformatting to fit a fridge magnet) made. Several legume images were used across the messages (e.g., legume-focused meals, tinned and dried legumes), with the choice of legume and legume-focused meals based on commonly consumed legumes (Figueira et al., 2019) and meals in Australia (McCrindle, 2017) (see Appendix G for pictures of magnets as shown to participants). The purpose of each fridge magnet was to target ingrained meat-eating habits (i.e., environmental restructuring by adding a prompt) and household influences (i.e., visible to all household members). Each participant viewed all 12 messages, with each message randomised and presented as fridge magnets.

Message Attributes

In the current study, we focused on the associations between (a) the presence or absence of the 11 message attributes in the magnets, and (b) the extent to which the magnets influenced participants’ intentions to add legumes to their diets. The 11 message attributes were developed in line with prior research and are presented in Table 6.1 along with how they link with the COM-B. Message attribute per magnet and percentages of messages with each attribute present are shown in Table 6.2. A correlation matrix showed low to moderate correlations, with 93% below .5 and the highest Pearsons $r = .63$.

Table 6.1

Message Attributes and their Associated Behavioural Barriers, COM-B Components, and Intervention Functions

Message attribute	Barriers	COM-B	Intervention function
Imagery and direct reference to legumes and familiar meat meals	Ingrained meat-eating habits	Automatic motivation	Training (meal names) Persuasion (imagery of meals)
Direct reference to taste	Meat dependence	Automatic motivation	Persuasion (imagery of meals)
Reference to convenience	Lack of time	Physical opportunity	Training (imagery of tinned legumes)
Direct reference to legumes as protein	Meat dependence	Psychological capability	Education
Reference to meat reduction	Ingrained meat-eating habits	Automatic motivation	Training (imagery of meat and legume portion sizes)
Direct reference to external organisation	Ingrained meat-eating habits	Automatic motivation	Persuasion
Direct reference to morals (environmental/animal welfare)	Meat dependence	Psychological capability / Reflective motivation	Education Persuasion
Direct reference to human health benefits	Meat dependence	Psychological capability / Reflective motivation	Education Persuasion
Direct reference to financial benefits	Meat dependence	Psychological capability	Education
Enablement (action planning and monitoring)	Ingrained meat-eating habits Lack of time	Automatic motivation Psychological capability	Prompts (shopping list) Action planning and self-monitoring (daily checklist)
Imagery of dried legumes	Ingrained meat-eating habits	Automatic motivation	Persuasion (imagery)

Table 6.2*Message Attribute per Magnet and Percentage of Magnets with each Attribute Present*

Message attribute	Magnet	Yes	No
Imagery and direct reference to legumes and familiar meat meals	1, 2, 9, 11	33%	67%
Direct reference to taste	1, 12	17%	83%
Reference to convenience	2, 3, 6, 10, 11	42%	58%
Direct reference to legumes as protein	3, 4, 7, 12	33%	67%
Reference to meat reduction	1, 2	17%	83%
Direct reference to external organisation	4, 6, 8	25%	75%
Direct reference to morals (environmental/animal welfare)	2, 7, 8	25%	75%
Direct reference to human health benefits	6, 7, 9, 12	33%	67%
Direct reference to financial benefits	3, 4	17%	83%
Enablement (action planning and monitoring)	5, 10, 11	25%	75%
Imagery of dried legumes	5, 6, 7, 8, 12	42%	58%

Legume Consumption and Behaviour Commitment Intentions

After each message, participants indicated how likely they would be to add legumes to their meals on a 5-point scale (1 = ‘extremely unlikely,’ 5 = ‘extremely likely’). After viewing all messages, participants indicated if they would wish to receive the magnet most liked by the study’s participants (Yes/No).

Statistical Analysis

Descriptive statistics were calculated for sociodemographic, food consumption frequency, and self-identified diet groups. A multivariate analysis of variance (MANOVA) explored differences in consumption frequencies within self-identified diet groups, with subsequent post-hoc tests conducted using analyses of variance (ANOVA). Multi-level modelling explored the message attribute efficacies to influence legume consumption intentions. All statistical analyses were conducted using IBM SPSS Statistics 28 (IBM corp., Armonk, NY, USA) and HLM 8 (Raudenbush & Congdon, 2021).

Ethics

The Human Research Ethics Committee of the University of New England provided ethics approval (Approval No. HE23-166).

Results

Descriptives Statistics

Respondents reported consuming poultry ($M = 1.69$, $SD = 0.85$) and red meat ($M = 1.58$, $SD = 0.83$) between 1 and 4 times a week. Fish ($M = 0.86$, $SD = 0.82$) and legumes ($M = 1.03$, $SD = 0.90$) were consumed approximately once a week (see Table 6.3). More than half of respondents (61.2%) stated that they would want the most liked fridge magnet.

Self-identified Diet Groups

Most participants identified as omnivore eaters (69.2%), followed by the Mediterranean (12.9%), flexitarian/semi-vegetarian (7.5%), vegetarian (5.5%), pescatarian, (2.5%) and vegan (2.5%) diet. To test the first hypothesis that self-identified diet groups match food consumption frequencies, a MANOVA explored current food consumption across the six diets. Using Pillai's trace, a statistically significant difference was found between the six self-identified diet groups for the four food consumption frequency variables taken together ($V = 0.844$, $F(20, 780) = 10.424$, $p < .001$, $\eta^2 = .211$). Post-hoc analyses, using the Games-Howell statistic and an alpha level of .05, found significant differences in consumption frequencies for food items across the six diet groups. Omnivores ate red meat significantly more often than all the plant-rich diets, while Mediterranean and flexitarian/semi-vegetarian eaters ate red meat significantly more often than pescatarians, vegetarians, and vegans. Omnivores ate legumes significantly less often than vegetarians and vegans, while Mediterranean eaters ate legumes significantly less often than vegans. Overall, Hypothesis 1 was generally supported, and the results support the presence of three broad diet

groups—high meat (omnivore), moderate meat (Mediterranean and flexitarian/semi-vegetarian), and no meat (pescatarian, vegetarian, and vegan) (see Table 6.3).

Table 6.3

Multivariate Analysis of Variance (MANOVA) of Average Consumption Frequency of Meat and Meat-Replacement Foods for Total Sample and Per Diet Group

Meat and meat-replacement foods	Mean and Standard Deviation Scores (<i>M</i> , <i>SD</i>)							<i>F</i> (5, 195)	<i>p</i> -value	<i>n</i> ²
	Total sample (<i>N</i> = 201)	Omnivore (<i>n</i> = 139)	Mediterranean diet (<i>n</i> = 26)	Flexitarian/ semi-vegetarian (<i>n</i> = 15)	Pescatarian (<i>n</i> = 5)	Vegetarian (<i>n</i> = 11)	Vegan (<i>n</i> = 5)			
Red meat	1.6 (0.8)	1.9 (0.7) ^a	1.4 (0.6) ^b	1.3 (0.6) ^b	0.0 (0.0) ^c	0.0 (0.0) ^c	0.0 (0.0) ^c	36.98	<.001	.487
Poultry	1.7 (0.9)	1.9 (0.7) ^a	1.9 (0.5) ^a	1.5 (0.8) ^a	0.0 (0.0) ^b	0.0 (0.0) ^b	0.0 (0.0) ^b	36.00	<.001	.480
Fish	0.9 (0.8)	0.9 (0.8) ^a	0.8 (0.6) ^a	1.1 (0.9) ^{ab}	1.8 (0.5) ^{bc}	0.0 (0.0) ^d	0.2 (0.5) ^{ad}	5.21	<.001	.118
Legumes/beans	1.0 (0.9)	0.9 (0.8) ^a	1.2 (1.0) ^{ab}	1.2 (0.9)	1.0 (1.0)	2.0 (0.8) ^{bc}	2.2 (0.5) ^c	6.42	<.001	.141

Four food categories scored 0-4: 0 = Never, 1=1 day/wk, 2=2-4 days/wk, 3=5-6 days/wk, 4=every day.

Values with different superscripts in rows differ significantly at $p < .05$.

Message Attributes Predicting Legume Consumption Intentions

Multilevel modelling was used to determine which message attributes would predict greater legume consumption intentions overall and within each of the three diet groups. As participants indicated how likely they were to eat legumes after viewing each message, the effects of the message attributes on intentions to eat legumes were nested within participants. In the Level 1 (within-person) analysis, regression equations were computed for each participant using legume consumption intentions as the dependent variable and the 11 message attributes (listed in Table 6.2) as predictors. The Level 2 (between-person) analysis used a restricted maximum likelihood approach, whereby the intercept and beta coefficients from the Level 1 analyses were regressed onto two Level 2 dummy coded participant diets (no meat versus high meat, and moderate meat versus high meat). High meat participants were used as the reference group, as the current study aimed to identify how to encourage people to reduce their meat consumption by increasing their legume intake. Using the Level 2 analysis, we were able to assess whether the relationship between the legume message attributes and legume consumption intentions varied according to participants' current diet patterns. In other words, we were able to determine which message attributes related to increased legume consumption intentions within each of the three diet groups—high meat, moderate meat, and no meat.

The sample size was informed by Maas and Hox's (2005) guidelines based on running simulations that varied in Level 1 and Level 2 sample sizes. Hence, simulations with small Level 2 samples (consisting of 50 or fewer cases) produced biased Level 2 standard errors, whereas all other simulations, including those with a sample size of five (in Level 1), produced accurate and unbiased regression coefficients, variance components, and standard errors at both Level 1 and Level 2. Given the current study had 201 respondents at Level 2

and 12 ratings per respondent at Level 1, the sample size exceeded Maas and Hox's (2005) recommendations.

Unconditional Model. First, an unconditional model (i.e., no predictors at within-individual or between-individual levels) separated the total variance in legume consumption intentions into within- and between-person components. The intraclass correlation from the unconditional model was $r_1 = .44$, indicating that almost half of the variance in legume consumption intentions was attributable to individual differences (between-subjects variance), and just over half reflected within-subjects variance across messages. Given the moderate magnitude of intraclass correlation, multilevel modelling was deemed an appropriate analysis strategy for the current study (Garson, 2013).

Level 1 Model: Which Message Attributes Predict Legume Consumption

Intentions? The Level 1 analysis involved regressing legume consumption intentions (the dependent variable) on the 11 message attribute predictors (see Table 6.4). For the analysis, each fridge magnet message was coded on whether or not the message attribute was present. Coding for all predictors equalled "1" if the fridge magnet messages included the attribute, or "0" if they did not. Multicollinearity occurred between two predictors: direct reference to morals (environmental/animal welfare) and enablement (action planning and monitoring). Subsequent analyses omitted the former and retained the latter as a conceptual decision to continue to explore the enablement function as an effective mitigation strategy for ingrained meat-eating habits, given research addressing this barrier is scarce (Godfray et al., 2018). Table 6.4 presents average unstandardised coefficients and robust standard errors for the intercept and the message attributes.

The intercept value indicated that, on average, respondents reported legume consumption intention ratings of 3.09 ($SE = .05$), just over the mid-point (neither unlikely nor likely) on the 5-point scale. Seven of the eleven message attributes significantly predicted

legume consumption intentions. Messages referring to taste and convenience significantly increased intentions to add legumes to meals, while those referring to protein, health, enablement strategies, meat reduction, or external organisations significantly decreased legume consumption intentions.

Table 6.4

HLM Level 1 Analysis: Relationships Between Message Attributes and Legume

Consumption Intentions

Variable	Coefficient	SE	<i>t</i> (200)
Intercept	3.09	.05	57.04**
Imagery and direct reference to legumes and familiar meat meals	-0.10	.06	-1.67
Direct reference to taste	0.40	.06	6.40**
Reference to convenience	0.20	.04	4.83**
Direct reference to legumes as protein	-0.29	.08	-3.58**
Reference to meat reduction	-0.28	.09	-3.11*
Direct reference to external organisation	-0.16	.06	-2.55*
Direct reference to human health benefits	-0.42	.08	-5.26**
Direct reference to financial benefits	-0.26	.15	-1.74
Enablement (action planning and monitoring)	-0.41	.09	-4.44**
Imagery of dried legumes	0.14	.08	1.85

Coefficients were computed using HLM's restricted maximum likelihood algorithm and are interpreted as average unstandardized beta weights. Group centering was used with random effects for each predictor assessed one at a time, with all other predictors fixed. Valid cases were 2201 for all Level 1 coefficient computations.

* $p < .05$.

** $p < .01$.

Level 2 Model: Do Message Attribute Effects Vary as a Function of Current

Diet? A second aim of the study was to determine whether the effects of message attributes on legume consumption intentions varied as a function of diet groups (i.e., high meat, moderate meat, no meat). We conducted a Level 2 analysis with diet group membership as the predictor variable for the intercept and beta coefficients associated with message attributes from the Level 1 analysis. Significant Level 2 effects are akin to cross-level interactions as they convey how the relationship between Level 1 predictors and the dependent variable varies as a function of one or more Level 2 predictors. Here, cross-level interactions are the effect of diet group membership on the predictive effects of message

attributes on legume consumption intentions. Using HLM's graph module, we plotted significant Level 2 effects to help interpret the cross-level interactions. Table 6.5 summarises the Level 2 analysis.

Table 6.5

HLM Level 2 Analyses: Message Attribute Effects on Legume Consumption Intentions Varied as a Function of Diet Groups

Effect	Coefficient	SE	t (198)
<i>L1 intercept (mean intention)</i>			
No meat	0.18	.19	0.98
Moderate meat	0.20	.11	1.73
<i>Imagery and direct reference to legumes and familiar meat meals</i>			
No meat	0.14	.18	0.76
Moderate meat	0.04	.16	0.25
<i>Direct reference to taste</i>			
No meat	-0.03	.13	-0.24
Moderate meat	-0.13	.15	-0.81
<i>Reference to convenience</i>			
No meat	0.05	.16	0.31
Moderate meat	0.02	.09	0.20
<i>Direct reference to legumes as protein</i>			
No meat	-0.13	.27	-0.49
Moderate meat	-0.12	.23	-0.52
<i>Reference to meat reduction</i>			
No meat	-0.08	.34	-0.22
Moderate meat	0.39	.21	1.81
<i>Direct reference to external organisation</i>			
No meat	-0.02	.16	-0.14
Moderate meat	0.02	.16	0.14
<i>Direct reference to human health benefits</i>			
No meat	0.86	.32	2.68*
Moderate meat	0.34	.20	1.73
<i>Direct reference to financial benefits</i>			
No meat	1.21	.60	2.01*
Moderate meat	0.60	.39	1.54
<i>Enablement (action planning and monitoring)</i>			
No meat	0.64	.31	2.06*
Moderate meat	0.26	.23	1.13
<i>Imagery of dried legumes</i>			
No meat	0.15	.24	0.62
Moderate meat	0.20	.19	1.06

Note. High meat members are the reference group for the no meat and moderate meat effects. All significance tests are based on robust standard errors.

* $p < .05$.

** $p < .01$.

Significant Level 2 effects were found between the high meat and no meat group for the direct reference to financial and human health benefits, and enablement strategies (action planning and monitoring). The no meat group scored 1.21 points higher on the 5-point legume consumption intention scale in response to messages that referred to financial benefits, relative to messages that did not. In contrast, mentioning financial benefits had a reduced effect on legume consumption intentions for high meat participants. This group reported relatively weak intentions when financial benefits were mentioned (see Figure 6.2a). People in the no meat group were also more engaged by messages that emphasised health benefits or enablement strategies relative to messages that made no reference to these attributes. High meat participants had relatively weaker legume intentions when health benefits or enablement strategies were emphasised (see Figure 6.2b and 6.2c, respectively). There were no significant differences in intercepts or beta coefficients between moderate or high meat respondents. That is, all legume message attributes elicited similar legume consumption intentions in both these diet groups.

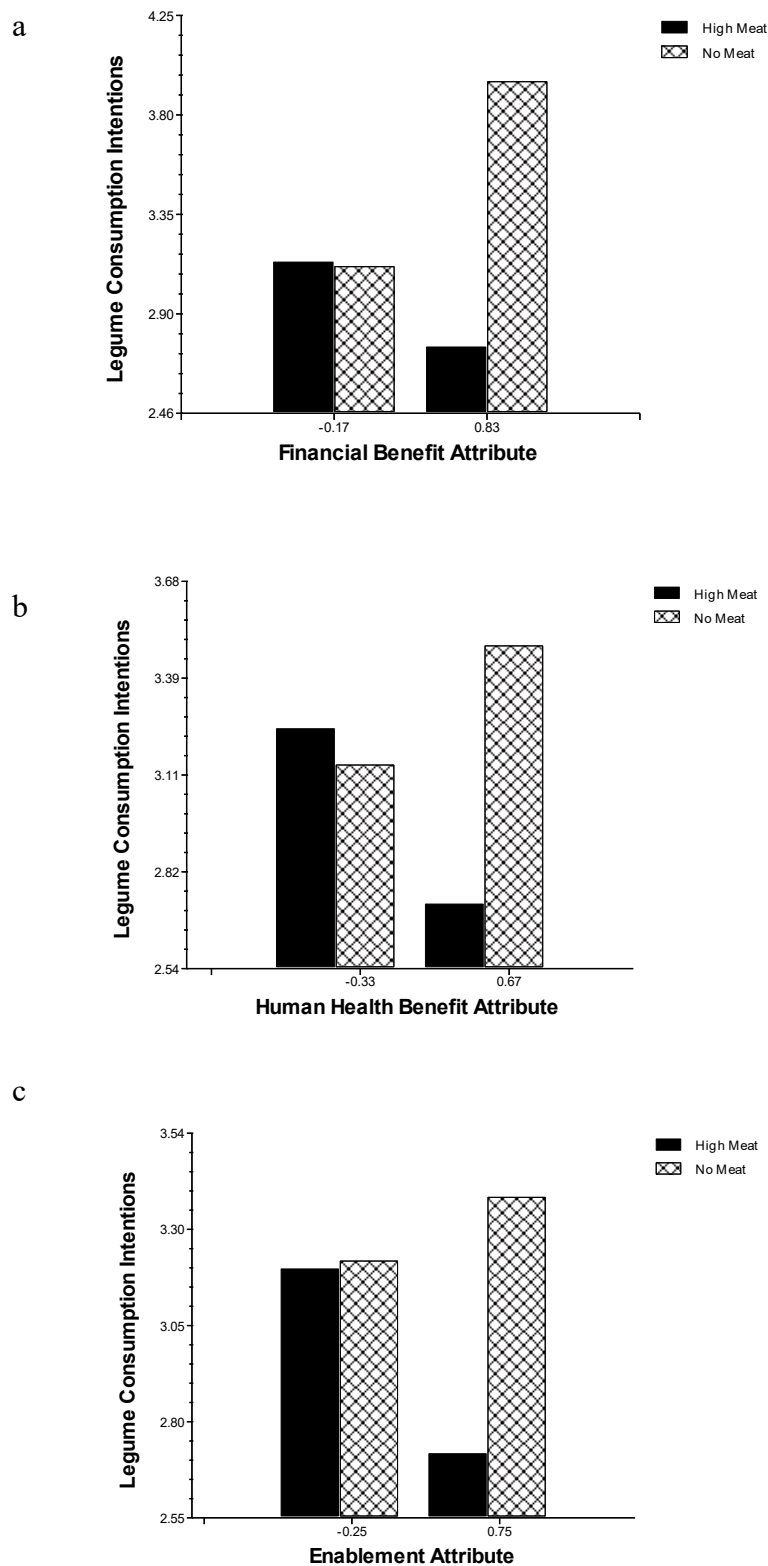


Figure 6.2

(a) Cross-level interaction indicate that messges referenc are high meat eaters, and increase intentions in those with health benefits decrease legume intentions Cross-level interaction indicates that provid increase intentions in those who eat a n

ns in respondents who indicate that messages o eat a no meat diet. (c) h meat eaters, and

Discussion

The current study aimed to determine which legume message attributes (informed by the COM-B behaviour change model) increased peoples' intentions to eat legumes, and if the effects on intentions differed between three diet groups (high meat, moderate meat, and no meat). Using hierarchical linear modelling, we determined that legume consumption intentions could be increased by including or excluding particular message attributes, and that matching message attributes with specific diet groups may render the messages more persuasive.

Diet Group Validation

We first assessed how frequently participants ate meat (red meat, white meat, and fish) and legumes, and matched them to people's self-identified diet group (omnivore, Mediterranean, flexitarian/semi-vegetarian, pescatarian, vegetarian, and vegan). As expected, and in line with past research (Allenden et al., 2024b), omnivore eaters ate red meat significantly more frequently than all plant-rich diet eaters, with Mediterranean and flexitarian/semi-vegetarian eaters consuming it more often than pescatarians, vegetarians, and vegans. Additionally, vegetarians and vegans ate legumes the most often and significantly more often than omnivore eaters, again consistent with past research (Allenden et al, 2024b; Jallinoja et al., 2016; Yurkow et al., 2017). These findings supported the creation of three diet groups, being high meat (69.2%), moderate meat (20.4%), and no meat (10.4%), to be used in the message analysis.

Our results emphasise the vast potential to increase legume consumption in the high meat group to align with the Mediterranean diet (i.e., 2 to 3 days a week to every day) (Bach-Faig et al., 2011; Serra-Majem et al., 2020). Interestingly, our participants who identified as Mediterranean diet eaters did not eat legumes, on average, in line with the above recommendations. This result may be due, in part, to almost two-thirds of participants

identifying as European Australian, thus growing up in a non-Mediterranean country (Scannell et al., 2020) where legume consumption is generally low (Hughes et al., 2022). Nevertheless, these findings signify the need to promote legumes to most Australians, irrespective of with which diet group they identify.

Message Attributes and Legume Consumption Intentions

A key objective of the current study was to determine if certain message attributes, presented as fridge magnets and related to the barriers identified in previous research (Allenden et al., 2025, 2024b) of *ingrained meat-eating habits, perceived lack of time (physical and mental), knowledge, and meat dependence*, would motivate people to increase their legume consumption. Our results found that taste and convenience attributes overall produced strong intentions to add legumes, and was thus motivating for all diet groups. Taste is an automatic motivation in the COM-B (Michie et al., 2011), as people tend to subconsciously perceive how tasty a food is based on past sensory cues (Dibb et al., 2014). This is not surprising given eating is a sensory experience (Farrar & Papies, 2023), though people in high meat consumption countries tend to associate meat with taste benefits more so than with vegetables and legumes (Lacroix & Gifford, 2019; Lea & Worsley, 2001). Nevertheless, our findings reveal that directly referring to taste can motivate people to increase legume consumption, regardless of diet group. However, showing images of meat and legume-based meals (for taste appeal) had no effect, which was surprising given the visual region of the brain is activated when people eat (Simmons et al., 2005). A possible explanation is that the meals used in the stimuli were less appealing or familiar than meat meals, even though they were variations of common Australian dinner meals (McCrindle, 2017). Additionally, some studies (Allenden et al., 2025; Haigh et al., 2019) have found that people with limited exposure to legumes tend to perceive them as unfavourable on taste and texture, which may have influenced people's responses to the visuals.

Referring to convenience also significantly increased legume intentions and was therefore motivating across all groups, with this attribute aimed at overcoming the *lack of time* barrier (Allenden et al., 2025; Allenden et al., 2024b; Figueira et al., 2019). Interestingly, this message attribute was in the form of visuals (i.e. tinned legumes) rather than a written description. This indicates that showing people *how* to save physical time with convenient products may be beneficial as it overcomes the perception that legumes take too long to cook (Figueira et al., 2019; Phillips et al., 2015). Furthermore, mental effort (i.e., decision-making) (Allenden et al., 2024b; Michie et al., 2011) may be alleviated by showing people the actual product to purchase and add to meals. Overall, messages focused on both taste and convenience have the potential to overcome the perceived lack of time and meat dependence barriers, and to encourage people to add more legumes to their meals and reduce their ingrained meat eating habits (Moore & Boldero, 2017).

Our findings also revealed that referencing protein, health, meat reduction, and external organisations *decreased* legume consumption intentions overall, and was therefore detrimental. Most people associate protein and health with meat (Allenden et al., 2024b; Antoniak et al., 2022), so linking these concepts to a lesser-known food like legumes may have contributed to these results. More educational information specifying these health benefits and protein nutrient levels (Didinger et al., 2020) may be warranted, particularly for people who regularly eat few to no legumes (Figueira et al., 2019). A reason for the meat reduction attribute decreasing legume intentions may be an indirect reference to loss. Carfora and Catellani (2023) found replacement messages (i.e., replacing meat with legumes) were less effective in increasing legume consumption compared to addition messages (i.e., add legumes) for people with negative views to (and less identification with) flexitarians. This may have been similar for our participants given most were omnivore eaters, though caution is required given this was not directly assessed. Finally, referencing a reputable external

organisation, while a common COM-B intervention function (Michie et al., 2011), may have been less effective in the current study due to participants being less familiar with the selected organisations. Overall, these results indicate that message attributes referring to protein, health, meat reduction, and external organisations (or at least, those selected for stimuli) may ultimately be detrimental for increasing legume consumption. Conversely, message attributes that promote convenience and taste may be beneficial.

Message Attributes and Diet Groups

Another key aim of the current study was to determine if message attribute effects differed across high meat, moderate meat, and no meat eaters. Our findings provide support for careful consideration of campaign message content based on these diet identities, given that some attributes were motivating and some were detrimental to the desired outcome. Table 6.6 conveys which message attributes significantly increased or decreased legume consumption intentions (i.e., were motivating or detrimental) for the diet groups investigated as well as those that had no effect. Direct reference to financial and health benefits and enablement strategies was determinantal for high meat eaters and motivating for no meat eaters. This may, in part, be due to no meat eaters consuming more legumes (Jallinoja et al., 2016; Yurkow et al., 2017), thus having greater knowledge of the cost savings and health benefits of legumes (Figueira et al., 2019) than high meat eaters. Providing more detailed information about these benefits may therefore be needed for high meat eaters (McEvoy et al., 2018). It was surprising that the enablement strategies were detrimental for high meat eaters as they are intervention functions that can help build new habits (Michie et al., 2011). However, these strategies may be more suited to people already motivated to eat legumes or adopt the Mediterranean diet (Allenden et al., 2025). Overall, these results provide important guidance on how to frame legume-focused messages depending on diet group. They also reveal no differences between high meat and moderate meat eaters.

Table 6.6*Summary of Messaging Recommendations for High Meat, Moderate Meat, and No Meat**Eaters to Eat Legumes*

Message attribute	High meat	Moderate meat	No meat
Imagery and direct reference to legumes and familiar meat meals	–	–	–
Direct reference to taste	✓	✓	✓
Reference to convenience	✓	✓	✓
Direct reference to legumes as protein	×	×	×
Reference to meat reduction	×	×	×
Direct reference to external organisation	×	×	×
Direct reference to human health benefits	×	–	✓
Direct reference to financial benefits	×	–	✓
Enablement (action planning and monitoring)	×	–	✓
Imagery of dried legumes	–	–	–

✓ = Motivating; × = Detrimental; – = No effect.

Morals (environmental/animal welfare) attribute not assessed due to multicollinearity.

Strengths and Limitations

To our knowledge, this is the first study to assess legume-specific message attributes to increase legume consumption intentions in an Australian community sample. Research into strategies to increase legume consumption is generally limited (Carfora & Catellani, 2023), particularly within populations less motivated by health concerns (Davis et al., 2015; McEvoy et al., 2018; Murphy et al., 2022). Using the COM-B (Michie et al., 2011) enabled us to design and test some intervention functions that could potentially overcome legume-specific barriers.

Our findings highlight the importance of promoting the convenience (tinned legumes) and taste attributes of legumes for all diet groups. Food industry manufacturers may consider products that combine both factors (i.e., flavoured, cooked legumes) to promote uptake (Figueira et al., 2019). Past legume research found environmental messaging increased consumption, particularly when paired with social norms (Carfora & Catellani, 2023).

However, our findings add to the literature by extending beyond personal attitudes to more automatic and external factors (Michie et al., 2011). Additionally, our results underscore which message attributes may be detrimental to high meat eaters—the main diet group to target. Furthermore, over 60% of participants stated that they would like to receive the most liked magnet, indicating that Australians may accept this form of messaging.

The current study has some limitations to consider. Firstly, our sample was not representative of the Australian population, with a greater number of women completing the survey, so caution is needed before generalising to the Australian population. It was also unknown whether participants did not cook or were the main/shared cook in the household, which may have influenced their intentions to add beans to meals. Yet, this may have been mediated by our higher proportion of female respondents in the study, given women contribute the most to cooking duties in Australia (Australian Bureau of Statistics [ABS], 2021). Secondly, people more interested in diets may have been more motivated to complete the survey. However, offering incentives in the form of money and course credits likely contributed to the inclusion of a range of eating patterns. Thirdly, the exclusion of the morals (environmental/animal welfare) attribute due to multicollinearity meant that this factor was not assessed and could not therefore be compared to past research (Carfora & Catellani, 2023). As reported above, a conceptual decision was made to include the enablement attribute to address the limited research on habit-focused interventions in the general community (Godfray et al., 2018). Future research could add this factor back in to assess its contribution to legume consumption intention.

A fourth consideration is that message design features (i.e., colour, imagery, bean packaging, and brands) were not assessed independently of the message content, potentially influencing participant responses (Becker et al., 2011; Green, 2018; Pombo & Velasco, 2021); future research should consider disentangling these factors. Additionally, the message

attributes in each magnet were assessed by the research team rather than externally, such as via a pilot study. While some attributes (e.g., ‘imagery of dried beans’) are relatively clear in the messages, other attributes (e.g., ‘enablement’) may be interpreted differently. As such, some caution is warranted when interpreting the results.

Finally, this study focused on intentions to increase legume consumption rather than actual behaviours. Future research would benefit from assessing legume consumption behaviours, specifically how these legume fridge magnets influence actual legume consumption for other household members and ingrained meat-eating habits (i.e., environmental restructuring using a prompt) (Michie et al., 2011).

Conclusions

Legume consumption remains low in Australia and many high income countries, with world averages also low relative to meat levels. If more people are to shift from a high meat diet to the plant-rich Mediterranean diet, their legume intake needs to increase. Our analyses provide key information on which legume message attributes can increase intentions, with convenience and taste vital factors to include for all diet groups. Critically, high meat eaters were *de-motivated* by financial, health, and enablement strategies relative to no meat eaters, indicating that these message attributes should be avoided for this diet group. High meat-eaters in high-income countries urgently need to reduce their meat levels to support a sustainable global food system. The current study provides guidance on cost-effective ways to support these dietary changes by increasing overall consumption of the “humble bean.”

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Appendix G

Legume Messaging Survey

Screening & Demographic Block

Please select the answer that best represents your current situation.

What is your age?

_____ (Scroll down bar to select age >18 up to 100, including prefer not to say)

**Discontinue if >18*

What is your gender?

- ☐ Male
- ☐ Female
- ☐ Non-binary / third gender
- ☐ I prefer not to say

What is the highest education you have completed?

- ☐ Less than High School
- ☐ High School
- ☐ Trade / Technical / TAFE
- ☐ Bachelor's degree
- ☐ Post-graduate (e.g., Master's, Doctorate)
- ☐ Other, please specify _____

With which ethnic group do you primarily identify?

- ☐ European Australian
- ☐ Australian Aboriginal/Torres Strait Islander
- ☐ New Zealander
- ☐ Māori New Zealander
- ☐ Other Oceanian (e.g., Melanesian, Papuan, Micronesian, Polynesian)
- ☐ Northwest European
- ☐ Southern European
- ☐ Eastern European
- ☐ North African/Middle Easterner
- ☐ Southeast Asian
- ☐ Northeast Asian
- ☐ Southern and Central Asian
- ☐ North American
- ☐ South American
- ☐ Sub-Saharan African
- ☐ I prefer not to say

What is your household type?

- ☐ Single person household
- ☐ Couple
- ☐ Couple family with dependent children
- ☐ Couple family with adult children
- ☐ One-parent family with dependent children
- ☐ One-parent family with adult children
- ☐ Multigenerational/Extended family (e.g., children, parents, grandparents)
- ☐ Group household (not family or related)
- ☐ Other, please specify _____

What is your current combined household income (previous year) before taxes, in Australian dollars? Please provide your best guess.

- ☐ Less than \$25,000
- ☐ \$25,000 - \$49,999
- ☐ \$50,000 - \$74,999
- ☐ \$75,000 - \$99,999
- ☐ \$100,000 - \$149,999
- ☐ \$150,000 - \$200,000
- ☐ More than \$200,000
- ☐ I prefer not to say

Which best describes your employment status?

- ☐ Employed - part time (less than 30 hours a week)
- ☐ Employed – full-time
- ☐ Self-employed
- ☐ Not employed
- ☐ Student
- ☐ Retired
- ☐ Other _____
- ☐ I prefer not to say

Current Eating Habits Block

The next few questions ask about your current eating habits.

IN THE LAST WEEK, how often did you eat the following

- ☐ Red meat (beef, lamb, pork)
- ☐ Poultry (chicken, turkey)
- ☐ Fish/seafood
- ☐ Beans/Legumes (e.g., black beans, lentils, chickpeas)
- ☐ Tofu, tempeh
- ☐ Plant-based meat alternatives (e.g., burger patties, sausages, mince, chicken)

5-point scale (1 = never; 2 = 1 day per week; 3 = 2 – 4 days per week; 4 = most day (5 – 6 days per week; 5 = every day)

Now, click on which diet is the closest to describing what you have eaten **OVER THE LAST WEEK**. Choose one only.

Omnivore diet consumes:

- Meat (beef, pork, lamb, poultry, fish, seafood) and other animal-based foods (dairy, eggs) one or more times per day
- Plant-based foods (fruits, vegetables, cereals, legumes, and nuts)

Mediterranean diet consumes:

- Very small or no processed meat
- Small amounts of red meat (beef, lamb, pork; one serving per week)
- Moderate amounts of fish, seafood, poultry, eggs and dairy (2-3 servings per week)
- Plant-based foods (fruits, vegetables, whole grains, legumes, nuts and olive oil)

Flexitarian / semi-vegetarian diet consumes:

- Two to six meat-free days per week
- Very small or no processed meat
- Small amounts of red meat (beef, lamb, pork; one serving per week),
- Small to moderate amounts of fish, seafood, poultry, eggs and dairy (2-3 servings per week)
- Plant-based foods (fruits, vegetables, cereals, legumes, and nuts)

Pescatarian diet consumes:

- No red meat (beef, pork, lamb) or poultry
- Fish, seafood, other animal-based foods (dairy, eggs)
- Plant-based foods (fruits, vegetables, cereals, legumes, and nuts)

Vegetarian diet consumes:

- No meat (beef, lamb, pork, poultry, fish, seafood),
- Animal-based foods (dairy, eggs)
- Plant-based foods (fruits, vegetables, cereals, legumes, and nuts)

Vegan diet consumes:

- No meat or other animal-based food (beef, pork, lamb, poultry, fish, seafood, dairy, eggs)
- Plant-based foods (fruits, vegetables, cereals, legumes, and nuts)

	Fruits / Vegetables	Legumes / Nuts	Dairy	Eggs	Fish / Seafood	Poultry	Red Meat (beef, lamb, pork)
Omnivore	✓	✓	✓	✓	✓	✓	✓
Mediterranean	✓	✓	MODERATE*	MODERATE*	MODERATE*	MODERATE*	LOW*
Pescatarian	✓	✓	✓	✓	✓	✗	✗
Flexitarian / Semi-Vegetarian	✓	✓	LOW – MODERATE**	LOW – MODERATE**	LOW – MODERATE**	LOW – MODERATE**	LOW*
Vegetarian	✓	✓	✓	✓	✗	✗	✗
Vegan	✓	✓	✗	✗	✗	✗	✗

*Low = one serving per week

**Moderate = 2 to 3 servings per week

Does everyone in the household eat the same diet?

- Yes
- No
- N/A

If No: Click on which diet is the closest to describing what other household members have eaten **OVER THE LAST WEEK**.

Omnivore diet consumes:

- Meat (beef, pork, lamb, poultry, fish, seafood) and other animal-based foods (dairy, eggs) one or more times per day
- Plant-based foods (fruits, vegetables, cereals, legumes, and nuts)

Mediterranean diet consumes:

- Very small or no processed meat
- Small amounts of red meat (beef, lamb, pork; one serving per week)
- Moderate amounts of fish, seafood, poultry, eggs and dairy (2-3 servings per week)
- Plant-based foods (fruits, vegetables, whole grains, legumes, nuts and olive oil)

Flexitarian / semi-vegetarian diet consumes:

- Two to six meat-free days per week
- Very small or no processed meat
- Small amounts of red meat (beef, lamb, pork; one serving per week),
- Small to moderate amounts of fish, seafood, poultry, eggs and dairy (2-3 servings per week)
- Plant-based foods (fruits, vegetables, cereals, legumes, and nuts)

Pescatarian diet consumes:

- No red meat (beef, pork, lamb) or poultry
- Fish, seafood, other animal-based foods (dairy, eggs)
- Plant-based foods (fruits, vegetables, cereals, legumes, and nuts)

Vegetarian diet consumes:

- No meat (beef, lamb, pork, poultry, fish, seafood),
- Animal-based foods (dairy, eggs)
- Plant-based foods (fruits, vegetables, cereals, legumes, and nuts)

Vegan diet consumes:

- No meat or other animal-based food (beef, pork, lamb, poultry, fish, seafood, dairy, eggs)
- Plant-based foods (fruits, vegetables, cereals, legumes, and nuts)

	Fruits / Vegetables	Legumes / Nuts	Dairy	Eggs	Fish / Seafood	Poultry	Red Meat (beef, lamb, pork)
Omnivore	✓	✓	✓	✓	✓	✓	✓
Mediterranean	✓	✓	MODERATE*	MODERATE*	MODERATE*	MODERATE*	LOW*
Pescatarian	✓	✓	✓	✓	✓	✗	✗
Flexitarian / Semi-Vegetarian	✓	✓	LOW – MODERATE**	LOW – MODERATE**	LOW – MODERATE**	LOW – MODERATE**	LOW*
Vegetarian	✓	✓	✓	✓	✗	✗	✗
Vegan	✓	✓	✗	✗	✗	✗	✗

*Low = one serving per week

**Moderate = 2 to 3 servings per week

Awareness of Mediterranean Diet Block

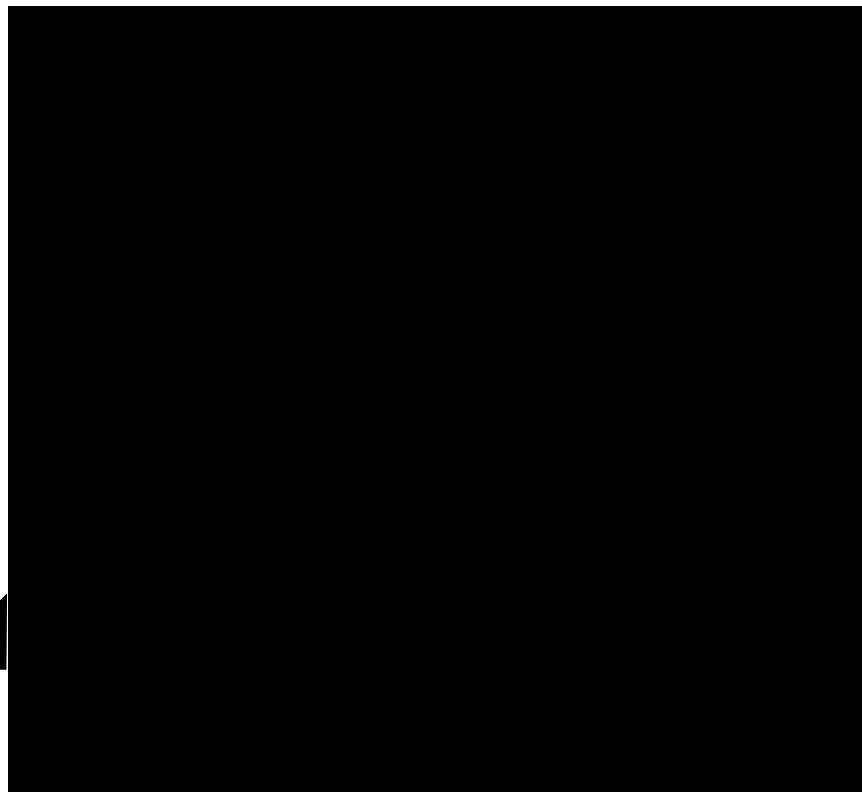
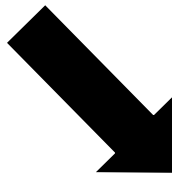
How familiar are you with the Mediterranean diet?

- 1 - Not at all familiar
- 2 - Slightly familiar
- 3 - Somewhat familiar
- 4 - Moderately familiar
- 5 - Extremely familiar

Mediterranean Diet Information Block

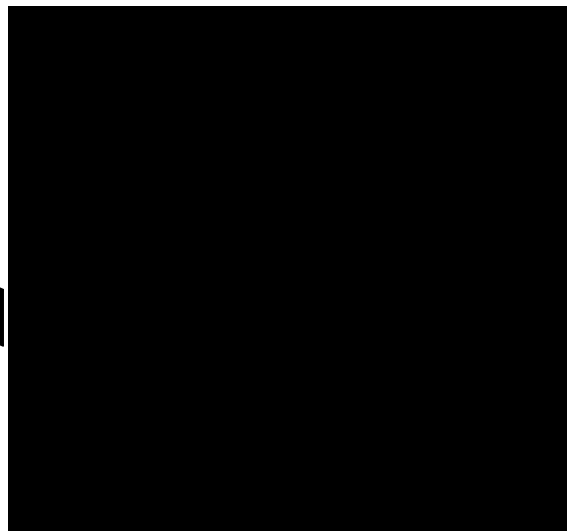
This is the Mediterranean Diet Pyramid which shows the main foods in this diet and how often each of these foods are consumed. **The Mediterranean diet includes high levels of beans and legumes.**

**Beans and
Legumes**



This is one example of a Mediterranean diet plate, showing portion sizes.

Beans and Legumes



The difference between an omnivore diet and the Mediterranean diet is:

Omnivore diet includes:

- High frequency of meat (beef, pork, lamb, poultry, fish, seafood) and other animal-based foods (dairy, eggs) one or more times per day
- Small to moderate amounts of plant-based foods (fruits, vegetables, cereals, legumes, and nuts)

Mediterranean diet includes:

- Very small to no processed meat
- Small amounts and low frequency of red meat (beef, lamb, pork; one serving per week)
- Moderate amounts and moderate frequency of fish, seafood, poultry, eggs, and dairy (2-3 servings per week)
- Large amounts and very high frequency of plant-based foods (fruits, vegetables, whole grains, legumes, nuts, and olive oil)

	Fruits & Vegetables	Legumes / Nuts	Dairy	Eggs	Fish/ Seafood	Poultry	Red Meat (beef, lamb, pork)
							
Mediterranean	✓	✓	MODERATE*	MODERATE*	MODERATE*	MODERATE*	LOW*

*Low = one serving per week

*Moderate = 2 to 3 servings per week

Likelihood of Adopting the Mediterranean Diet Block

How likely are you to adopt the Mediterranean diet in the next month?

- 1 - Extremely unlikely
- 2 - Unlikely
- 3 – Neither likely nor unlikely
- 4 - Likely
- 5 - Extremely likely

Likelihood of Putting a Bean Fridge Magnet on Fridge Block

We are now going to ask you to rate a series of fridge magnet ideas about beans and legumes.

First, how likely are you to put a magnet on your fridge about beans and legumes?

- 1 - Extremely unlikely
- 2 - Unlikely
- 3 – Neither likely nor unlikely
- 4 - Likely
- 5 - Extremely likely

Message Block

Please read each fridge magnet and answer the questions about each one.

Message 1



Please indicate how much you like this fridge magnet.

- ☐ 1 - Strongly dislike
- ☐ 2 - Dislike
- ☐ 3 - Neither like nor dislike
- ☐ 4 - Like
- ☐ 5 - Strongly like

To what extent did you find this message easy to understand?

- ☐ 1 – Extremely difficult
- ☐ 2 – Moderately difficult
- ☐ 3 – Neither easy nor difficult
- ☐ 4 – Moderately easy
- ☐ 5 – Extremely easy

How likely are you to add beans to your meals after seeing this fridge magnet?

- ☐ 1 - Extremely unlikely
- ☐ 2 - Unlikely
- ☐ 3 - Neither unlikely nor likely
- ☐ 4 - Likely
- ☐ 5 - Extremely likely

How likely would the people you live with eat beans after seeing this fridge magnet?

- ☐ 1 - Extremely unlikely
- ☐ 2 - Unlikely
- ☐ 3 - Neither unlikely nor likely
- ☐ 4 - Likely
- ☐ 5 - Extremely likely

How likely are you to put this fridge magnet on your fridge?

- 1 - Extremely unlikely
- 2 - Unlikely
- 3 - Neither unlikely nor likely
- 4 - Likely
- 5 - Extremely likely

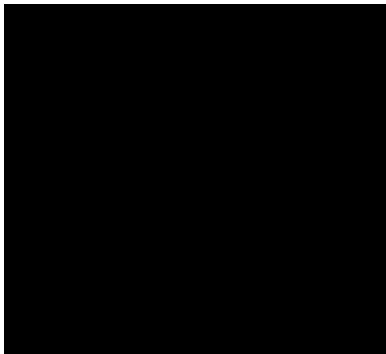
To what extent would you share this fridge magnet with friends or family?

- 1 - Extremely unlikely
- 2 - Unlikely
- 3 - Neither unlikely nor likely
- 4 - Likely
- 5 - Extremely likely

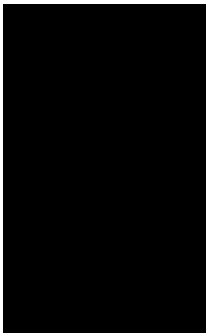
*****Questions asked after each message***

Message 2

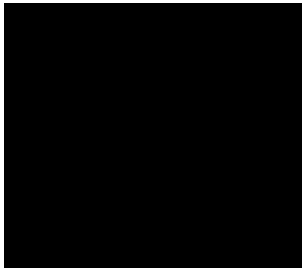
1/2 Meat 1/2 Beans Better for the planet



+



=



Beef and Lentil
Bolognaise

Message 3

Beans... the affordable protein



Message 4

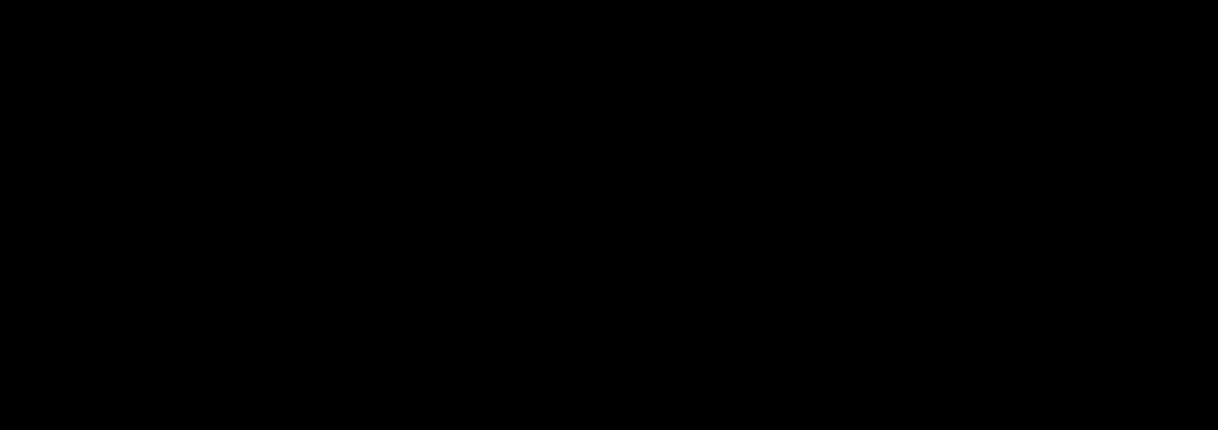
Beans benefit the budget

Legumes provide a valuable and cost effective source of protein. Enjoying legumes more often is a great way to help your meals go further.



Message 5

Mediterranean BEAN Mondays



Message 6

Message 7

**BEANS...the better
protein**

**For the environment
For your health
For animals**

Message 8

**The humble BEAN...great
for the environment**



Message 9

Just add BEANS

Healthy Recipes

Chicken and Chickpea
Curry

Tuna and Four Bean
Salad

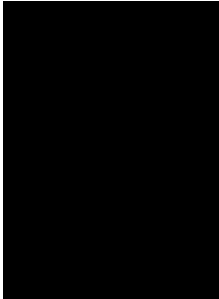
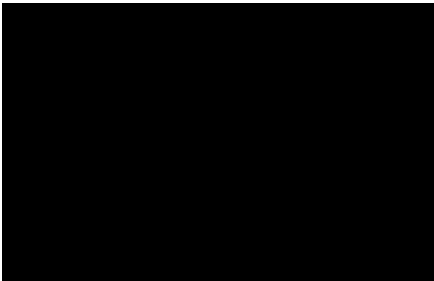
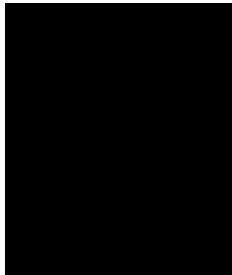
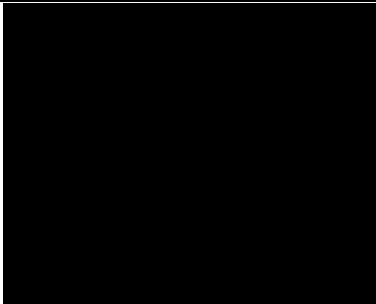
Beef and Lentil
Bolognese

Message 10

Just add BEANS

Shopping List

Message 11

Just add BEANS			
	 Chicken and Chickpea Curry	✓	
		Monday	
		Tuesday	
		Wednesday	
		Thursday	
		Friday	
		Saturday	
		Sunday	
	 Beef and Lentil Bolognaise	Monday	
		Tuesday	
		Wednesday	
		Thursday	
		Friday	
		Saturday	
		Sunday	

Message 12

BEANS...the tasty & healthy protein

Behavioural Commitment Block

If the most liked magnet were to be made into an actual magnet, I would want one.

- Yes/No

Higher Degree Research Thesis by Publication
University of New England

Statement of Originality

(To appear at the end of each thesis chapter submitted as an article/paper)

We, the Research Master/PhD candidate and the candidate's Principal Supervisor, certify that the following text, figures and diagrams are the candidate's original work.

Type of work	Page number/s
Text (inclusive of tables)	238 - 291

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Name/title of Principal Supervisor: ASSOCIATE PROFESSOR AMY LYKINS



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Date



Principal Supervisor

3 December, 2024

Date

Higher Degree Research Thesis by Publication
University of New England

Statement of Authors' Contribution

(To appear at the end of each thesis chapter submitted as an article/paper)

We, the PhD candidate and the candidate's Principal Supervisor, certify that all co-authors have consented to their work being included in the thesis and they have accepted the candidate's contribution as indicated in the *Statement of Originality*.

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Chapter 7

General Discussion and Conclusions

As the world edges towards surpassing several environmental tipping points (Wunderling et al., 2021), we must make the necessary changes to combat this crisis. Plant-rich eating is one way to reduce the negative environmental effects of livestock production, and at the same time, support human and animal health (Intergovernmental Panel on Climate Change [IPCC], 2019, 2022). Plant-rich eating, however, is generally elusive in high-income countries, such as Australia, where high-meat diets remain the norm (Whitton et al., 2021). As such, the outcomes of this thesis provide urgent and practical guidance on how to boost plant-rich eating in Australia, with our learnings also applicable to other high-meat, high-income countries.

Using behaviour change models within a ‘One Health’ framework (Zinsstag et al., 2011), the current thesis identified the Mediterranean diet as the plant-rich diet to target in an intervention (objective 1); novel qualitative and quantitative investigations revealed multiple capability, opportunity, and motivation (COM-B) (Michie et al., 2011) factors impeding Mediterranean diet adoption (objective 2). Our collated findings then informed the design of a messaging intervention aimed at increasing consumption of the core Mediterranean diet food, legumes (objective 3). As Australians and other high-income countries continue to consume meat at alarmingly high rates (Whitton et al., 2021), we urgently need to align our eating patterns to a sustainable food system. The current thesis provides a novel approach to tackle this critical issue, leading to new insights on where to start and how to get there.

Where to Start—Selecting a Target Plant-Rich Diet

Study 1 aimed to identify which plant-rich diet to target in an intervention designed to increase plant-rich eating in Australia. Despite the importance of selecting a target behaviour in the behaviour change process (McKenzie-Mohr, 2011; Michie et al., 2011), this vital first

step has generally been overlooked in the sustainable eating field (Lea & Worsley, 2003; Rattenbury & Ruby, 2023; Rosenfeld & Tomiyama, 2020). Including this step in our approach is a major contribution to the field as it safeguards our starting point by reducing the risk of investing in the wrong (or less effective) plant-rich diet. To ensure a thorough approach to plant-rich diet selection, we applied the community-based social marketing (CBSM) (McKenzie-Mohr, 2011) behaviour change model to assess the effectiveness of five plant-rich diets (Mediterranean, flexitarian/semi-vegetarian, pescatarian, vegetarian, and vegan) across three key metrics—environmental, human health, and animal welfare. The holistic ‘One Health’ approach informed the selection of these metrics, and life cycle assessments (LCA) (Aleksandrowicz et al., 2016; Batlle-Bayer et al., 2020), health (Biesbroek et al., 2014; Mitrou et al., 2007; Orlich et al., 2013; Sabate et al., 2015; Soret et al., 2014; Springmann et al., 2018), and animal welfare data (Scherer et al., 2019) were applied in the analysis. The essential ‘human element’ was then measured by assessing the likelihood of people adopting each plant-rich diet, along with current diet penetration levels (of each plant-rich diet and the high-meat omnivore diet) (McKenzie-Mohr, 2011). Using this novel inter-disciplinary approach, the Mediterranean diet had the highest overall weighted impact score on the behaviour prioritization matrix (BPM) and thus was identified as the plant-rich diet to target.

Essentially, the Mediterranean diets’ high performance on the BPM was due to it being moderately effective—it was the third most effective plant-rich diet after the vegan and vegetarian diets—and had the highest probability of adoption. In fact, both meat-reduced diets had the highest probability scores; and while these results were expected, given over 70% of participants were omnivore eaters and eliminating meat altogether is generally not preferred by meat eaters (Malek et al., 2019), it was unknown *which* meat-reduced diet would attain the highest score. The Mediterranean diet is highly recommended by prominent

Australian health organisations (Dieticians Australia, 2023; The Royal Australian College of General Practitioners, 2014), so this greater exposure may partly explain why our participants were more likely to adopt this plant-rich diet relative to the more recent and potentially lesser-known flexitarian/semi-vegetarian diet (Derbyshire, 2017; Hudders & de backer, 2014; Springmann et al., 2018).

Despite this higher probability score, the Mediterranean diet was consumed by 5.5% of participants, being less than double the flexitarian/semi-vegetarian diets' penetration rate (14.2%). This corresponds with other Australian research where 18.9% of participants identified as flexitarian eaters (Estell et al., 2021), though their higher penetration rate may relate to them including only one meat-reduced diet. Additionally, in our later studies (Study 3 and 4), variations to these penetration levels were observed, with more people consuming the Mediterranean diet relative to the flexitarian/semi-vegetarian diet, though Study 4 had a greater number of female participants. Nevertheless, the flexitarian diet is clearly growing in popularity in high-meat, high-income countries (Dagevos, 2021; Estell et al., 2021; Mathieu & Ritchie, 2022; Wozniak et al., 2020). People motivated to reduce their meat levels for environmental and health reasons may find a flexible approach to meat reduction attractive, especially if shifting from a current diet that is high in meat (Dagevos, 2021).

Despite these penetration trends and high probability score, the flexitarian/semi-vegetarian diet was the *least effective* plant-rich diet in our study; that is, it had the lowest environmental, human health, and animal welfare effectiveness score, and the second lowest overall impactful score. As such, the flexitarian/semi-vegetarian diet is considered easier to implement (i.e., higher probability of adoption) (Kneebone et al., 2017), but less effective within a 'One Health' framework, and so is likely not a good candidate for promotion (McKenzie-Mohr, 2011). This finding is pertinent (and emphasises why plant-rich diets need to be assessed on a wide-range of effectiveness and behavioural metrics) given the growing

popularity of this diet (Dagevos, 2021; Estell et al., 2021; YouGov, 2024; Wozniak et al., 2020). Comparatively, the Mediterranean diets had the highest human health score (being almost five points higher than the flexitarian/semi-vegetarian diet) and a higher environmental score, possibly due to its stricter red meat levels (i.e., once per week) (Bach-Faig et al., 2011; Ulaszewska et al., 2017). Additionally, most flexitarian eaters only ‘mildly’ reduce their meat intake (Dagevos, 2021), further signifying that a flexible approach to meat eating, at least at the mild end, is less likely to meet the environmental and human health outcomes needed to combat this meat crisis.

The flexitarian diet has no consistent definition (Dagevos, 2021), as we discovered with the inclusion of (slightly) different flexitarian/semi-vegetarian definitions in our analysis (Biesbroek et al., 2014; Bryngelsson et al., 2016; Martin et al., 2016; Springmann et al., 2018; Vieux et al., 2012), with this potentially impacting our assessment. Nevertheless, specific meat guidelines, as found in the Mediterranean diet (Bach-Faig et al., 2011; Ulaszewska et al., 2017), appears more conducive to achieving a moderate effectiveness score. By contrast, eating no meat, while highly effective, is unlikely to be adopted by high-meat eaters. In fact, our study showed that the more meat was removed from a diet, the lower the probability of adoption. This provides a clear narrative for individuals and policy makers—meat exclusionary diets are highly effective but difficult to implement, and so probably should not be targeted if we are aiming for maximum potential impact (McKenzie-Mohr, 2011). Despite these findings, LCA literature has traditionally focused on meat-exclusionary diets (as we found in our analysis), though meat-reduced diets are increasingly being assessed (Chen et al., 2019; Kim et al., 2020; Springmann et al., 2018; van Dooren et al., 2014). This shift in LCA research is vital given high-meat eaters appear more amenable to reducing, rather than eliminating meat from their diet. It should be noted that the vegetarian diet had the second highest overall impact score but was more than 10 points

lower than the Mediterranean diet, signifying a large gap between the Mediterranean diet and all other plant-rich diets assessed—a result of the Mediterranean diet achieving moderate to high scores across *all* indices relative to the other plant-rich diets.

Considering the above findings, applying an inter-disciplinary behaviour change approach to identify *which* plant-rich diet to target, cannot be understated. By combining these effectiveness and behavioural measures in a BPM (rather than relying on either one independently), our findings significantly help individuals, researchers, and policy makers focus their efforts on a plant-rich diet that supports the ‘One Health’ approach *and* is likely to be adopted. To that end, Study 1 provides a clear starting point—the Mediterranean diet is a realistic and potentially more successful plant-rich diet to promote to omnivores, with enormous potential to help people shift from high-meat to high-plant eating.

Identifying the Barriers and Drivers to Eating a Mediterranean Diet

With the Mediterranean diet now established as the diet to target, step 2 of the CBSM was employed to identify the barriers and drivers to adoption to inform the development of an intervention aimed at increasing uptake. Using the comprehensive behaviour change wheel (BCW) (Michie et al., 2011), Studies 2 and 3 aimed to identify which capability, opportunity, and motivation (COM-B) factors influence peoples’ adoption of the Mediterranean diet. In Study 2, ethnographic semi-structured interviews were conducted with 16 Australian residents who were currently eating an omnivore or plant-rich diet. This is the first time a comprehensive inductive (reflexive thematic analysis) (Braun & Clarke, 2019; Braun et al., 2022) and deductive (COM-B) (Michie et al., 2011) approach has been used to identify key drivers and barriers to Mediterranean diet adoption. Five key themes were identified across the COM-B: ingrained eating habits, perceived lack of physical and mental availability, social influences, taste and satiety, and human health.

Study 3 extended these findings by being the first to develop a Mediterranean diet COM-B survey (informed by Study 2), to identify which barriers predicted Mediterranean diet adoption. This was conducted by surveying a representative sample of 443 Australian residents. Hierarchical regression further informed how significant each barrier was, with *Mediterranean Diet Familiarity*, *Lack of Time and Knowledge*, and *Not Having to Cook for Others* being top predictors of Mediterranean diet adoption. *Meat Dependence* and *Household Dietary Preferences* also impacted adoption, though to a lesser extent. Another key and novel feature of our quantitative study was the assessment of current eating habits (i.e., meat and meat-replacement foods) across three diet groups (omnivore, Mediterranean, and flexitarian/semi-vegetarian), with our findings confirming that omnivores' high red meat and low legume eating habits misaligned with the Mediterranean diet (Bach-Faig et al., 2011; Serra-Majem et al., 2020). Taken together, these barriers correspond directly with one's capability, opportunity, and motivation to eat a Mediterranean diet, signifying the need for a multi-faceted intervention approach. Using this holistic and thorough approach not only enabled a better understanding of people's current eating choices, but comprehensive information on what, and how, to shift dietary behaviours towards Mediterranean diet eating (using the COM-B as a map) as detailed below.

Capability impacted Mediterranean diet adoption with multiple barriers linked to this source of behaviour. Firstly, people were simply less familiar with which foods (and in what portions) formed the Mediterranean diet, impacting their psychological capability. Clearly people need to know the specifics of the Mediterranean diet if they are to adopt it; and while our findings are consistent with past qualitative research (Moore et al., 2018; Scannell et al., 2020; Tsofliou et al., 2022), using hierarchical analyses established *Mediterranean Diet Familiarity* as the strongest barrier that predicted Mediterranean diet adoption. As such, providing specific Mediterranean dietary information—meat type/frequency and legumes—

should form the baseline of any intervention designed to increase adoption. Despite limited Mediterranean diet (specific) knowledge, our participants perceived the Mediterranean diet as healthy *and* environmentally friendly. While this health finding was expected (due to this diets' health credentials and promotion, as highlighted above), the environmental findings were less expected given our study was the first (to our knowledge) to assess this vital measure. As such, our findings confirm that both health and environmental concerns may be leveraged to encourage uptake, especially for people motivated by these factors.

People's limited mental availability was another capability factor that significantly impacted Mediterranean diet adoption. This factor formed part of the greater barrier—lack of time and knowledge—impacting one's physical opportunity (i.e., less physical availability to change diets and buy the necessary ingredients) and psychological capability (i.e., less knowledge of Mediterranean diet recipes and mental availability to learn them). Lack of time and the perceived 'inconvenience' of changing to a Mediterranean or other plant-rich diet is documented in the literature (Malek et al., 2019, Middleton et al., 2015; Scannell et al., 2020). Using the COM-B, however, highlighted how broad and inter-related this barrier is, impacting both individual and external factors, thus contributing to the design of potentially more effective interventions to overcome this key barrier. These time constraints also matched our pantry and fridge visual observations, with 'convenience foods' (some of which were ultra-processed, and thus conveying their own risks to human health) (Monteiro et al., 2018), a feature for all participants, regardless of diet membership. With the convenience food category rapidly growing (Wooldridge et al., 2021), people clearly seek quick and easy meals regardless of which diet they eat. Adopting a new diet places pressure on these already limited psychological capabilities and physical opportunities, suggesting the need to promote small changes (Lacroix & Gifford, 2020) using familiar and convenient foods. People clearly

need to be motivated to change their current dietary habits, but showing them easy ways to achieve the necessary changes will most likely increase their chances of success.

Motivation was another prominent factor impeding Mediterranean diet adoption. Specifically, people automatically ate their high meat diets (and preferred the taste of meat), making dietary change difficult. Clearly, these ‘auto-pilot’ meat eating habits need to be modified, with our findings drawing attention to two foods—red meat and legumes. While these foods are referenced as barriers in the Mediterranean diet research (Moore et al., 2018; Tsofliou et al., 2022), our results were the first to quantitatively confirm that omnivores eat red meat significantly more frequently (and legumes significantly less frequently) than Mediterranean diet and flexitarian/semi-vegetarian eaters in a community sample. Additionally, legumes were the most frequently consumed meat-replacement food across all diet groups, relative to tofu/tempeh and plant-based meat alternatives (PBMA). Thus, legume habit formation appears to have occurred for some omnivore participants (Gardner, 2015), indicating that this meat-replacement food may be more successful to prompt (i.e., repeat an existing habit) as opposed to the less (or not) consumed tofu/tempeh and PBMA (i.e., forming a new habit).

Additionally, the Mediterranean diet represents a ‘healthy’ plant-rich diet, encompassing whole grain foods (such as legumes) (Bach-Faig et al., 2011; Serra-Majem et al., 2020). While PBMA are most likely part of the meat crisis solution, their varied health credentials (Harnack et al., 2022; Miller et al., 2024) makes their promotion concerning in our ultra-processed food environment, further supporting the need to promote nutritious and healthy foods such as legumes (Calles et al., 2019; Margier et al., 2018). Advising people (through education) that legumes are a core, convenient (i.e., tinned legumes) and inexpensive Mediterranean diet food, and that their nutritional qualities are somewhat

comparable to meat, however, is also needed to overcome *Mediterranean Diet Familiarity*, *Lack of Time and Knowledge*, and *Meat Dependence* barriers, respectively.

Our application of ethnographic visual research techniques (i.e., viewing participants' fridge and pantry), combined with people's dinner meal and shopping descriptions, provided a unique opportunity to examine eating habits across the eating spectrum. Essentially, our findings emphasised that habitual behaviours extend beyond eating, to purchasing, preparation, and decision-making processes (Rees et al., 2018). Our observational techniques also aided in reducing the intention-behaviour gap, a well-known issue that can influence behaviour change (Webb & Sheeran, 2006), with no key discrepancies found, supporting a more robust assessment of these eating habits.

Taste was another automatic motivation impacting Mediterranean diet uptake as confirmed quantitatively (i.e., *Meat Dependence* barrier) and qualitatively (i.e., taste preferences for meat as opposed to vegetables/legumes) in our studies, corresponding with past research (Corrin & Papadopoulos, 2017; de Boer et al., 2007; Graça et al., 2015; Lea & Worsley, 2001; McEvoy et al., 2018). The benefits of using a deep dive, reflexive thematic analysis (Braun & Clarke, 2019; Braun et al., 2022), however, was particularly relevant for this theme, as all participants' spontaneously mentioned taste (and their meat taste preferences). Eating is a sensory experience and stimulates our reward system (de Boer & Aiking, 2017; Farrar & Papies, 2023), so it not surprising that taste was mentioned, unprompted, by everyone interviewed. Our findings, however, support the vital inclusion of this automatic motivation in an intervention design. As legumes are a core Mediterranean diet food, people clearly need to overcome these taste barriers if they are to adopt this diet.

Finally, social opportunity also presented as a key barrier, namely that other household members would not adopt the Mediterranean diet. Lack of family support can hinder Mediterranean diet adoption and meat reduction (Kretowicz et al., 2018; Lacroix &

Gifford, 2020; Stoll-Kleemann & Schmidt, 2017), though this external factor has received less attention in the research. As such, our analysis significantly extends the research in this field by explicitly considering how people's eating experiences are influenced by their social environment. Specifically, our findings provided vital information on how children's taste preference for meat and 'carbs' can influence dinner meal selection, emphasising the importance of considering taste preferences for the whole household as opposed to simply those of individual research participants. One question in the COM-B survey, *Not Having to Cook for Others*, was a key predictor of Mediterranean diet adoption, further emphasising how influential other household members can be. The inter-relationship between household influences and other COM-B factors is particularly salient, stressing the need for tailored interventions—lack of time influenced how much energy participants (particularly parents) had to 'enforce' the consumption of vegetables and legumes, with people often reverting to familiar meat-focused meals (i.e., current eating habits) that everyone would eat. Given most households ate the same diet (and dinner meals), this barrier is clearly vital to consider, highlighting the need for interventions aimed at the whole household (Harrison et al., 2015).

Findings from our two studies clearly show that all three COM-B factors need to be addressed in an intervention design. By applying a behaviour change model, we were able to conduct a thorough and systematic examination of how one's capability, opportunity, and motivation individually and collectively (Michie et al., 2011) impede Mediterranean diet adoption and, consequently, which barriers to prioritise in intervention development. High-meat eaters in non-Mediterranean diet countries clearly need considerable support to adopt the Mediterranean diet (Scannell et al., 2020; Tsofliou et al., 2022; Whitton et al., 2021). With our current eating patterns contributing to rising temperatures, human diseases, and animal suffering (Aleksandrowicz et al., 2016; Battle-Bayer et al., 2020; Scherer et al., 2019), we cannot waste time and money on less effective interventions (McKenzie-Mohr, 2011). To

that end, our findings come at a critical time, providing a clear road map on how to achieve vital components of these crucial dietary shifts.

Designing and Evaluating a Behaviour Change Intervention

Equipped with a target diet and key adoption barriers, Study 4 involved the development of a pilot intervention (with 201 participants) aimed at increasing Mediterranean diet adoption by targeting low legume consumption. The purpose of using a pilot intervention, being step 4 of the CBSM (McKenzie-Mohr, 2011), was to evaluate efficacy prior to investing in a full-scale implementation, showcasing the advantages of using a behaviour change model that incorporates investment effectiveness in its process. Specifically, we designed and evaluated several persuasive messages aimed at increasing legume consumption. The decision to focus on one primary Mediterranean diet food was informed by our COM-B findings and the literature in non-Mediterranean diet countries (Moore et al., 2018; Tsofliou et al., 2022), with our in-depth assessment of habitual eating behaviours also driving this decision. As legumes are a *low* eating habit for omnivore eaters (further confirmed in our intervention study), increasing consumption is clearly needed if people have any chance of adopting the Mediterranean diet; so, targeting a healthy meat-replacement food appeared apt. To alleviate the perceived time pressures of shifting to a Mediterranean diet, we decided to focus on adopting one critical component of the Mediterranean diet rather than the whole diet. This decision was further informed by our target audience—the community. Essentially, we were keen to assess the effectiveness of a less intensive intervention for broader scale application, contrasting with past research in health settings (Davis et al., 2015; McEvoy et al., 2018; Murphy et al., 2022). Additionally, persuasive messages increased legume consumption in an Italian study (Carfora & Catellani, 2023); we were interested to assess whether this format may prove successful in a non-Mediterranean diet country, such as Australia.

Message attributes were designed to target the key barriers identified from our previous studies, specifically lack of time and knowledge, meat dependence, and ingrained meat-eating habits. Our findings provided evidence that when referencing taste and convenience (e.g., specifically showing *tinned* lentils), message attributes can increase *all* participants' intentions to consume legumes, whereas referencing protein, health, cost savings, meat reduction, and external legume organisations (or possibly those we selected to use in our study) can be detrimental. Legume consumption frequency was again assessed and corresponded with Study 3's findings—omnivores ate legumes less frequently than plant-rich diet eaters (Mediterranean, flexitarian/semi-vegetarian, pescatarian, vegetarian, and vegan); however, compared to the Mediterranean diet guidelines legumes (Bach-Faig et al., 2011; Serra-Majem et al., 2020), all participants under-consumed this vital food group. These eating habits are perhaps unsurprising given participants were from a non-Mediterranean, high meat-eating country, but they do indicate how far-reaching our findings can be for all Australians. This is a critical finding given legumes are significantly under consumed in Australia and world-wide irrespective of a person's typical diet (Gilham et al., 2018; Hughes et al., 2022; Marinangeli et al., 2017).

Legumes are often perceived as inconvenient, as they take too long to cook (Figueira et al., 2019; Phillips et al., 2015). Targeting the lack of time barrier in our messages (i.e., by showing tinned lentils) clearly increased people's intention to eat lentils, and for some, possibly debunked the idea that they have no time to eat this food, or the Mediterranean diet in general. Showing people which product to buy may have also acted as a visual 'shopping list' cue, further reducing decision-making demands (Michie et al., 2011). While not directly assessed, this format may help shift people's purchasing habits to incorporate (and increase) legumes consumption.

Taste was the other key message attribute identified, which is somewhat expected given the strong link between taste and food, as highlighted in our previous studies and the literature (Farrar & Papies, 2023; Lacroix & Gifford, 2019). Directly referring to taste by adding ‘tasty’ in the message may have stimulated a positive sensory cue (Farrar & Papies, 2023); though unexpectedly, showing visuals of meat-and-legume-based meals (being a less direct reference to taste) did not prompt a significant increase in legume consumption intentions. This may relate more to the meals shown (e.g., variations of common Australian meat-based meals) (McCrindle, 2017), rather than meal visuals being less effective, though it does partly correspond to some of our qualitative participants responding negatively to visuals of legume-focused meals. More research is clearly needed to tease this finding apart.

Omnivore eaters (referenced as the *high meat* group) also had comparable red meat (high) and legume (low) eating habits to Study 3 (and relative to other plant-rich diets), providing a consistent snapshot of eating habits per diet group in Australia. Assessing eating habits in this manner facilitated the assessment of message attributes per diet group, with those referencing health and financial benefits or enablement strategies significantly *decreasing* legume consumption intentions (and was, in fact, detrimental) for the *high meat* group compared to the *no-meat* group (pescatarian, vegetarian, and vegan eaters). Given high meat eaters are our target audience, these findings clearly signify the need to exclude these attributes for legume promotion in messages targeting this group. The positive association between meat and health (Antoniak et al., 2022) may have impacted our health finding, given health was linked with a potentially lesser-known food. Given the health message attribute was detrimental for all participants, more education may be needed outlining the health credentials of legumes and their protein properties (Didinger et al., 2020). Additionally, no differences were found between the *high meat* and *moderate meat* (Mediterranean and

flexitarian/semi-vegetarian eaters) groups, indicating that similarly framed messages can be used when targeting these (majority) diet groups.

Two other key barriers, *Mediterranean Diet Familiarity* and *Household Dietary Preferences*, were also considered in our intervention design, though not directly assessed. Specifically, participants viewed the Mediterranean diet pyramid and plate example in the survey (with specific reference to legumes), and each message was presented online in the form of a fridge magnet. As such, the above effective persuasive messages could be developed into actual fridge magnets and assessed (e.g., using environmental restructuring) (Michie et al., 2011) to further determine how this mode of messaging can act as a reminder to include legumes in meals (i.e., alleviating mental availability demands), and as a prompt for *all* household members (i.e., to increase social opportunity). As over 60% of participants said ‘yes’ to receiving the most liked magnet across all participants, extending this research appears warranted, specifically as a relatively inexpensive wider-scale intervention with community members.

As the first legume messaging intervention conducted with an Australian community sample to our knowledge, our findings critically add to the limited literature in this field. Our pilot study provides confidence that persuasive messaging (in the form of a fridge magnet) may be a relatively inexpensive way to motivate people to increase their legume intake and should be further explored in future research. By matching the COM-B barriers (from our previous studies) with the intervention functions (from the second layer of the BCW), we were able to design and assess message attributes methodically, with clear outcomes guiding additional research. This systematic approach to intervention design demonstrates the advantages of applying the comprehensive BCW, with our findings contributing much needed direction on how to edge people closer to plant-rich diet consumption.

Limitations of the Research

There were some limitations across each of the four studies. In Study 1, extensive variability existed across the studies used in our effectiveness assessment, as such, the median was used to increase internal consistency (Aleksandrowicz et al., 2016). Limited human health data also made comparison analysis somewhat difficult. Three to four studies were available for each plant-rich diet, except for the Mediterranean diet, with this diet's high performance based on one study (Biesbroek et al., 2014; Mitrou et al., 2007; Orlich et al., 2013; Sabate et al., 2015; Soret et al., 2014; Springmann et al., 2018). Our findings, however, do correspond with the Mediterranean diets' high performance on other health measures (Chen et al., 2019; Clarys et al., 2014; Rosi et al., 2017; van Dooren et al., 2014), though more data would clearly be beneficial. Our human health assessment was also based on 'all-cause mortality' and/or 'deaths averted,' due to data availability for the plant-rich diets assessed (Aleksandrowicz et al., 2016). Given human health is vital for a sustainable food system, (Food and Agriculture Organization [FAO] of the United Nations, 2010), additional measures may provide a broader understanding of this 'One Health' factor.

The varied definitions in the analysis of the flexitarian/semi-vegetarian diet possibly impacted effectiveness results as highlighted above, and potentially our data on the probability of its adoption. Additionally, the flexitarian/semi-vegetarian diet definition varied slightly across the studies (i.e., from three meat-free days per week in Study 1 and 2, to two to six meat-free days per week in Study 3 and 4), a decision made by the researchers to align with the latest published research (Dagevos, 2021). This modification may have impacted penetration levels across the studies, though given the small variations, this impact was most likely minimal.

Various recruitment methods were also used in Study 2, possibly attracting participants who were more interested in plant-rich eating than the average Australian.

Offering students study credits and all participants a cash reward, however, reduced this bias, as did recruiting omnivores who were less interested in adopting the Mediterranean or another plant-rich diet. Additionally, most of the participants' household income and education levels were higher than the average Australian population (Australian Bureau of Statistics [ABS], 2021), thus potentially impacting the ability to generalise our qualitative findings to people in low socio-economic groups (SEGs). Low SEGs in Australia often have greater food-related health concerns (e.g., higher rate of diabetes, heart disease, and obesity) (Australian Institute of Health and Welfare, 2016, 2021; Harris et al., 2017) and higher rates of food insecurity. Despite recommended healthy diets (including the Mediterranean diet) being more affordable than unhealthy 'Western' diets (ranging from 9% to 36% less) in Australia (Bracci et al., 2023; Fishlock et al., 2025), both healthy and less healthy diets can account for 25.5% to 45.9%, respectively, of one's household income, making both challenging to afford (Fishlock et al., 2025). Using the COM-B to assess people in low SEGs may raise additional capacity, opportunity, and motivation factors and warrants further study.

This study was also conducted during the COVID pandemic, with some participants in lockdown during the interviews. This clearly impacted people's eating habits (e.g., reduced restaurant eating) and resulted in less exposure to external social influences—this may have impacted the assessment of these possible barriers/drivers. To lessen these limitations, participants described their previous eating behaviours and social experiences.

In Study 4, more women completed the online intervention, thus caution is needed when generalising these findings. Additionally, participants were all first-year psychology students, further impacting generalisation, though this was reduced by all students being from a rural university with a diverse age group, as noted in our results (i.e., mean age of 33.75 years). Finally, Study 4 assessed intentions to increase legumes and not actual behaviours,

with our pilot study providing support for future research assessing the influence of fridge magnets (as highlighted above) on legume consumption behaviours.

A final consideration is that the current thesis focused on meat consumption rather than meat *and* dairy, which are both implicated in livestock production emissions. This decision was made due to the greater negative environmental impacts of meat (i.e., beef emits higher global GHG emissions than dairy) (Ritchie et al., 2022) prompting urgent reductions in the consumption of this animal product. These results also correspond to Australia, whereby products consumed at home (in 2019) amounted to 31 million tonnes of GHG emissions, with meat and meat products accounting for 49%, and dairy 17% (Gaines et al., 2024). Nevertheless, given dairy's contribution to GHG emissions, additional research would benefit from a deeper dive into these animal products, similarly to our meat focus.

Implications

With the ever-increasing environmental, human health, and animal welfare concerns linked to what we eat (Aleksandrowicz et al., 2016; Batlle-Bayer et al., 2020; Scherer et al., 2019), we urgently need broad scale action to increase plant-rich eating in high-income countries (Nelson et al., 2016; Springmann et al., 2018). Increasing plant-rich eating through dietary change supports a 'One Health' framework, making it a vital sustainable food initiative. Our efforts to make the necessary dietary changes, however, have not materialised at the level required, with high-meat eating habits remaining stable in Australia and several other high-income countries (Whitton et al., 2021). If dietary change solutions are to keep a seat at the table, we need robust methods to design and test interventions that work. If not, supply-focused technological solutions (driven, in part, by profit) (Sherrington et al., 2023) may further overshadow this more holistic solution to our food crisis. To that end, the current thesis uses a unique approach to address the meat crisis, demonstrating how behaviour change models can fulfill this crucial need.

Assessing which plant-rich diet to target using the CBSM was the first vital step in our process, reducing the risk of targeting the wrong (or less impactful) plant-rich diet (McKenzie-Mohr, 2011; Michie et al., 2011). The BPM not only highlighted the Mediterranean diet as the diet to target but outlined its performance (and all assessed plant-rich diets) on several key measures. The information in this publication provides other researchers and policy makers with a clear starting point and greater confidence to invest in wide-scale interventions. To our knowledge, this is the first time a target diet has been identified using behavioural measures, LCAs, and health data (Aleksandrowicz et al., 2016; Batlle-Bayer et al., 2020; Scherer et al., 2019), within a ‘One Health’ framework. The inclusion of the often overlooked animal welfare measure also adds to the preliminary research in this area (Scherer et al., 2019), showcasing a new and evidenced-based approach to applying this metric in the sustainable eating field. The complex nature of our food systems warrants a multi-disciplinary approach. Our findings reveal how an inter-disciplinary approach can obtain robust and informative outcomes to aid intervention development.

Evaluating two meat-reduced diets (Mediterranean and flexitarian/semi-vegetarian) further extended the research, given past studies have typically focused on meat-exclusionary diets (i.e., vegetarian, vegan) (Rattenbury & Ruby, 2023; Rosenfeld & Tomiyama, 2020). Including a range of meat-reduced and meat-exclusionary plant-rich diets in the one study supports a more complete and potentially more realistic approach to addressing the meat crisis, specifically given both meat-reduced diets were more amenable to our participants, who were predominantly omnivore eaters. This is a vital consideration given research suggests that up to 85% of vegans and vegetarians revert to eating meat again (Faunalytics, 2014), emphasising the need to consider plant-rich diet adoption *and* maintenance.

Our diet penetration findings also provided a unique snapshot of Australians’ current eating patterns. With approximately 70% of participants consistently identifying as omnivore

eaters, we can confirm that there is enormous potential to promote the plant-rich Mediterranean diet in Australia. Additionally, approximately 10% of people consumed a meat-exclusionary diet (pescatarian, vegetarian, vegan) across our studies, with is generally consistent with past research (Ray Morgan, 2019). Clearly, Australia's continued high meat consumption levels (Whitton et al., 2021) suggests that vegetarian and vegan eating has not translated into consistent behaviour, further confirming why our Mediterranean diet findings are so critical.

Using the COM-B (Michie et al., 2011) enabled a thorough assessment of multiple barriers (and drivers), specifically the explicit assessment of habits (via the COM-B's motivation component) and household influences (via the COM-B's opportunity component); two factors that have received less attention in the literature (Kretowicz et al., 2018; Lacroix & Gifford, 2020; Stoll-Kleemann & Schmidt, 2017; Tsofliou et al., 2022). As the first study to use an ethnographic, inductive and deductive approach to understanding Mediterranean diet adoption barriers (and drivers), we were able to gather a more complete picture about the highly routine behaviour of eating (Pink, 2012). Specifically, automatic motivation (ingrained eating habits and taste) cannot be underestimated, with our intervention aimed at targeting these ingrained eating habits by increasing legume consumption. Taste being identified as a significant motivator to increase legume consumption intentions further emphasises the influence of this factor. The benefits of using the COM-B are also proven in the model's holistic assessments *amongst* capability, opportunity, and motivation factors. For example, the lack of time barrier impacted *both* physical opportunity and psychological capability; as such, both need to be considered when targeting this barrier. Our quantitative approach is also the first to provide concrete information on which barriers *predict* Mediterranean diet adoption, as opposed to observational and/or qualitative studies (Davis et al., 2015; McEvoy et al., 2018; Murphy et al., 2022; Scannell et al., 2020; Zacharia et al., 2020). Taken together,

these findings greatly contribute to the development of tailored interventions to help people in the community make the broadscale dietary changes we desperately need.

Finally, interventions in the sustainable eating field continue to be limited, with the few Mediterranean diet interventions conducted more focused on intensive programs with specific populations (i.e., elderly, individuals with chronic diseases) (Davis et al., 2015; McEvoy et al., 2018; Murphy et al., 2022). If we are to achieve ‘One Health,’ plant-rich eating needs to become the norm rather than the exception. To that end, our intervention study showcases a potentially effective way to edge people and their families closer to Mediterranean diet adoption.

Future Research Directions

It would be important to extend our intervention by assessing whether or not the observed significantly impactful and beneficial message attributes increase people’s legume consumption *behaviours*. Given our messages were in the form of a fridge magnet, information about legumes was also brief. This brevity may have hindered legume consumption intentions for some message attributes (e.g., health and protein), given lack of knowledge was identified as barrier. Modifying these messages to incorporate more information may be warranted to further evaluate these message attributes. Targeting purchasing habits in the supermarket food environment may also support legume adoption, for example, by collaborating with food manufacturers and supermarkets to modify legume placement (i.e., increase physical opportunity), and further develop legume ready-made meals that are convenient and hit those taste markers (e.g., spice and sauce blends).

Future research would also benefit from more investigation of household influences on Mediterranean diet adoption. Specific populations (e.g., families with dependent children, low SEGs) may be targeted to further tailor interventions for this household type, specifically how to overcome both parent and child ingrained meat-eating habits (Erhardt & Olsen, 2021).

Furthermore, the intervention function of environmental restructuring may be applied outside of the home to other locations (e.g., schools). Applying ‘nudges’ in restaurants and university canteens has increased vegetarian eating (Sparkman & Walton, 2017), while a peer support program (for adults with health conditions) supported Mediterranean diet adoption (McEvoy et al., 2022), with these learnings possibly applicable to school environments. In Australia, the Tasmanian Government (2024) has recently extended its successful ‘Healthy School Lunch Program’ due to positive health eating outcomes—a unique initiative in a country that does not typically provide school lunches. Rolling out similar programs in Australia aimed at Mediterranean diet eating helps build early healthy eating habits that could function to reduce health risks such as obesity (López-Gil et al., 2023), along with supporting positive environmental and animal welfare outcomes (Batlle-Bayer et al., 2020; Scherer et al., 2019).

The current thesis focused on the first two layers of the COM-B (i.e., sources of behaviour and intervention functions). The third layer addresses policy initiatives (e.g., marketing, social planning, regulation) (Michie et al., 2011), a vital factor for wide-scale implementation. Food systems are susceptible to shocks in the global environment (e.g., COVID-19, extreme weather events, and global conflict). In Australia, these shocks have disrupted food supply, with the cost of a recommended healthy diet (specifically fruit and vegetables) increasing 17.9% between 2019 and 2022 in the Greater Brisbane, Queensland region (Lewis et al., 2023). As such, social, political, and economic factors must be given consideration when implementing a plant-rich diet intervention (such as for the Mediterranean diet), and should be considered in the context of these results.

Finally, while the ‘One Health’ model is an expansive framework, other key metrics were not considered due to available data. More health data (e.g., Nutrient Rich Food Index) (Fulgoni et al., 2009) and nutritional LCA (nLCA) assessments may further support health effectiveness outcomes, including different protein qualities (McAuliffe et al., 2023). Other

ethical production considerations (e.g., international labour rights, fair prices) (Browne et al., 2000) and economic indicators (e.g., cost of diets) (Fresán et al., 2019) may also add to our understanding on plant-rich diet effectiveness.

Concluding Remarks

To address the meat crisis, people in high-meat, high-income countries urgently need to shift to plant-rich eating. This shift, however, has not occurred at the level required, prompting a critical examination of how we approach this problem. As such, the current thesis aimed to re-examine how to increase plant-rich eating in high-income countries, using a holistic and evidence-based framework. Our series of novel studies achieved this by applying a new approach; using a broad lens, we combined learnings from the environmental, human health, animal, and behavioural sciences to identify and test realistic solutions. Below is an outline of what we did and how our findings move the field forward in the race to achieve a sustainable global food system.

Contribution 1: Identified the Mediterranean diet as the plant-rich diet to target in a high-income country. Study 1 was the first to apply a behaviour prioritization matrix to identify *which* plant-rich diet to target in an intervention aimed at increasing plant-rich eating in a high-income country, such as Australia. This is a critical, though often overlooked, first step, as it ensures efforts are focused on plant-rich diets that are not just effective from an environmental, human health, and animal welfare perspective, but likely to be adopted by high-meat eaters. Overall, the Mediterranean diet outperformed the other plant-rich diets (flexitarian/semi-vegetarian, pescatarian, vegetarian, and vegan), with the highest probability of adoption and human health score, and moderate environmental and animal welfare benefits. These findings have enormous implications as they pinpoint where to focus our attention and in turn, direct the conversation towards more realistic solutions. Essentially, our findings emphasised that there is little benefit in promoting (or researching ways to promote)

meat-exclusionary diets to high-meat eaters as they are unlikely to adopt them. This finding also extends to the flexitarian/semi-vegetarian diet, due to this diet being the least effective plant-rich diet in our assessment. Our assessment established that the Mediterranean diet has the potential to go mainstream *and* benefit the planet, humans, and animals. To that end, increasing uptake of this plant-rich diet is where we should direct our time and money. With global meat levels remaining dangerously high, our findings come at a crucial time, providing clear direction on where to start to achieve mass dietary change.

Contribution 2: Determined plant-rich diet effectiveness using the ‘One Health’ model. Study 1 was also the first to assess plant-rich diet effectiveness using the expansive ‘One Health’ model. The inter-dependent relationship between the planet, humans, and animals cannot be understated and warrants our full attention if people and policy makers are to make informed decisions about plant-rich eating. To that end, our methodology showcases a new and robust way to quantify these key metrics in the sustainable eating field, and importantly showed the target Mediterranean diet to have moderate-to-high effectiveness across these metrics. As such, people can confidently adopt the Mediterranean diet (and policy makers can promote it), knowing that it meaningfully improves our ‘One Health.’

Contribution 3: Used a deep dive ethnographic approach to inform the design of more targeted Mediterranean diet interventions. Study 2 was the first to apply an in-depth ethnographic approach to help identify ways to increase Mediterranean diet eating in a high meat-eating country. Our unique methodology combined inductive (reflexive thematic analysis), deductive (COM-B), and visual research measures, enhancing the robustness and richness of our findings. Specifically, we delved into the less studied automatic motivations, ingrained meat-eating habits and meat taste preferences, and identified not only how influential these barriers are individually, but how they intersect with capability (lack of knowledge) and opportunity (lack of time and household influences) barriers. Preferencing

people's voices through reflexive thematic analysis provided a more nuanced understanding of this routine but complex behaviour, providing a greater understanding of why people choose (and do not choose) to eat a sustainable healthy diet such as the Mediterranean diet. The COM-B then provided a comprehensive framework to assess and organise key barriers (and drivers); significantly contributing to the design of more tailored and potentially more effective Mediterranean diet interventions that have a greater chance of delivering the dietary changes we so urgently need.

Contribution 4: Identified which barriers predict Mediterranean diet adoption to inform the design of more robust interventions. Study 3 was the first to quantitatively assess factors that predict Mediterranean diet adoption using our specifically designed COM-B Mediterranean diet survey. Key barriers that significantly predicted Mediterranean diet adoption (in order of strength) were low familiarity of the Mediterranean diet, lack of time and knowledge, a general dependence on meat, and household dietary preferences. Not having to cook for other people functioned as a significant driver that predicted adoption, and in fact, was one of the strongest predictors. Quantitative assessments of Mediterranean diet adoption are scarce, so our findings are the first to provide reliable outcomes that can be generalised to the population – a significant contribution to increasing knowledge on *how* to support sustainable eating, in the form of the Mediterranean diet, for Australians in general. Additionally, using hierarchical regression within the COM-B framework provides clearer direction on which barriers are the most important to target in an intervention. Plant-rich eating remains relatively low in high-meat eating countries, such as Australia, so we need interventions that work. For this reason, our findings contribute a much-needed evidence-based road map that researchers and policy makers can use to design Mediterranean diet interventions that have a greater chance of success.

Contribution 5: Identified how ingrained meat-eating habits are a major barrier to Mediterranean diet adoption. The COM-B incorporates automatic motivation as a source of behaviour, so our deep dive and quantitative analysis thoroughly evaluated the influence of ingrained eating habits on Mediterranean diet adoption. Specifically, Study 3 was the first to quantitatively confirm that omnivore eaters' high red meat and low legume frequency levels (in Australia) misalign with Mediterranean diet, prompting the need to target these foods in an intervention. This is a vital contribution as eating habits have generally received less attention in the literature. If we are to help omnivore eaters (being most Australians) make the necessary dietary changes, we need cost effective and relatively easy interventions that target ingrained eating habits on a large scale. Our findings provide a blueprint on how to achieve this—rather than targeting the whole Mediterranean diet in an intervention, changing the meat/legume ratio (using our COM-B findings) may be a better starting point to make these dietary changes in the broader community. This is a vital contribution given the importance of not only adopting sustainable eating, but sustaining it over time.

Contribution 6: Identified household influences as a major barrier to Mediterranean diet adoption. Study 2 and Study 3 were the first to apply the COM-B to assess the influence of household members on Mediterranean diet adoption in the community. Our decision to assess this external factor is a major contribution to the sustainable eating field as social-environmental influences, especially in the home, have been less studied and targeted in interventions. Our findings not only confirmed that household members are a significant barrier to Mediterranean diet adoption, but can be the main barrier for some families, further emphasising why this approach is so important. With most households eating the same diet, our discoveries stress that individual-focused interventions are at risk of failing. Tailoring interventions to household structure is a potential game changer in helping people make these urgent dietary changes and sustaining them.

Contribution 7: Identified how to shift Australians to Mediterranean diet eating.

Study 2 and Study 3 identified key barriers and drivers to Mediterranean diet adoption with Australian community members—a vital contribution given Mediterranean diet research typically has focused on participants with health concerns. Additionally, little research has been conducted in Australia (or other high-meat, non-Mediterranean diet countries), where meat levels need to urgently decrease. As such, our evidence-based road map is aimed at the Australian population, being people in a high-meat, non-Mediterranean diet country who are less driven by health issues. Large scale dietary change is needed now so our findings come at a critical juncture, providing vital tools to make these widespread changes.

Contribution 8: Provided direction on how persuasive messages can increase legume consumption. Armed with our comprehensive and directed findings, these barriers were targeted in the first behaviour change intervention to assess how persuasive messages can increase legume consumption in Australia. Our findings highlighted that two message attributes—taste and convenience—increased legume consumption intentions for all diet groups. Given interventions in the Mediterranean diet and meat reduction fields are generally scarce, including in Australia, our findings add much needed information on how to increase Mediterranean diet adoption with high-meat eaters. Legume consumption remains low for most Australians, so our findings extend beyond omnivore eaters to those who eat a meat-reduced diet but not the recommended legume amounts per the health guidelines. So, these findings contribute to the health of all Australians and in turn, have the potential to support a sustainable food system *and* reduce the high health costs linked to eating-associated diseases.

Taken together, the outcomes of this thesis contribute vital information to support a sustainable global food system. Individuals, policy makers, and food industries can use our findings to achieve this goal on a large scale. Helping high-meat eaters, eat in line with ‘One Health’ requires enormous effort, particularly in countries with long-standing meat-eating

habits. To that end, our findings come at a critical time, providing practical solutions that have the potential to make these urgent dietary changes a reality.

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