

Identifying effective evidence-based strategies to promote sustainable and healthy diets

By

Golsa Saberi

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Primary supervisor: Dr Rimante Ronto

Co-supervisor: Dr Josephine Y. Chau



MACQUARIE
University
SYDNEY · AUSTRALIA

Statement of Originality

This work has not previously been submitted for a degree or diploma in any university. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made in the thesis itself.

Golsa Saberi

Date: 07/12/2020

Golsa Saberi (45881537)

Master of Public Health (MPH) Research

Department of Health Systems and Populations

Faculty of Medicine and Health Sciences

Macquarie University

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دنیای با تو بودن در اوج همیشه هایم جان میگیرد

و هر لحظه تعبیری می گردد از فردایی بی پایان

در تبلور طلوع ماهتاب

کیستی که من اینگونه

به اعتماد

نام خود را با تو می گویم...

Golsa Saberi

Abstract

Global food systems and our dietary behaviours have significant impact on health outcomes and environment. More specifically, they increase greenhouse gas emissions, deforestation of agricultural land, and the use of freshwater resources. Therefore, there is a need for whole food systems transformation to address these negative impacts. Although, there has been an increase in interventions developed to promote sustainable and healthy diets, there is no synthesised evidence on the effectiveness of such interventions and lack of research on people's understanding of sustainable and healthy diets. Therefore, this thesis aimed to address these gaps in the literature.

This thesis consists of two research studies: 1) a systematic literature review which synthesised the evidence on the effectiveness of interventions aiming to promote sustainable protein intake; and 2) a qualitative study, which explored young Australian's understanding of sustainable diets and their efforts in achieving it. The first study was a systematic literature, which was conducted in accordance to PRISMA guidelines. The second study was a qualitative study, which used semi-structured interviews to collect data.

The systematic review included 50 studies which were categorised into individual and micro-environmental level studies. The findings demonstrated reduction of unsustainable protein intake post intervention, mainly decrease in red and/or processed meat intake. However, there is a need for: i) longitudinal studies to see if the behaviour change sustains over time; ii) development of interventions targeting population without a risk factor or disease to investigate if these strategies are effective; and iii) further research is needed to test some micro-environmental strategies in changing unsustainable protein intake. For the qualitative study, 22 young Australians (aged 18 to 25 year old) were recruited. Two thirds of participants were aware of some aspects of sustainable and healthy diets. Although, majority of participants showed an intention in practicing sustainable diets, less than half of them were practicing it due to barriers such as high costs, unavailability of sustainable and healthy food and low food literacy levels including cooking skills.

This thesis contributes to the body of knowledge on our understanding of implemented strategies to promote sustainable protein intake and young Australians' understanding of sustainable diets. It identified numerous barriers and enablers in promoting sustainable and healthy diets which could be used in development of effective health promotion interventions to improve health and environmental outcomes.

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Chapter 1 Introduction

1.1 Research background

The food systems include food production, processing, packaging, storing, transportation, distribution, advertising, consumption and food waste (1). Our current global food systems have significant negative impact on the environment and increase greenhouse gas emissions (GHGEs) (1). More specifically, they produce 19% to 29% of GHGEs globally (1). GHGEs is one of the major factors of global warming, which rises by about 3% each year (1). It is a serious problem, because global food temperature has increased 2 °C since 1750s (2). In addition, food systems are also using about 86% of global fresh water (3), and is responsible for loss of natural habitats, forests and biodiversity (1, 4, 5). To mitigate this problem, there is a need for significant GHGEs cuts in different parts of food chain (2).

Our current dietary behaviours have significant impact on our health and the environment. Unhealthy dietary behaviours such as high intake of ultra-processed foods, animal-derived products, in particular red meat, sugar-sweetened beverages and low intake of fruits and vegetables, legumes impose a greater burden on individuals' health and our healthcare system (6). These unhealthy dietary behaviours are linked to development of many diet-related chronic diseases such as obesity, type 2 diabetes, cardiovascular disease and certain cancers (7).

Reduction in animal-derived foods can lead to significant decrease in GHGEs and reduce the risk of cardiovascular diseases (6). Increased consumption of plant-based foods as a protein source such as grains, legumes, nuts and fruits and vegetables have beneficial effects on health and environment (8). It is estimated that manufacturing of animal-derived products produces 50% of total food-produced GHGEs (2). One kilogram of beef releases about 60 kilograms of GHGEs, compare to peas, which only release 1 kilogram per kilogram (9). Producing feed for animals plays an important role in GHGEs, as a result of utilising fossil fuel for farming, transportation and feed procedures, as well as loss of natural areas due to grazing or feed farming (1). In addition, ruminants (like cows, goats and sheep) consume additional feed for each kilogram of meat, compared to monogastric animals (like pigs and rabbits). Thus, GHGEs of ruminants is higher and producing their meat produces higher amount of GHG (1,9). For example, lamb releases about 20 kilograms CO₂-equivalent per kilogram, while poultry and pork emit 6 and 7 kilograms CO₂-equivalent respectively. Although it is by far

lower than lamb emission, it is still higher than the majority of plant-based food CO₂ emission (9). People are overconsuming red meat and exceeding the recommended intake in many developed countries, including Australia (10,11). Therefore, the reduction in red meat intake may be one of the most significant strategies to reduce health and environmental impacts. It is evident that population dietary behaviour and environmental sustainability are interrelated. The concept “sustainable and healthy diets” received increased attention in the last five years, however, the concept is not new (8). In the 1920s, Gussow and Clancy presented a dietary guideline that considered the influence of food choices on the environment (8), similar to what we have today. It also included the reduction of food waste and animal-derived foods and increase of local food consumption (8). Many countries have dietary guidelines to support individuals to consume diets that improve health and decrease risk of non-communicable diseases (NCD), like the Australian Guide to Healthy Eating (AGHE) (12), and Eatwell Guide in the United Kingdom (UK) (13). However, some countries such as Canada and Sweden have extended dietary guidelines by embracing environmental sustainability (8, 14, 15).

The recent EAT-*Lancet* Commission on healthy diets from sustainable food systems has indicated that there is a need for global food transformation and stated that we need to shift our diets to more plant-based diets and reduce or eliminate animal-derived food consumption (6). Five strategies were introduced on how we can achieve global food transformation: i) request international and national obligations to move towards healthy diet; ii) redirect cultivation focus from producing more food to producing healthy food; iii) increase sustainable food production to enhance the quality of yield; iv) full supervision over land and ocean (to cultivate on existing agricultural land and ensure that fisheries do not harm the ecosystems); and v) reduce food waste and losses by half (6).

sustainable diets could have various meanings in different circumstances (8), including food safety, providing healthy food without harming the environment and decreasing food waste (17). Considering the variety that the term “sustainable diets” refers to and the complication of this term, it is crucial that every study clarify which part of sustainable diets they are referring to and which context it is being utilised in (8). The Food and Agricultural Organization (FAO) of the United Nations provided a comprehensive definition of sustainable diets, they described it as *“diet with low environmental impacts, which contributes to food and nutrition security and to healthy life for present and future generations. Sustainable diets are protective*

and respectful to biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable, nutritionally adequate, safe and healthy; while optimizing natural and human resources” (16).

Although growing evidence suggests that adhering to the EAT-Lancet reference diet (18, 19) and other similar healthy and sustainable national dietary recommendations is associated with better human and environmental health outcomes (18), most Australians fail to meet the *Australian Dietary Guidelines for Healthy Eating* (ADGHE) (12). According to the Australian Institute of Health and Welfare, only 5% of Australian adults had adequate consumption of fruit and vegetables, and 95% of young adults did not have recommended servings of fruit and vegetables. (20). Moreover, 40% of Australian food expenses is spent on meat (21). In addition, 34% Australians spent on take away from home foods which are often high in sugar, salt and saturated fat (22). These unhealthy dietary behaviours contribute to poor health (23) and pose significant burden on the environment (18). In order to develop effective policies and interventions to change our current dietary behaviours to more sustainable and healthier practices, there is a need to explore consumers’ behaviours and their motivations in achieving it.

There has been increase in interventions aiming to increase sustainable and healthy diets, for example; a nudge that aimed to reduce meat consumption by changing the menu order in a university restaurant (24). However, there is no synthesised evidence on interventions that have aimed to increase environmentally sustainable protein consumption. Also, a few studies have explored Australians’ knowledge, awareness, and attitudes towards healthy and environmentally friendly dietary patterns, which showed that Australians have limited understanding of the impact of their dietary behaviours on the environment (25-27). More specifically, they believed that their diets had an insignificant effect on the environment (28). However, the most recent climate change protests in Australia showed that young Australians care about sustainability and climate change and are interested in addressing issues associated with climate change (30). Also, they have shown more environmentally friendly intentions, which are associated with community’s role in preserving the environment, such as considering consumption of less meat and more organic local products, increase in vegetarianism and recycling food waste (29). Understanding young Australians view about sustainable diets could lead to development of interventions with synergies for improving their own health and environmental sustainability. Therefore, this research intends to address

these gaps in the literature by synthesising the evidence on the effectiveness of meat reduction interventions on individual behaviour change and to exploring in more depth young Australians' perspectives, motivators, and current practices in achieving sustainable and healthy diet.

1.2 Problem statement and research questions

With continuous rise in global warming and the negative impact of unsustainable food related practices on the environment, it is important to synthesise current evidence aiming to reduce such practices and explore the perceptions, motivators and barriers in achieving sustainable diets. Therefore, this research project aimed to: 1) synthesise evidence on interventions aiming to increase environmentally sustainable protein consumption; and 2) explore young Australians' perspectives, motivators, and current practices in achieving sustainable and healthy diet. The reason for choosing young Australian (between 18 to 25 years) was that early adulthood has been recognised as a crucial age for dietary/health interventions (31), as they are in transition between adolescents to adulthood and are mostly living independently or with their partners. They are exploring different dietary patterns; they tend to experience different dietary patterns and their habits are still developing. Therefore, it is important to intervene at this stage of life as their dietary pattern developed at this stage continues into adulthood (31).

The following research questions (RQ) and sub questions were developed for this research project (see Table 1.1):

RQ1: What types of interventions have been implemented globally to promote sustainable protein consumption (reduce in animal-derived proteins and increase in plant-based proteins) and how effective are these interventions?

RQ2: What are young Australians' understanding of sustainable diets and their perceptions, awareness and current efforts in decreasing unsustainable protein (e.g. red meat) consumption?

Table 1.1: Research questions.

Key research questions:	Sub questions:
What types of interventions have been implemented globally to promote sustainable protein consumption (reduction in animal-derived proteins and increase in plant-based proteins) and how effective are these interventions?	<p>a) What approaches have been used? What were their effects on behaviour change?</p> <p>b) What outcomes were measured (e.g. changes in knowledge, awareness, willingness to try, food purchasing and consumption behaviour)? was the behaviour sustain over time?</p> <p>c) What meat substitutes have been suggested/offered? How the shift was measured? Which foods were increased as a substitute for meat?</p> <p>d) Were behaviour change theories or theoretical framework(s) used in intervention/program development?</p> <p>e) Were there any demographic differences (age, gender, educational level)?</p>
What are young Australians' understanding of sustainable diets and their perceptions, awareness and current efforts in decreasing unsustainable protein (e.g. red meat) consumption?	<p>a) What are young Australians' understanding of a sustainable and healthy diet? Which components of a sustainable and healthy diet do they focus on?</p> <p>b) What are they currently doing to achieve a sustainable and healthy diet?</p> <p>c) What are the enablers and barriers associated with achieving a sustainable and healthy diets?</p>

These research questions were answered by two research studies: a systematic literature review (RQ1) and a qualitative study (RQ2). A systematic literature review approach helps systematically review the literature on a specific research question. It recognises, assesses and sums up the information of all appropriate studies to draw more comprehensive conclusions for decision makers and researchers (32). The systematic literature review provided more comprehensive evidence on effectiveness of interventions aiming to increase sustainable protein intake. More specifically, this review helped to identify: i) different types of interventions and their positive and negative impacts on a behaviour change (e.g. reduction in red meat consumption, increase in intentions to try plant-based protein consumption etc.); ii) any meat substitutes used; and iv) any demographic differences.

A qualitative study assisted in exploring young Australians' understanding of sustainable and healthy diets and their current practices in achieving it. More specifically, it helped to: i) understand young Australians' perceptions about their food choices and its impact on health and environment; ii) identify any barriers and enablers associated with achieving sustainable diets; and iii) identify any resources and support needed to help them achieve sustainable diets. A qualitative study approach was chosen for this as it can provide an in-depth understanding of new concepts under investigation.

1.3 Conceptual framework

This research project was guided by the Socio-Ecological Model, which shows the relationship between different levels (individual, community, societal) and how they interact with each other (33) (see Figure 1.1.). This is a useful framework used widely in investigating and explaining how different factors impact on people's behaviour (e.g., dietary behaviour) (34). This framework also indicates that no single factor on its own can impact or explain why certain people behave the way they do or in a certain way. The levels of this model and relationship with current study are described in more detail below.

Individual: this level identifies personal knowledge, history, skills and identity, which determine individual behaviour and understanding of sustainable diets and their practices in this regard. These factors include education, time, income, ethnicity, knowledge and lifestyle. Research indicates that food and nutrition knowledge and skills can have an impact on positive dietary behaviours (35,36).

Social: the second level identifies the relationship between individual and family, friends, partners and immediate social circle (e.g., peers and family) and its impact on individuals' understanding, perception, awareness or current practices regarding sustainable diets. Evidence shows that social connections are associated with dietary behaviours, and subsequently impacts health. For example; being single or living alone is associated with consuming lower variety of vegetables, while it increases with rise in frequency of contact with friends or family members, especially in women (37). Besides, having a health-conscious circle of friends or vegetarian parents could influence whether people decide to eat more plant-based diet (37).

Community: the third level refers to communities of which individual is part of. This level argues that workplace setting, and school's or university's environments could determine the

impact on food intake and behaviour. For example; encouraging healthy eating in schools in European countries was associated with increase in healthy dietary patterns in children (38). Growing evidence suggests that food and nutrition education in schools and supportive food environment play an important role in children and adolescent's dietary behaviour and encourage better food choices (38, 39).

Societal: this level explores a broader societal factor that could influence people's food choices and behaviours, for example, social norms, national and global policies on food and nutrition. (40). For example, social and cultural norms that discourage sustainable consumption and encourage consuming less environmentally sustainable diet has an impact on health and environment.

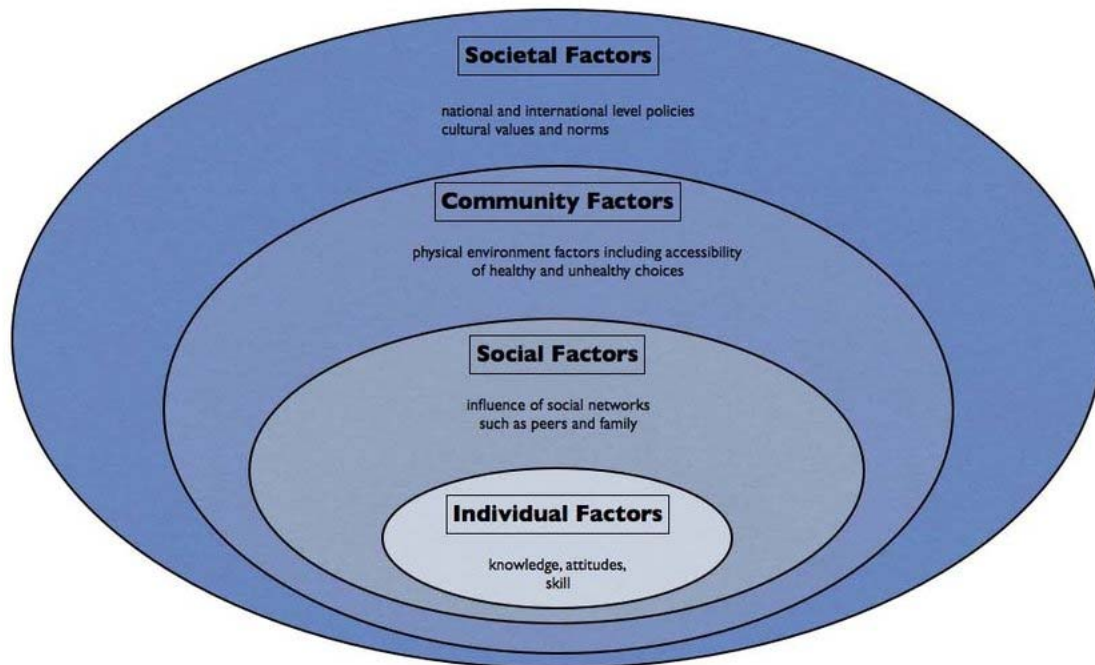


Figure 1.1: Socio-Ecological Model (41).

1.4 Study significance

The findings of this study will contribute to a better understanding about different interventions that have been conducted to promote sustainable and healthy diets and the effectiveness of these interventions, which have implications not only for human, but also for planetary health. Besides, this research will contribute to a better understanding about young Australians understanding of sustainable and healthy diet and current practices in achieving it, which could be used as baseline for policy development.

1.5 Thesis structure

This thesis consists of five chapters. Chapter 1 presents the background of research, briefly explains the problem, illuminates the research question, conceptual framework and the significance of the study. Chapter 2 synthesises current literature on global food systems and its impact on environment; current dietary behaviours and its impact on our health and environment and finally it critically reviews interventions implemented to address these issues. Chapter 3 systematically reviews and identifies effective evidence-based interventions implemented to increase environmentally sustainable protein consumption. Chapter 4 presents a qualitative study on young Australians' understanding of sustainable and healthy diet, including the method used. Finally, Chapter 5 provides the conclusions and future research recommendations.

Chapter 2 Literature review

2.1 Agriculture, food systems and environment

Eating, like any other human behaviour, connects us to mother nature (3, 16). The food we eat and the way we consume food have great environmental impacts, and some scholars say they have the greatest environmental impact of all human activities (3). Industrial revolution and machinery significantly changed the productive capacity of farms, procedure of rearing livestock, the way farming products are distributed, as well as the way they are purchased, cooked and consumed (3,1). We have witnessed remarkable environmental effects from agricultural practices, such as air, water, soil and land pollution, deforestation and global warming (3,42,43). However, there has been no evidence of concern or desire to face these environmental issues until a few years ago, when phrases like food miles, greenhouse gas emissions (GHGEs) and food waste were brought into public attention (1,3,4).

Currently, there is compelling evidence of the significant contribution of agricultural and global food systems to climate change (3). It is estimated that our food systems increase GHGEs by about 3% every year, which is associated with producing 19% to 29% of GHGEs worldwide (1,4). Marine biodiversity is influenced by water quality, which is impacted by the amount of carbon in the atmosphere (43,45). Other species biodiversity is also dependent on climate stability, and climate change threatens their health and sustainability (43,45). In addition, agriculture has used about 50% of world's habitable land for cultivation, which is estimated to be one of the greatest impacts on the environment, as it has changed biodiversity and ecosystems (42,43,46). It is estimated that out of 28,000 endangered species, 24,000 are being threatened by land use, as their habitats have been destructed for agricultural purposes (43,47,49). Food systems are also using freshwater excessively to produce different food products and has caused freshwater scarcity in various parts of the world (42,46). It uses about 86% of world's fresh water and it is predicted that each person could consume up to 5000 liters of global fresh water through the food they consume (3).

Food systems refer to the whole range of activities including producing, processing, transportation, consuming and disposing of foods. (44). Food systems contain various sub-systems, such as agricultural systems and waste disposal systems, and it is connected to other fundamental systems, such as energy, health and marketing systems (44). Global GHGEs and other environmental impacts differ significantly by different stages of food systems (1,48). All

the stages in food systems are linked and change to one stage impacts other stages across the system (1,48). For example, utilising fertilisers and producing animal feed, which create the high amount of GHGs (1), are responsible for nitrous oxide (N₂O) emissions (1). In addition, another stage of food chain is packaging, which significantly impacts the environment (50). Packaging is one of the main contributors to food losses (50), and can reduce negative environmental effect, if it keeps food safe from physical harm and decay, reduces leftover and delivers accurate information about products (50). Furthermore, food transportation has created the term “food miles”, and increases GHGs remarkably, as a result of fuel consumption to transport food by truck, train, ship or air (1). CO₂ from animal product transport alone reaches 0.8 million tonnes every year (51). One of the last stages of food chain is food waste, which creates GHGs through generating CH₄ from landfills (1). The amount of CH₄ from landfills vary significantly according to the composition of waste and the way it is supervised (1,3). Thus, consumer behaviour also has a huge impact on what is produced and consumed. The kind of food consumers select to eat and the way they prepare, store and consume it, as well as individual circumstances are the factors that not only influence supply and demand, but also guarantee people’s health and preserve the environment (48).

2.2 Diet, health and environment

2.2.1 Diet and health

Malnutrition in all its forms, including undernutrition (wasting, stunting, underweight), inadequate vitamins and minerals, overweight and obesity, is a significant global health issue (17). The percentage of undernourished people has been rising in the past several years around the world, and simultaneously the percentage of overweight and obese population has increased (52). While 462 million people do not have access to adequate food in 2020, 1.9 billion people are suffering from overweight or obesity (52). In addition, 38.3 million children under five are overweight or obese globally and at the same time 47 million children are wasted, 14.3 million are significantly wasted and 114 million are stunted (53). Moreover, about 45% of under five-year-old mortality in low- and middle-income countries is due to undernutrition (53). In Australia, in 2017-18, 17% of children were overweight and 8.1% were obese. 35.5% of adults were overweight and 31.3% were obese and 4% of Australian adults were experiencing food insecurity (54). Poor dietary behaviours are one of the major factors

impacting on development of Non-Communicable Diseases (NCDs), such as cardiovascular diseases, type II diabetes, and some certain type of cancers (55,58). In Australia, 4.1% of people had suffered from type II diabetes and 4.8% had cardiovascular diseases in 2017-18 (53).

A healthy diet reduces the risk of development of diet related NCDs and other diseases (51). The World Health Organization (WHO) states that increased consumption of various plant-based foods, and decreased consumption of sugar, salt (especially non-iodized salt) and saturated fat can improve our health (51). Although the link between diet and health is clear, the majority of people fail to adopt healthy dietary behaviours globally (56). Thus, many countries, such as Australia, have developed dietary guidelines in order to help people to achieve a healthy diet (57). The Australian Guide for Healthy Eating (AGHE) was developed based on the most recent scientific literature and provides the latest guidance on quality and quantity of food that Australians need to consume, in order to achieve good health and decrease the risk of NCDs (57). The guidelines recommend consuming foods from five food groups such as variety of fruits and vegetables, legumes, grains, lean meats, dairy or alternatives and limit consumption of ultra-processed foods, sugar, salt, and saturated fat (57). Research shows that intake of nuts, fruits and vegetables, legumes, olive oil and fish are associated with decrease in mortality and diseases such as coronary heart disease (CHD), colorectal cancer, diabetes and stroke (58). While high intake of red meat (processed and unprocessed), sugar sweetened beverages (SSBs) is associated with great rise in mortality and risk of development of NCDs (12, 58). However, majority of Australians fail to adhere to the AGHE. Only 7% of adults, 5% of children and 4% of young Australians (aged 19 to 24) consumed adequate serving of vegetables, 9% of adults and 7% of children consumed SSBs daily and young adults (between 18-24) had the highest average intake of added sugar among all Australians (20,59). One third (30%) of Australians met dietary intake recommendations for grains (cereal) and 14% of Australians met recommendations for lean meats and alternatives in 2015 (51,58,60). In addition, meat, in particular red meat, is a significant part of Australians' diets and forms 40% of their food cost (18).

Research indicates that high intake of refined carbohydrates increases the risk of obesity and type II diabetes (61), refined grains can lead to increase in blood pressure, glucose and triglyceride while consuming brown rice, for example, as a substitute for white rice (50 grams per day) decreases type II diabetes (T2DM) by 16% (61). In general, increasing whole grain

and cereal fibre intake, while reducing refined carbohydrate, are beneficial dietary strategies to reduce T2DM as well as cardiovascular diseases (CVD) in all individuals (58). In addition, red meat is a major contributor to CVD and metabolic disorders (62), and it could increase the risk of colorectal and renal cancer (5). Although meat is high in iron, vitamin B and protein, excessive consumption of it could be harmful to our health, due to high amount of cholesterol and saturated fat (21,49). Whereas higher consumption of fruits and vegetables decreases blood pressure and CHD. It can also decrease T2DM risk by at least 27% (61).

In summary, Australians' current dietary behaviours are unhealthy which contributes significantly to burden of diet related diseases and poses significant burden on individuals, wider community, and systems. Overweight and obesity contribute to 7% of the entire burden of disease in Australia and impacts mortality and living with a situation caused by excess weight (63). It is inevitable to change these unhealthy dietary behaviours. Therefore, there is a need to identify effective strategies to promote healthy diet, while environmental impacts are also considered.

2.2.2 Diet and environment

A healthy diet, one with enough nutrients and calories to provide metabolic needs, can build environmentally sustainable food systems (52). The EAT- *Lancet* Commission on Healthy Diets from Sustainable Food Systems stated that we need to shift our current diets in order to achieve positive health and environmental outcomes and contribute to achieving the United Nations Sustainable Development Goals and Paris Agreement (6). They suggested to reduce consumption of unhealthy foods by 50%, (including red meat and sugar) and increase in consumption of healthy foods by 100% (including nuts, fruits, vegetables, and legumes). More specifically, they stated we need to replace (where possible) meat-based protein sources to plant-based proteins; improve production practices (e.g. rebalancing nitrogen and phosphorus fertiliser application, improved water and manure management, increase in nitrogen use efficiency); and reduce food waste and loss (6).

Current dietary patterns, particularly in wealthy countries, have been moving towards overconsumption of foods, which rises the risk of overweight and obesity and has greater environmental impacts due to overproduction and unequal use of resources (58). Livestock manufacturing has been recognised as one of the significant contributors to environmental issues (57, 58), due to the amount of freshwater and land use and waste created (59).

Manufacturing one portion of unprocessed and processed red meat has a significant effect on acidification, eutrophication, GHGEs, land and freshwater use (58). More specifically, the livestock industry uses 30% of world's land and 70% of agricultural land and produces 18% of GHGEs (64). In addition, wide areas of trees are cleared to create grazing land and land to grow animal feed (66). The livestock industry is also the most significant source of methane and accelerates soil erosion (66). Comparing different types of animals, ruminants (like cows or sheep) produce higher amounts of GHGEs, compared to monogastric animals (like pig and poultry), as they consume more feed than the latter (1,66). About 33% of freshwater use is consumed for livestock production (66).

The five most sustainable eating patterns with regards to GHGEs are: 1) veganism (no animal-derived food intake); 2) monogastric (no ruminant) meat and no dairy diet; 3) vegetarianism (no meat but dairy intake); 4) meat with low dairy intake; 5) pescatarian (no meat but seafood intake) (55). These dietary patterns contribute to land and freshwater reductions as well (55). In addition, diets which creates lower GHGEs are recognised to be healthier, with 1% and 19% decrease in mortality for vegetarian and vegan diets respectively (55).

The diet change is reached by replacing unhealthy foods with healthy foods, making healthier alternatives more accessible and providing education, information and marketing to promote healthier options (6). Nevertheless, changing eating behaviour is a remarkable social, political and economic challenge for every country, which needs much more effort (52). Governments and individuals should be involved in various changes in different parts of food chain, social and cultural value of the state and supply and demand model (52). However, if sustainable diets are achieved, they will have positive effect on public health (through disease reduction), society (through reducing inequality in health and food availability and affordability) and animal welfare (67).

2.3 Sustainable and healthy diet

2.3.1 What is a sustainable and healthy diet?

As the *EAT-Lancet* Commission on Healthy Diets from Sustainable Food Systems and other organisations such as World Health Organization (WHO) and Food and Agriculture Organization (FAO) of the United Nations advocate to shift our diets to be healthier and more sustainable; therefore, it is important to describe what a sustainable and healthy diet is

(6,16,52). The FAO defined sustainable diets as “*diets with low environmental impacts, which contributes to food and nutrition security and to healthy life for present and future generations. Sustainable diets are protective and respectful to biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable, nutritionally adequate, safe and healthy; while optimizing natural and human resources*” (16). The schematic representation of the key components of sustainable diets identified by FAO can be seen in Figure 2.1. (16)

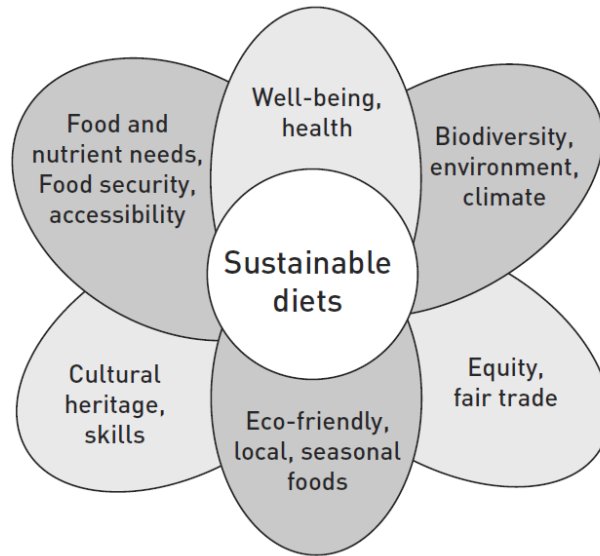


Figure 2.1: Schematic representation of the key components of a sustainable diet (16).

According to the EAT-Lancet Commission “*food is the single strongest lever to optimize human health and environmental sustainability on Earth*” (6). Therefore, this commission considers two aspects in the food systems: food consumption (healthy food) and manufacturing (sustainable food production), which both influence the environment, people’s health (physical, cultural and economic) and animal welfare (6). WHO described sustainable healthy diets from different aspects: health, environment and sociocultural (see Table 2.1). In addition, WHO and FAO have developed guiding principles stating that sustainable healthy diets start in early stage of life and continues with balance in various food groups and variety of unprocessed food, being low in pathogens and toxins, being align with WHO guidelines to decrease food-related NCDs, decrease GHGEs and water and land use, decrease overfishing and loss of biodiversity and being culturally acceptable and accessible as below (52):

Guiding Principles for Sustainable Healthy Diets (52):

- Include wholegrains, legumes, nuts and an abundance and variety of fruits and vegetables.
- Can include moderate amounts of eggs, dairy, poultry and fish; and small amounts of red meat.
- Are adequate (i.e. reaching but not exceeding needs) in energy and nutrients for growth and development, and to meet the needs for an active and healthy life across the lifecycle.
- Include safe and clean drinking water as the fluid of choice.
- Minimize the use of antibiotics and hormones in food production.
- Minimize the use of plastics and derivatives in food packaging.
- Are built on and respect local culture, culinary practices, knowledge and consumption patterns, and values on the way food is sourced, produced and consumed.
- Reduce food loss and waste.

Table 2.1. Sustainable Healthy Diets (52).

Sustainable healthy diets:	
Health aspect	Start early in life with early initiation of breastfeeding, exclusive breastfeeding until six months of age, and continued breastfeeding until two years and beyond, combined with appropriate complementary feeding. They are based on a great variety of unprocessed or minimally processed foods, balanced across food groups, while restricting highly processed food and drink products. Contain minimal levels, or none if possible, of pathogens, toxins and other agents that can cause foodborne disease. They are consistent with WHO guidelines to reduce the risk of diet related NCDs, and ensure health and wellbeing for the general population.
Environmental impact	Maintain greenhouse gas emissions, water and land use, nitrogen and phosphorus application and chemical pollution within set targets. Preserve biodiversity, including that of crops, livestock, forest-derived foods and aquatic genetic resources, and avoid overfishing and overhunting.
Sociocultural aspects	Avoid adverse gender-related impacts, especially with regard to time allocation (e.g. for buying and preparing food, water and fuel acquisition). Sustainable and healthy diet are accessible and desirable.

Some high-income countries have included environmental sustainability aspects of foods into their national food-based dietary guidelines to advise the residents about sustainable and diets. For example, Public Health England (PHE) national food model (The Eatwell Guide)

added 'beans, pulses and other proteins' within the main food group concerned with protein consumption in order to promote more environmentally sustainable protein intake (68). The Swedish National Food Agency has revised the Swedish Dietary Guidelines (Eat greener, not too much, be active) as well, in order to emphasise on both health and environmental aspects of dietary behaviours (14). This guideline highlighted dietary transformation from consuming animal-derived products to more plant-based food (57). Furthermore, Canada's Food Guide suggests Canadians to choose protein foods that come from plants more often and provides tips on how to eat more plant-based proteins (15). The Australian Dietary Guidelines identified the importance of environmental sustainability and identified the key messages and areas of importance: overconsumption is unsustainable, food wastage and food safety and eating seasonally (12). These guidelines are reliable sources for people to choose more sustainable eating patterns to improve nutrition and sustainable agriculture.

Apart from dietary guidelines, several interventions have been developed to help people in achieving sustainable and healthy diets. The majority of these interventions focus on the individual and micro levels such as educational programs and campaigns and some environmental changes to nudge the behaviour change. For example, dietary interventions in the UK and Sweden, regarding reducing meat for environmental purposes among University students revealed that interventions were successful in increasing purchases of vegetable dishes and all participants were successful in replacing meat with meat alternatives (69,70). A few meat reduction interventions conducted in Australia have also shown that behavioural interventions can successfully decrease meat consumption among Australians (71,72). Moreover, interventions targeted other aspects of sustainable diets, such as food waste reduction for environmental purposes, have been effective in reducing food waste by around 57% in households, with changing the size of the plates (73,74,75). The food waste reduction interventions have also been successful to reduce vegetable waste at schools by around 28%, by changing school dietary guidelines (73,75). Besides, educational campaigns were revealed to be successful in decreasing food waste by 28% in small group interventions (73,76). However, it is important to explore people's understanding, perceptions, attitudes and current practices in achieving sustainable and healthy diet in a broader context in order to identify effective strategies to help people to shift current unhealthy and unsustainable dietary behaviours.

2.3.2 Sustainable protein consumption

The environmental impact of our current food systems is significant, and it is increasing quickly. Thus, it must be thoughtfully controlled, as food production is exceeding our planetary boundaries (48). There is no doubt that animal-derived products have the biggest impact on the environment, including deforestation, freshwater and soil use, loss of biodiversity and significantly contributes to global warming and climate change (4,42,51). Although meat is a quality source of protein and nutrients, studies in western countries have shown that high consumption of red and processed meat is associated with higher mortality rates (58,61,65). There is a comprehensive agreement that a diet low in red and processed meat and dairy and high in fruits, vegetables, legumes and whole grains contributes to quality nutrition and has lower environmental degradation impact (6,16,44,23). Among all human activities, reduction in meat consumption could save 0.8 tonnes of carbon dioxide equivalents (tCO₂e) per person year (77). This diet is considered a win-win diet, as it is beneficial for both people, through decreasing risk of various NCDs, and for the environment, through GHGEs and other negative impact reduction (6).

Apart from preventing people from consuming unhealthy and unsustainable diets, interventions should be involved in motivating people to choose healthier and more sustainable eating patterns (23). Conducting an evidence-based intervention to encourage healthy and sustainable eating behaviour is a significant challenge for researchers and policy makers (23). However, there has been an increase in behaviour change interventions aiming to reduce unsustainable protein consumption (23). Interventions can influence consumers through different ways, including direct and indirect strategies (23,78). Direct strategies focus on individual behaviour change either through educational interventions or changes in micro-environments (schools, universities, workplaces). Informing people about the impact of their dietary intake, on their health and the environment, can help them make better food choices (23). There has been an increase in interventions to promote sustainable protein consumption, in order to preserve the environment (78-80). For example, a study in the UK in 2012 aimed to reduce meat consumption by 50% among university students revealed that with proper support, students can substitute 50% of their meat intake with alternatives (79). This intervention provided two knowledge-based encouraging activities around reduction in meat intake, including presentation of alternatives (79). These meat alternatives contained

various plant-based protein foods, in line with individual preferences (79). The intervention took four weeks and participants successfully decreased 50% of meat in their diet and shifted to non-meat alternatives (79).

At the upstream level, several non-governmental organisations (NGOs) located in the US, Canada and Sweden advocated for reduction in meat consumption through campaigns and policy implementation including tax on meat products (65). Bianchi et al. (2018) found that educational interventions and restructuring physical micro-environments may have positive impact on reduction in meat consumption and demand. However, there is limited synthesised evidence on interventions aiming to promote sustainable protein consumption (e.g. increase in legumes, beans, nut consumption and reduction in meat consumption). Therefore, the following research question was developed for this thesis to fill this gap in the literature:

RQ1: What types of interventions have been implemented to promote sustainable protein consumption (reduce in animal-derived proteins and increase in plant-based proteins) and how effective are these interventions?

2.3.3 Understanding, perceptions, and attitudes towards sustainable and healthy diet

How people assess the environmental effect of different products they consume and what encourage them to consider environmentally friendly foods when shopping are significant study questions. From the environmental sustainability point of view, reducing red (processed) meat consumption is one of the factors that can have the biggest positive impact on the environment (65,66). A systematic literature review, across different European countries, has shown that people's awareness around the environmental impact of food choices, as well as their inclination to change their diet to smaller meat portions daily or weekly, were very low, and when it came to food shopping, they considered other factors when choosing foods such as cost, brand and healthiness (81,82). Another systematic literature review has reviewed 14 studies conducted in western countries, such as Netherlands, Switzerland, England, Finland and Belgium in regards to the footprint of reducing meat consumption on the environment. The results indicated that people's awareness about the carbon footprint of meat consumption was also low (83). The majority of participants from the mentioned European countries considered meat as the slightest or second slightest impact on environment, comparing to other activities such as transport pollution (83). In addition, the number of participants, who were willing to lower meat in their diet for the

environment was relatively low (83), and reducing meat consumption was not their favourite option to preserve the environment (83). Furthermore, less than 40% of participants had awareness around environmental impact of meat, and when people obtained information in regards to meat production impact on the planet, the percentage rose to 58% (82). Moreover, different studies argued that some participants thought that more facts and research was required about diet transformation (84,85), and the majority of participants were unfamiliar with the effect of the food choice on the climate change. The main reason behind it was that animal products were the main part of European farming and cultivation; it was financially supported by the governments and was publicised as environmentally friendly (85).

Australian studies suggest local behaviour and attitudes towards environmentally friendly food related practices are similar to those reported overseas (25,26,86). Australian consumer's (representing various degrees of involvement with health and environment in every day food options) refusal to lower meat intake and more vegetable consumption, and their low level of knowledge about the negative impacts of certain foods on the environment was revealed in the studies (25). Some people believed that Australia has never faced significant environmental problems, thus, this country should not be worried about 'green' product consumption (26). Some Australians believed that a diversity of practices around food consumption could preserve the environment except lower meat and higher organic intake (27). The lack of awareness was also seen among vegetarians, who were familiar with health advantages of eating less meat, as well as animal welfare, but unaware of the environmental impacts (27). Nevertheless, this is likely different in the last 2-3 years with increased awareness about sustainability, climate change, waste and overconsumption in Australia (77). In 2019 global climate strike, hundreds of thousands of Australians across the country protested as a part of this strike movement, which raised consciousness and awareness about these issues in Australia (77).

Although Australians have limited understanding of the environmental impact of their dietary behaviours (25-27), the most recent climate change protests in Australia showed that young Australians are interested in addressing issues associated with climate change (30). Also, there has been an increase in young Australians trying vegetarian and vegan diets, which may show animal right and environmentally friendly intentions, such as considering consumption of less meat and more plant-based foods, organic local products, and recycling food waste (29). Furthermore, young individuals (between 18 to 25 years) are still in transition from

young adulthood to later adulthood. They are mostly living independently or with partners, becoming parents and are at high risk of gaining weight (31). Therefore, their health behavioural pattern forms in the middle of this transition, often lasts for the rest of their lives, impacting their and their family's health (31). Thus, there is a need to explore in more depth young Australians' perspectives, motivators, and current practices in achieving sustainable and healthy diet. Therefore, the following research question (RQ) were developed for this thesis to fill this gap in the literature:

RQ2: What are young Australians' understanding of sustainable diets and their perceptions, awareness and current efforts in decreasing unsustainable protein (e.g. red meat) consumption?

Chapter 3 Identifying effective evidence-based interventions to increase environmentally sustainable protein consumption: a systematic literature review

3.1 Overview

Growing evidence demonstrates that population level dietary changes can improve health and environmental sustainability. The recent EAT-*Lancet* Commission on Healthy Diets from Sustainable Food Systems stated that there is a need for a 'Great Food Transformation' and suggested shifting to more plant-based diets and reducing animal-derived foods (6,18,19). There has been an increase in advocacy and behaviour change interventions aiming to reduce animal-derived food consumption and increase in plant-based food consumption. However, there is limited evidence on their effectiveness in changing people's behaviour. Therefore, a systematic literature review was conducted to synthesise evidence on interventions aiming to increase environmentally sustainable protein consumption. This section presents methods, results, and discussion of the systematic literature review. This review aimed to answer the following research question:

What types of interventions have been implemented globally to promote sustainable protein consumption (reduction in animal-derived proteins and increase in plant-based proteins) and how effective are these interventions?

The following sub-questions were developed for this review:

- a) What approaches have been used? Which of these approaches showed positive and which showed negative effects on behaviour change and how?
- b) What outcomes were measured (e.g. change knowledge, awareness, willingness to try, food purchasing and consumption behaviour)? Did the behaviour sustain over time?
- c) What meat substitutes have been suggested/offered? How the shift was measured? Which foods were increased as a substitute for meat?
- d) Were behaviour change theories or theoretical framework(s) used in intervention/program development?
- e) Were there any demographic differences (age, gender, educational level)?

3.2 Methods

3.2.1 Eligibility criteria

PICO (Population, Intervention, Comparison and Outcome) was used to frame the research question for this review. Details of each eligibility criteria are expanded under the subheadings and in Table 3.1. This systematic review included quantitative studies only published in peer review academic literature in English language, but it had no restriction on the study design or year of publication (up until April 2020). The protocol of this systematic literature review was registered in PROSPERO (registration number: CRD42020178683).

Table 3.1. Eligibility criteria

	Inclusion	Exclusion
Population	All except those ones listed in the exclusion criteria.	People diagnosed with clinical condition(s) for which it is required to consume specific amounts of red meat.
Intervention	Interventions targeting to reduce the demand for red/processed meat and increase in plant-based protein including structural (physical) environment changes.	Dietary interventions aiming to promote a general dietary pattern. Interventions with structural (physical) environment changes but with no evaluation.
Comparator	No- or minimal-intervention controls, pre-intervention baseline, or other eligible intervention(s).	-
Outcome	Objective or self-reported measures of demand for red meat and/or plant-based protein, defined as actual or intended consumption, purchase, or selection of meat in real or virtual environments.	-

3.2.2 Search strategy

A scientific database search was conducted searching the following databases: Medline, Web of Science, Scopus, Embase and Global Health. These databases afford broad coverage of public health, health promotion and nutrition literature. Initially, five primary concepts (meat, plant, food, intake and intervention) were adopted, in order to identify search terms (see Table 3.2). Subsequently, search strings were developed by the research team and with the help of Macquarie University research librarian (see Appendix 2).

Two researchers (the candidate (GS) and a research assistant (GR) conducted searching all databases independently. Then, potential articles were imported into Covidence software where duplicates were removed. Covidence is a web-based software that assists researchers

to screen references and undertake data extraction. The screening of search results was conducted and recorded using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist (87) (Appendix 1), by two researchers (GS and GR) independently and in consultation with a third researcher (a principal supervisor of the candidate- RR). First, two researchers (GS and GR) independently performed the title and abstract screening of all imported studies against inclusion and exclusion criteria. Where a consensus regarding the inclusion of a study between the first and a second researcher was not reached, it was resolved with a third researcher (RR). Then, full-text versions were obtained for all studies identified to be suitable in the first stage of data screening and reviewed by two researchers (GS and GR) independently. The reference lists of all included studies were hand searched for relevant studies not identified in the first search strategy. Authors of identified studies and experts of the field were consulted, where further details were required.

Included studies comprise individual level studies and micro-environmental level studies. Individual level studies refer to studies that directly focus on individuals aiming to impact their dietary behaviour. While, micro-environmental level studies refer to studies which aimed to make some changes to the environment by making it easier for people to choose preferable option. The PRISMA flow diagram was used to document the number of articles at each screening stage (Figure 3.1).

Table 3.2: Search terms

Primary concept	Search Terms
Meat	Animal-derived, animal-based, animal, meat
Plant	Plant, plant-based, sustainable, nuts, legumes, grain, soy
Food	Food, diet, protein, substitute
Intake	Intake, consumption, reduction
Intervention	Intervention, program, campaign, policy, evaluation

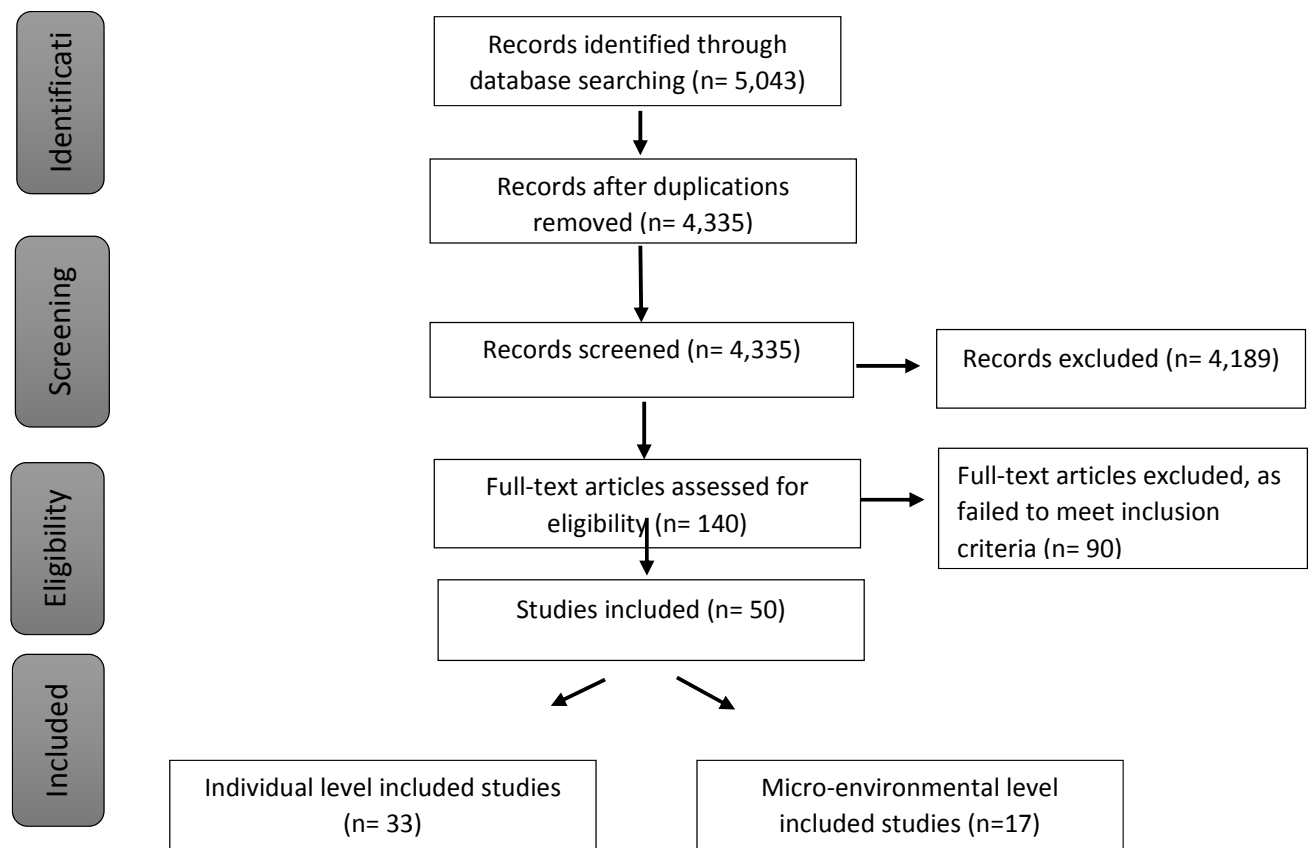


Figure 3.1: The PRISMA flow diagram.

3.2.3 Data extraction and analysis

The data extraction sheet was developed by the research team. Data extraction sheet included the following information: author(s), year of publication, country of study, title, location, study type (structural/individual), intervention year, intervention length, target audience, sample characteristics, aims, intervention design, behaviour change theory/framework used, eligibility, recruitment, demographic characteristics, measure/tool(s) used, outcomes measured, results, follow up period, follow up results. Three researchers (GS, GR and RR) tested the data extraction sheet by extracting data from five articles; minor disagreements were identified and discussed. Then, two researchers (GS and GR) extracted data from all included studies independently and then cross-checked all extracted data. Any disagreements were resolved in consultation with the third researcher (RR). Finally, summary tables were prepared by two researchers (GS and GR).

The risk of bias of each included study was assessed by two researchers (GS and GR) independently by using the Quality Assessment Tool for Quantitative Studies (88). This tool was developed to assess the quality of a diverse group of empirical studies. Each included study was assessed on study design, selection bias, confounders, blinding, data collection method, withdrawals and dropouts and assigned to either strong, moderate or weak category. Finally, the overall rating was determined based on these ratings as indicated in the assessment tool. Any disagreements were resolved with a third researcher (RR). Finally, all quantitative data was summarised.

3.3 Results

Search results and characteristics of included studies

The included studies (see Figure 3.1) were divided into two categories: individual and micro-environmental level studies. The summary of each study is provided in Tables 3.3 and 3.4.

Of the 50 included studies, 33 were categorised as individual level studies (89-121). They included 24 Randomised Controlled Trials (RCT) (89-112), two Non-randomised Controlled Trials (CT) (100, 101), and seven pre-post design studies (115-121).

The number of participants ranged from 7 to 48,835 and the participants' age ranged from 6 months (infants) to 75 and older with only one study including participants below 18-year-old (107). Out of 32 studies with adult participants, four studies included participants younger or equal to mean age of 23.5 (89,92,93,120), who were mostly University students. Nine studies had 100% or close to 100% female participants (90,91,104,108,109,112-114,118), and three studies had 100% male participants (89,95,119). In six studies, gender distribution was either even or the difference between them was less than 10% (92,94,100,102,110,115).

Of the 50 included studies, 17 studies were categorised as micro-environmental level studies (122-138). They included nine RCTs (122-130), two CTs (131,132), two field experimental design studies (133,134), one quasi-experimental design study (135), and three pre-post design studies (136-138). The number of participants ranged from 24 to 3,066 participants, and the participants' age ranged from 12 to 75 years and older. In eight studies, there were no significant differences in gender ratio of the sample (less than 10%) (122-124, 128, 129, 132, 135, 136), and six studies did not provide the sex differences between the participants (1125,126,131,133,137,138). Of 17 micro-environmental level studies, 16 studies took place

in dining facilities, for example restaurant, café or worksite canteens (123-135,137,138). One study selected a farm and a small community and their residents as their participants (136).

Table 3.3: Summary table of individual level studies

Author(s) (year), country	Sample characteristics	Perspective	Intervention	Behaviour change theory	Outcomes	Results	Overall quality assessment
Randomised controlled Trials (RCT)							
Amiot et al., 2018 Canada (89)	Adults Age: M=23.5 (SD 3.1) Sample size: IG=16 CG=16 Male: 100%	Health and environment	The intervention comprised of 4-week multicomponent intervention aimed to reduce meat intake which included 5 components: a social norm; an informational/educational; an appeal to fear; a mind attribution induction; and a goal setting/self-monitoring. It also included 3 in-lab sessions for the intervention group and 2 for the control group.	Social psychological theories and Self-determination theory (SDT)	All outcomes were measured at baseline (T1), 2 weeks (T2) and 4 weeks (T3) later using dietary journal: total , during the week and weekend meat, red meat, white meat, and cold cuts consumption (in grams).	No significant changes were observed for total meat intake; total, week and weekend white meat intake; weekend red meat intake; weekend fish intake; and weekend cold cuts intake. However, participants in the intervention group consumed significantly less red meat in total and at T3 ($M_{diff}=186.06, p<0.025$); and during the week from T1 to T3 ($M_{diff}=73.91, p<0.025$).	2
Archarya et al. 2004 USA (90)	Adults (premenopausal women) Age: M(IG)=43.2 (SD 2.7); M(CG)=42.8 (SD 2.8). Sample size: IG=100, CG= 106. Female: 100%	Health	The intervention aimed to increase in soya intake among premenopausal women. The intervention group was supplied with approx. 50mg of isoflavones per day for 2 years. All participants were counselled by a registered dietitian to learn how to incorporate best soya products into their regular diet.		Red/processed meat and soya intake using validated FFQ at baseline and telephone administered 24-h recalls.	IG consumed more soyabean products and reduced intake of red meat from baseline to 1-year intervention (Mean \pm SD): red meat 1.2 \pm 1.0 to 1.1 \pm 0.9; soyabean products 0.1 \pm 0.1 to 1.8 \pm 0.6.	2
Beresford et al., 2006 USA (91)	Adults (postmenopausal women) Age: between 50 to 79 years	Health	The intervention was an intensive behavioural modification program aimed to reduce dietary fat and meat intake, which used 18 group sessions in the first year and quarterly		Red meat intake (servings/d) were measured at baseline and at year	The intervention was associated with statistically significant reduction in red meat intake (IG= Mean -9.7 (SD 128.4); CG= Mean 10.5 (SD 114.1)); Mean $_{Diff}$ = -20.2 (-25.5 to -14.8).	3

	Sample size: IG= 19,541, CG= 29,294 Female: 100%		sessions thereafter led by specially trained and certified nutritionists. Each participant was given their own dietary fat-gram goal according to the height. It emphasized self-monitoring techniques and introduced other tailored and targeted strategies. CG: received a copy of the US Department of Health and Human Services' Dietary Guidelines for Americans and other health related materials but were not asked to make dietary changes.		3 using FFQ and 4-day food record.		
Carfora et al., 2017a Italy (92)	Adults (undergraduate students) Age: M=19.37 (SD 1.55) Sample size: IG=55, CG= 57 Male: 44%	Health and environment	The intervention aimed to reduce processed meat consumption (PMC) in young adults and consisted of a combination of encouragement of written self-monitoring of behaviour and anticipated regret as behaviour change techniques. IG received a daily SMS for 1 week on <i>Whats App</i> , which focused on anticipated regret and urged them to self-monitor PMC. CG: no intervention.	Theory of Planned Behaviour (TPB)	An online food diary was used to measure PMC and questionnaire to measure intensions, affective and instrumental attitudes and anticipated regret.	The intervention was associated with statistically significant changes in reduction of PMC ($F(1,112)= 13.09$; $p < 0.001$, $np^2=0.11$). Also, it showed significant effects on instrumental attitude ($F(1,112)= 8.81$; $p < 0.004$, $np^2= 0.09$), anticipated regret ($F(1,112)= 5.40$; $p < 0.02$, $np^2=0.06$) and intentions ($F(1,112)= 7.32$; $p < 0.008$, $np^2=0.06$).	2
Carfora et al., 2017b Italy (93)	Adults (undergraduate students) Age: M(IG)=19.29 (SD 1.75); M(CG)=19.29 (SD 1.04) Sample size: IG=116, CG=112 Male: IG=28%; CG=29%	Health and environment	The intervention aimed to reduce red meat consumption (RMC) in young adults. It used text messaging interventions to decrease RMC. IG received a daily SMS, which focused on anticipated regret and urged them to self-monitor RMC. CG: no intervention.	Theory of Planned Behaviour (TPB)	An online food diary was used to measure RMC and online TPB questionnaire to measure intensions, affective and instrumental attitudes, subjective norms.	The intervention was effective in increasing intentions and reducing RMC. Results showed significant effects of condition for intention ($F(1,226)= 9.36$; $p < 0.01$, $n^2 = 0.04$), PBC ($F(1,226) = 5.14$; $p < 0.05$, $n^2= 0.02$), instrumental attitude ($F(1,226) = 23.84$; $p < 0.001$, $n^2= 0.10$), healthy-eating identity ($F(1,226) =11.08$; $p < 0.001$, $n^2= 0.05$), and weekly RMC at T2 ($F(1,226) = 29.76$; $p < 0.001$, $n^2= 0.12$).	2

Celis-Morales et al., 2017 Ireland, The Netherlands, Spain, Greece, UK, Poland and Germany (94)	Adults Age: M= 39.8 Sample size: IG1=312, IG2=324, IG3=321, CG=312. Male: 41%	Health	The intervention aimed to evaluate the effect of different levels of personalized nutritional (PN) advice on intakes of major food groups including red meat. The Food4Me four-arm RCT conducted across 7 European countries. Participants were randomized to a CG (Level 0) or to one of three PN IG with increasingly more detailed personalized dietary advice (Levels 1–3) for a 6-month period.		Red meat intake (gram/d) following 6 months' intervention using online questionnaire.	Individuals receiving PN advice consumed less red meat (8.5%). Red meat (g/day) for IG=59.3 and CG=64.7 (-5.48 (-10.8 to -0.09), $p=0.046$.	2
Carmody et al., 2008 USA (95)	Adults (patients with an increasing prostate-specific antigen (PSA) level and their partners) Age: M=69.1 (SD 9.0) Sample size: IG=17, CG=19 Male: 100%	Health	The intervention was 11 weekly 2.5-hour classes aimed to reduce meat intake. IG classes integrated didactic and experiential components on learning to shop for, and cook meals compliant with the study diet, and the use of mindfulness as a support in the dietary change. The participants received a study manual with background nutritional information and a cookbook of study-compliant meals and cooked and ate together a study-compliant meal at each class. CG: received the usual care, with the option of the intervention after their study participation.		Red meat intake, which measured at baseline, immediately after intervention and 3 months after intervention, using the 24-Hour Dietary Recall Nutrition Data System.	The IG showed significant reductions in: animal proteins (g)- baseline: 48 ± 19 , immediately after intervention: 28 ± 17.1 , 3 months after intervention: 28 ± 16.3 , $p=0.03$; and vegetable protein (g): baseline: 27 ± 8.4 , immediately after intervention: 39 ± 14.8 , 3 months after intervention: 43 ± 15.1 , $p=0.0002$.	3
Dalgard et al., 2001 Denmark (96)	Adults (patients with ischemic heart disease) Age: M(IG)= 55.5 (SD 11.3), M(CG)= 56.2 (SD 8.2)	Health	The intervention aimed to change dietary habits (including reducing meat intake) of patients 1 year after they received dietary advice. IG received either dietary advice on using the Plate Model and how to increase intakes of fruits and		Meat intake using food records.	The comprehensive counselling group significantly reduced meat intake (g/day): difference between groups from baseline to Week 52 $34(6;61)$, $p=0.01$.	3

	Sample size: IG=17, CG=19. Male: N(IG)=15, N(CG)=16.		vegetables in a 10-minute session and CG received dietary advice primarily based on the National Cholesterol Education Program provided in 2 individually tailored 50-min session held 3 months apart.				
Delichatsios et al, 2001a USA (97)	Adults Age: M(IG)=49.9 (SD 12.5); M(CG)=56.8 (SD 12.9) Sample size: IG=195, CG=252 Male: 30%.	Health	The intervention aimed to improve dietary habits among adult primary care patients. It comprised of mailed personalized dietary recommendations and educational booklets, verbal endorsement by the primary care provider; and 2 motivational counselling sessions with telephone counsellors.	Transtheoretical model	Red/processed meat intake (weekly serving) using baseline and 3-month follow-up FFQ.	There was no intervention effect on red meat and dairy products in IG and CG. Red/processed meats (weekly servings): Adjusted difference (95% CI)= 0.0 (-0.3, 0.3).	2
Delichatsios et al, 2001b USA (98)	Adults Age: M(IG)= 46.2 (SD 12.2), M(CG)=45.7 (12.5) Sample size: IG=148, CG= 150 Male: 28%.	Health	The intervention aimed to improve individuals' diet, which was delivered via a totally automated, computer-based voice system. IG: the system monitored dietary habits and provided educational feedback, advice, and behavioural counselling. CG: received physical activity promotion counselling.	Social Cognitive Theory	Red/processed meat intake from baseline to 3 months and from baseline to 6 months, using validated, semiquantitative, 131-question FFQ.	Changes in intakes of red and processed meats showed trends in more healthful intake, although these trends were not statistically significant: Adjusted difference from baseline to 3 months (95% CI)=-0.1 (-0.3, 0.2) and from baseline to 6 months (95% CI)=-0.1(-0.3, 0.1).	2
Emmons et al, 2005a USA (99)	Adults (patients who resided in low-income, multiethnic neighbourhoods) Age: M(IG)=50.8, M(CG)=47.8. Sample size: IG= 1088, CG=1131. Male: IG= 39.5%, CG= 29.1%.	Health	The intervention aimed to change diet and comprised of: (1) study endorsement from the participant's clinician at a scheduled routine care visit, including provision of a tailored prescription for the recommended health behaviour changes; (2) an initial in-person counselling session with a health adviser; (3) 4 follow-up telephone counselling sessions with the health adviser; sets of tailored materials written for low-literacy		Red meat intake per week using an abbreviated form of the semiquantitative FFQ.	Significantly greater change was found among participants in IG in red meat intake (3 or fewer servings per week) ($p<.001$). 12% of the IG reduced red meat intake to < 3 servings per week, compared with no change in the CG.	

			audiences that targeted social contextual factors and links to relevant local activities.				
Emmons et al- 2005b USA (100)	Adults (patients who had undergone either sigmoidoscopy or colonoscopy) Age: 40-59 years=47.6%. 60+ years=52.4%. Sample size: IG=591, CG=656. Male: 58%.	Health	The project PREVENT aimed to change in the multiple risk factors that pose risk for colorectal cancer and other cancer development. IG received (a) a motivational and goal-setting telephone session; (b) 4 follow-up telephone counselling calls at monthly intervals. CG: received usual care.	Social Cognitive Theory	Red meat intake using an abbreviated form of the semiquantitative FFQ.	IG experienced significantly greater improvement in reduction in weekly servings of red meat < 3 servings per week than the CG ($p=0.002$).	1
Grimmett, et al, 2015 UK (101)	Adults (colorectal cancer survivors) Age: M=65 Sample size: 29 Male: 38%.	Health	The intervention targeted physical activity, and intakes of fruit, vegetable, red and processed meat. It comprised 2-weekly telephone consultations with researcher for 12 weeks and supporting resources including meat-free menus. CG: Social support was encouraged.	Behaviour change techniques (goal setting, review of behavioural goals, self-monitoring of behaviour, and feedback on performance)	Red/processed meat intake, using a modified version of the Health Education Authority FFQ.	Red/processed meat intake decreased from pre- to post-intervention (mean reduction for red meat: 147.4, $p=0.013$; mean reduction for processed meat: 0.83, $p=0.002$).	2
Hatami et al, 2018 Iran (102)	Adults Age: +50 Sample size: IG= 48, CG = 50. Male: IG=54%, CG=50%	Health	The intervention targeted dietary changes based on the health belief model (HBM) using multimedia. The IG group received an audio-visual compact disc (CD) that contained information about nutritional behaviour of colorectal cancer prevention based on HBM that lasted 45 min.	Health Belief Model	Red meat intake using questionnaires, and a 3-day dietary recall at the baseline, 1 week after, and 3 months after the intervention	There was a significant decrease in red meat servings ($P=0.016$) in IG compared to the CG. In the CG, the results demonstrated a significant increase red meat intake ($p= 0.045$).	2
Jaacks et al, 2014 USA (103)	Adults	Health	The intervention targeted dietary intake, with an emphasis on food groups. Participants were		Red meat intake was assessed using a FFQ	Participants in the lifestyle arm had significantly lower red meat intakes compared with the participants in the	2

	(at high risk of developing Type 2 diabetes) Age: 20% >65 years old. Sample size: IG(lifestyle)= 1079, IG(metformin)= 1073, CG(placebo)= 1082. Female: ≥ 50%		randomized to 3 groups (lifestyle intervention, metformin or placebo) for an average of 3 years. The lifestyle intervention involved a 16-session core curriculum over the first 24 weeks, followed by an individualized counselling curriculum (at least monthly contact).		at baseline and at 1, 5, 6 and 9 years.	metformin and placebo arms. This change was statistically significant at 5 and 9 years ($p<0.05$).	
Johansen et al, 2009 Norway (104)	Adults (women living in Norway and born in Pakistan or women born in Norway for 2 Pakistani parents) Age: M(IG)=40.9; M(CG)=41.5 Sample size: IG=101; CG=97. Female: 100%	Health	The intervention aimed to change dietary behaviour for Pakistani women living in Norway. IG received culturally adapted lifestyle education, including diet and physical activity. CG did not receive lifestyle advice except for the advice that they might have received by their GP or at the health-care centre.	Transtheoretical Model	Red meat intake measured using FFQ which applied before and after the 7-month intervention and included questions on intentions to change.	The daily intake of red meat was reduced in the IG ($P=0.001$) but it was insignificant when comparing to CG ($p=0.063$).	2
James et al, 2015 Australia (105)	Adults (cancer survivors and carers) Age: M(IG)= 56.2 (SD 12.6) M(CG)= 58.1 (SD 11.2). Sample size: IG=75, CG=58. Male: IG=20%, CG=26%.	Health	The intervention targeted physical activity (PA) and diet. IG: face-to-face, group-based intervention (6 theory-based 2-hour sessions delivered over 8 weeks targeting healthy eating and PA). CG: Waitlist (after completion of 20-week data collection).	Social Cognitive Theory	Red meat intake using the 74-item FFQ.	No significant changes in red/processed meat intakes between groups after 8 or 20 weeks. Red meat (g/day): adjusted mean difference (95% CI) 8 weeks=-4.1(-28.3 to 20.1); 20 weeks= 6.8 (-17.3 to 30.9), $p=0.4208$. Processed meat (g/day): adjusted mean difference (95% CL) 8 weeks=1.8(-3.2 to 6.7); 20 weeks=3.1 (-3.9 to 10.1), $p=0.6659$.	2

Lee et al, 2018 China (106)	Adults (colorectal cancer survivors) Age: M= 65.2. Sample size: IG (Dietary and PA)=55, IG(Dietary)=56, IG(PA)=56, CG=56. Male: 63%	Health	The intervention targeted diet and PA. The interventions included individual face-to-face motivational interviews, fortnightly motivational phone calls, mailed monthly stage-of-change matched educational pamphlets, mailed quarterly newsletters, and quarterly group meetings.		Red/processed meat (RPM) intake using a validated FFQ measured at months 6, 12, 18, 24.	Dietary interventions significantly reduced RPM at all time-points (95% CI)=0.88 (2.32 to 6.50), $p<0.001$.	1
Matthews et al, 2019 Finland (107)	Infants to 20-year-old adults Age: 13 months to 20 years. Sample size: IG =540, CG = 522.	Health	The intervention (STRIP) targeted dietary behaviour. IG received dietary counselling biannually from age 7 months to 20 years. CG did not receive any intervention.		Red/processed meat intake was assessed annually using 4-day food records.	No difference in the intake of red/processed meat (b: $\beta = -1.19$, 95% CI = -3.76–1.39 g/day, $p=0.37$).	3
Merrill et al, 2009 USA (108)	Adults Age: M (IG)=56.8 (SD 8.7); M(CG)=58.0 (SD 9.0) Sample size: IG=69; CG=50 Female: 100%	Health	The plant-based dietary intervention targeted the intake of dairy products and meat. It included an intensive 40-hour educational course delivered over a 4-week period. Physical and dietary behaviours were promoted using health education and positive reinforcement.	Learning Theory (Behaviourism)	Meat intake using the Block 98 full-length dietary questionnaire which was administered at baseline, 6 weeks, and 6 months.	After 6 months, those in the IG showed significant decreases in daily meat intake. Difference in means between baseline and 6 weeks in IG=-0.3 (95% CI= -0.5,-0.1). Difference in means between baseline and 6 months in IG=-0.5 (95% CI=-0.7,-0.3).	1
Saffari et al, 2014 Iran (109)	Adults (obese/overweight women) Age: M(IG)=33.9 (SD 6.49), M(CG)=34.62 (SD 5.63) Sample size: IG=157, CG= 170. Female: 100%	Health	The intervention targeted dietary habits. IG sessions were carried out on a one-to-one basis with the implementation of 5 60-minute face-to-face sessions in the health centres. Motivational Interviewing (MI) techniques was used to encourage the participant's involvement, confirmation of the positive statements, using reflection to promote positive thinking.		Meat intake using FFQ measured at baseline and at months 3, 6, 9 and 12.	The intake of meat was significantly reduced in IG after intervention ($P<0.05$). IG: meat (g/d) change from baseline to one year after MI= -12.08 and CG: meat (g/d) change= -1.09.	2

Sacerdote et al, 2005 Italy (110)	Adults Age: M(IG)=44.7 (SD 12.6); M(CG)=44.2 (SD 12.1). Sample size: IG=1,592; CG=1587. Male: IG=50%; CG=50%	Health	The intervention targeted dietary changes which included a non-structured 15-min educational intervention by general practitioners (GPs) on modifications of daily diet among healthy adults. IG: at the first visit the GP administered a 15-min personalized nutritional intervention. It focused on higher intake of fruits, vegetables, fish, and olive oil and lower intake of red meat, snacks, and sweets. CG received 'sham' intervention, which is a simpler and non-personalized conversation without the use of a brochure.		Red meat intake per week using 40-items FFQ.	IG showed a slightly reduced net intake of meat. The net change of meat intake (portions per week) at 1 year in the IG was -0.22 (CI -0.11 to -0.69).	2
Shai et al, 2012 Israel (111)	Adults (health care providers (HCP) and patients) Age: M(HCP/IG)=43.5 (SD 13.9); M(HCP/CG)=48.6 (SD 11.3); M(patients/IG)=34.5 (SD 9.1); M(patients/CG)=35.8 (SD 9.1). Sample size: HCP(IG)=55; HCP(CG)=22; patients(IG)=346; patients(CG)=150.	Health	The Promoting Health by Self Experience (PHASE) intervention was multidisciplinary lifestyle intervention which comprised of 5 workshop days over 3 months in a small group sessions.	Theories of experimental learning and Bridges' model of change	Red meat intake using questionnaire.	Among patients in IG, there was an overall improvement in dietary patterns, with decrease in red meat intake ($p<0.05$).	3
Zuniga et al, 2018 USA (112)	Adults (overweight and obese, early-stage breast cancer survivors (BCS))	Health	The intervention aimed to increase adherence to a Mediterranean style, anti-inflammatory dietary pattern in BCS. In the 6-month intervention, IG received monthly nutrition and		Red meat intake using questionnaire at baseline and 6 months.	IG significantly reduced red meat intake to < 1 serving/day. At 6 months, 86.4% of the IG reported consuming less than one serving of red meat a day ($p=0.002$).	2

	Age: M(IG)=55.3 (SD 10.3), M(CG)= 58.4 (SD 8.2). Sample size: IG=76, CG=77. Female: 100%		cooking workshops, motivational interviewing telephone calls, and individualized newsletters. CG: received monthly informational brochures and no navigational services.				
Non-randomised controlled Trials (CT)							
Schiavon et al, 2014 Brazil (113)	Adults (women with breast cancer) Age: M=51 Sample size: IG = 18, CG= 75. Female: 100%	Health	The 12-month intervention targeted nutritional factors (red/processed meat and fruit and vegetable intake) and oxidative stress during treatment of breast cancer. It comprised of information bi-weekly phone calls, bi-monthly 24-hour dietary recalls followed by researchers' feedback and supporting materials. CG received basic healthy lifestyle guidelines at baseline and follow up.	Social Cognitive Theory	Red/processed (RPM) meat intake was measured using a validated FFQ.	A significant reduction in RPM consumption was observed between the groups in unadjusted analyses (B(exp)=0.5, $p<0.05$).	1
de Liz et al, 2018 Brazil (114)	Adults (women undergoing breast cancer treatment) Age: NR Sample size: IG=18, CG=68. Female: 100%	Health	The intervention targeted diet including meat intake. IG participated in 12-month program by biweekly phone calls, personal meetings, and monthly handouts, while targeting the intake of at least 400 g/day of fruits and vegetables, and no more than 500 g/week of red or processed meats.		Red/processed meat intake (<500 g/week) using a validated FFQ for Brazilian adults.	The IG improved their adherence and intake of red/processed meat intake to the guidelines (<500g/week). Change in meat intake before and after the intervention IG= -219.6 (-778.1;-77.0).	2
Pre-post design							
Hawkes et al- 2009 Australia (115)	Adults (patients who had undergone surgery or chemotherapy) Age: Median= 66.0 Sample size: 20. Male: 50%	Health	The intervention (CanChange) was a 6-week telephone-delivered intervention by health coaches and supported by an interactive participant handbook. It targeted intake of red/processed meat, fruit and vegetable, alcohol, weight	Social Cognitive Theory	Red/processed meat intake (in servings per week) measured by self-report survey.	There was a significant decrease in the intake of from baseline (Median=1) to post intervention (Median=0, $p=0.01$). No changes for red meat intake pre- and post- intervention.	1

			management, PA and smoking. It included lifestyle support, health risks information, behaviour change strategies, self-efficacy and outcome expectations.				
Hawkes et al, 2012 Australia (116)	Adults (first-degree relatives of colorectal cancer survivors) Age: M=47.3 (SD 13.4). Sample size: 22 Male: 18%	Health	The intervention targeted behavioural risk factors for colorectal cancer including PA, diet (red/processed meat intake, fruit and vegetable intake), alcohol, weight management and smoking). The intervention included 6 x 1hour telephone health coaching sessions focus on motivation, expectations, values, mindfulness, expectations, action planning, goal-setting, self-monitoring, and a participant handbook and a pedometer.	Social Cognitive Theory	Red/processed meat intake using validated questionnaire.	Processed meat intake decreased pre- to post- intervention (mean change, 95%CI=-1.2, -1.8 to -0.5, $p<0.01$). No changes for red meat intake pre- and post- intervention.	2
Flynn et al, 2013 USA (117)	Adults (Food Pantry clients) Age: M=51.8 (SD 16.6) Sample size: 63. Male: 16%	Health	The intervention aimed to improve the food purchases of food pantry clients while decreasing food expenditures. It consisted of a 6-week cooking program which included plant-based recipes with a goal that participants would use the recipes for 3 meals per week. The cooking classes lasted about 30 min and involved a demonstration of one of the recipes.		Meat intake and purchasing measured by a questionnaire at baseline, after 4 prior to the cooking program, 6 weeks of cooking, and after 6 months.	Grocery receipts showed a decrease in purchases of meat ($p<0.01$). Average dollars/week spent on meat decreased significantly at baseline to follow-up (16.45 ± 2.20 to 7.54 ± 0.71 ; $P<0.001$). The number of meals per week that were plant-based recipes and did not contain meat/poultry/seafood increased significantly from baseline to follow-up (0.6 ± 1.1 vs 2.8 ± 1.3 ; $P<0.01$).	2
Lessem et al- 2019 USA (118)	Adults (nurse practitioners) Age: ranged from 25 to older than 65 years.	Health	The intervention aimed to increase health care providers' knowledge and acceptance of whole-food plant-based (WFPB) diets and increase their likelihood of counselling patients on this dietary pattern. It was an online program comprising of	Pender's health promotion model	Meat and legume intake using FFQ.	Participants decreased intake of animal-derived foods. The largest change was in a 174% increase in legume serving (pre- 4.43 to post- 12.13 and an 86% decline in meat servings per week (pre-intervention 8.57, post-intervention 1.2).	2

	Sample size: 30 Female: N= 29.		a daily meal plan, shopping lists, education and motivational information. Participants received a weekly email with an educational voiceover PowerPoint presentation and WFPB information and resources.				
Maryuyama et al, 2017 Japan (119)	Adults Age: 30-49. Sample size: 33. Male: 100%.	Health	The intervention targeted metabolic risk factors for atherosclerotic cardiovascular disease in middle-aged men. Participants attended a one-hour nutrition education class to learn food items and recommended volumes comprising the Japan Diet, and were encouraged to consume the Japan Diet for 6 weeks.		Meat and poultry intake using a 3-day weighted dietary records.	Intakes of meat and poultry decreased significantly post intervention ($P=0.011$) from baseline (g)= 134.3 \pm 52.3 to 6 weeks(g)= 95.4 \pm 73.0.	1
Ring et al, 2019 USA (120)	Adults Age: M(cohort 1)= 22.44 (SD 0.88); M(cohort 2)= 22.08 (SD 1.08) Sample size: cohort 1=9, cohort 2=12. Female: cohort 1= 6, cohort 2= 8.	Health	The intervention (<i>Cooking Up Health</i> (CUH)) aimed to improve medical students' cooking and nutrition confidence, attitudes, and behaviours. CUH culinary elective module was developed to students and included: combination of lectures and readings, group meetings for interactive in counselling and motivational interviewing to promote healthy behaviours. Each class concluded with a hands-on chef-led culinary session on preparing plant-based meals along with a group dinner.		Meat intake using PrimeScreen Dietary Screening Tool.	Participation in CUH elective was associated with decreased meat consumption over time for students in cohort 1 ($p=0.045$) and the effect size was large ($ds=1.49$); and cohort 2 also showed decrease in red meat intake but effect was marginal in statistical significance ($p=0.08$), effect size ($d=1.55$).	1
Spees et al, 2016 USA (121)	Adults (cancer survivors) Age: M=62. Sample size: 22. Male: 23%	Health	The intervention was a 4-month multifaceted intervention focusing on nutrition, PA and behavioural modifications delivered within a garden setting. It included harvesting	Social Cognitive Theory	Red/processed meat intake using a validated 26-item dietary screener questionnaire at	The intervention resulted in significant decreased consumption of red and processed meats ($p=0.030$).	1

			produce >3 times a week, biweekly group education classes, access to remote motivational interviewing caching by a trained registered dietitian nutritionist, access to a secure online web portal for lifestyle behaviour recommendations and wellness tips, recipes and other resources.		baseline and immediately post-intervention.		
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Table3.4: Summary table of micro-environmental level studies.

Author(s) (year), country	Sample characteristics & comparison	Perspective	Intervention	Behaviour change theory	Outcomes	Results	Overall quality assessment
Randomised Controlled Trials (RCT)							
Attwood et al. (2020), UK (122)	Adults Study 1 Age(yrs): 18 to 65+ Sample size: 147 Male: 39.5% Study 2 Age(yrs): 18 to 65+ Sample size: 452 Male: 42%	Health and environment	This study investigated menu-based nudges (the decoy effect) on encouraging diners to move away from selecting meat-based meals and towards plant-based alternatives when choosing from food menus across different menu scenarios. Participants were randomly allocated to either a control (decoy absent) or intervention (decoy present) group. Participants were asked to choose between three dishes- a 'competitor' meat option, a 'target' vegetarian option and a 'decoy' vegetarian option.	Nudge theory	Choice of vegetarian option across different menu scenarios using online survey.	There was no significant effect of the intervention in study 1: decoy absent-(CG) vs. decoy present (IG): OR 0.50, 95% CI 0.22 to 1.15; $p=0.1$. In study 2 across 7 menu conditions and testing a more expensive decoy also showed no effect of the intervention decoy absent vs. decoy present: OR 0.68 (95% CI 0.41 to 1.12).	2
Bacon et al. (2018a), UK (123)	Adults Setting: Restaurant Age(yrs): Median=34 Sample size: 750; CG=194 IG(recommendation menu)=185 IG(descriptive menu)=185 IG(vegetarian menu)=186 Male: 47%	Health and environment	In an online scenario, participants were randomly assigned to 4 different restaurant menu conditions: control (all dishes presented in the same manner), recommendation (vegetarian dish presented as chef's recommendation), descriptive (more appealing description of vegetarian dish), and vegetarian (vegetarian dishes placed in a separate section). Participants were asked to imagine a scenario in which they were catching up with a friend for dinner and asked	Theory of Planned Behaviour	Frequency of choosing vegetarian dishes.	The recommendation menu (OR 1.1, 95% CI [0.618, 1.973] and the descriptive menu (OR 0.917, 95% CI [0.503, 1.673] did not influence vegetarian food choice in comparison to control menu. Vegetarian menu decreased the odds of selecting a vegetarian dish (OR 0.406, 95% CI [0.195, 0.848], $p=0.016$).	2

			to choose a meal from allocated menu. Vegetarians and vegans were excluded.				
Campbell-Arvai et al. (2014), USA (124)	Adults Setting: Dining facilities on university campus Sample size: 319 Male: 47%	Health and environment	The intervention was a menu choice experiment with undergraduate university students over a 2-week period. Participants were given approx. 5 min to consult one of eight randomly assigned menus and make their selection. A 2x2x2 factorial design was used in menu choice experiment varying: 1) IG menus included five appealing meat-free options and a range of non-vegetarian dishes and CG menus included five less appealing meat-free options and a range of non-vegetarian dishes; 2) IG menus- meat options were removed and repositioned on a board 3.5m away and CG menus contained a range of meat-free and meat-based options; 3) IG menus contained a range of meat-based options and meat-free options with a leaf symbol indicating that consuming less meat can help to reduce our environmental impact and CG menus contained a range of meat-free and meat-based options.	Nudge theory	Selection of meat-free food options on menus measured using a survey.	Participants viewing IG menus with five appealing meat-free options had lower odds of selecting meat options than did those viewing CG menus (OR 0.49, 95% CI 0.36-0.66). Also, participants viewing IG menus with removed meat options and repositioned on a board had lower odds of selecting meat options than did those viewing CG menus (OR 0.24, 95% CI 0.18-0.36). However, the odds of selecting a meat-based dish did not differ between participants viewing the IG meat-free menus with a leaf or the CG menus (OR 0.92, 95% CI 0.69-1.2).	2
Gravert & Kurz (2019), Sweden (125)	Adults Setting: Restaurant Sample size: 1 restaurant	Health and environment	The intervention consisted of 2 weeks intervention and 1-week post-intervention. The restaurant had front and back part, which served as control and intervention area during lunch times. The back of the restaurant served as CG and received	Nudge theory	Sales of vegetarian (meat-free) dishes.	Only 2.5% of all dishes sold were vegetarian without the vegetarian option on the menu. The share of meat dishes during the intervention dropped from 47% to 34%, a reduction of 38% ($p<0.01$). The vegetarian dishes increased from 3% to 9% on average, a	3

			a menu listing 1 meat and 1 fish option and the sentence "Vegetarian meal available on request". The front area served as IG and customers received a menu listing 1 vegetarian and 1 fish option (no meat) but with the sentence "option of meat available".			200% increase ($p<0.01$). Of all dishes sold, 15% were vegetarian in the vegetarian area but only 3.5% were vegetarian in the meat area ($p<0.01$).	
Herbert et al. (1993), USA (126)	Adults Setting: Workplaces Sample size: 16 worksites assigned to either IG or CG, questionnaire responses N=2365 (baseline).	Health	The intervention focused on 8 discrete food-based eating pattern messages aimed to increase fruit, vegetable, high fibre cereals, whole grain breads and rice or pasta, potatoes and fried beans, peas or lentils, substitution of low-fat dairy products and removal of skin from chicken and trimming visible fat from meat or substitution of fish and poultry for other meat. It consisted of classes, taste tests, food demonstrations, labelling of recommended foods in cafeteria and bulletin board displays. Intervention was tailored for each worksite.		Ground and processed meat intake (serves) assessed using self-administered health habits questionnaire (HHR) including FFQ measured at baseline and after intervention.	A significant decrease in ground and processed meats were observed among intervention companies ($p=0.05$).	1
Kongsbak et al. (2016), Denmark (127)	Adults Setting: Ad libitum buffet Age(yrs): Mean(IG)= 23.8±0.4 Mean(CG)=24.4±0.4 Sample size: N(IG)=33, N(CG)=32 Male: 100%	Health	A single one-day lunch meal study was conducted in a FoodScape Laboratory where an Intelligent Buffet was used to register the exact weight of each meal component self-served by each participant. The choice architecture in the IG consisted of altering the serving sequence and serving fruit and vegetable components in 8 separate bowls. In CG, all salad components were served together.	Choice architecture	Selection of self-served meatballs in grams using radio frequency identification technology.	There was no significant difference in selection of meatballs between IG (mean 156.2, SD 71.1; $p=0.078$ and CG (mean 194.6, SD 78.6) after adjusting for BMI, age, and selection of salad, pasta and bread.	2

McClain et al. (2013), USA (128)	Adults Setting: University dining halls Age(yrs): 20 Sample size: 4 university dining halls; 92 IG and 2 CG; questionnaire responses N(IG)=247, N(CG)=278 Male: 47%	Health	The intervention was a 4-week multicomponent, point-of-selection marketing intervention. For the intervention, four prototypes were developed: (1) Students were given menus upon entry into the dining hall to help them decide their meal; (2) a “dimsum” style vegetable cart was pushed throughout the dining hall; (3) prepared balanced meals were placed on display at the dining hall’s entrance; (4) a Chef’s “Pic” of the day that included a portrait of the chef and a plated vegetarian meal were placed on display at the front entrance of the dining hall. CG: 4 weeks of business as usual.	Social Cognitive Theory Transtheoretical Model	Intake of fruits, vegetables and high-fat meat measured as servings per week assessed at baseline and after intervention using FFQ.	Students in the intervention dining halls consumed significantly less junk food and high-fat meat and increased their perceived importance of eating a healthful diet (more fruits and vegetable servings per week) relative to the CG. In the IG, high-fat meat intake reduced by 0.9 servings per week and in CG increased by 0.9 servings per week; $p=0.04$.	2
Reinders et al. (2017), Netherlands (129)	Adults Setting: Restaurant Age(yrs): Mean=48.6±17.5 Sample size: 1006; IG=470, CG=536 Male: 46%	Health and environment	Three restaurants were randomly assigned to a sequence of an intervention and control condition. In the intervention period, the vegetable portion sizes on the plates of main dishes were doubled (150g of vegetables instead of 75g) and the portion sizes of meat on the plates were reduced by an average of 12.5% for 6 weeks. In the control period, the portion sizes of the main dishes were maintained as usual for 6 weeks.		Vegetable and meat intake measured by subtracting the grams of meat returned to the kitchen from the average grams of meat in each of the targeted dishes.	Vegetable consumption from plates was significantly higher during the intervention period (Mean=115.5g) than during the control period (Mean=61.7g). Total vegetable intake (including side dishes) was significantly higher during the intervention period (Mean=178.0 g) than during the control period (Mean=137.0g). Meat intake was significantly lower during the intervention period (Mean=183.1g) than during the control period (Mean=211.1g) $p<0.001$.	2
Sorensen et al. (2005), USA (130)	Adults Setting: Worksites/small businesses	Health	The worksite intervention was 18-month multicomponent intervention aiming to increase fruit and vegetable intake, physical activity and reduce red meat intake and		Fruit, vegetable, and red meat intake measured in servings per week using FFQ at	At follow-up, 22% of workers at intervention worksites were eating 5 servings of fruits and vegetables per day, compared with between 12% and 15% of workers and managers at control	2

	Age(yrs): Mean(IG)=44 Mean(CG)=43 Sample size: N(IG)=13 N(CG)=13; questionnaires N(IG)=807; N(CG)=933 Male: 67%		smoking. It included policies aimed at offering healthful food options at company meetings, interactive activities, and education.		baseline and directly after intervention.	worksites. The change in percentage of participants eating ≤ 3 servings per week of red meat did not differ between intervention (+4.1%) and control group (+3%), $p=0.72$.	
Non-randomised controlled Trials (CT)							
Kurz (2018), Sweden (131)	Adults Setting: University restaurant Sample size: 2 university restaurants (IG=1 and CG=1)	Health and environment	The intervention tested if nudging can increase the consumption of vegetarian food. At the treated restaurant, the salience of the vegetarian option was increased by changing the menu order and enhancing the visibility of the vegetarian dish. The other restaurant served as a control.	Nudge theory	Daily sales data on three main dishes (one of which vegetarian) at the baseline (first 9 weeks) and intervention period of 17 weeks.	The nudge increased the share of vegetarian lunches sold by on average 6% point, and that the treatment effect increased over time. The change in behaviour was partly persistent, as the share of vegetarian lunches sold remained 4% point higher after the intervention ended than before the experiment.	1
Polak et al. (2019), Israel (132)	Adults and children Setting: Rural Kibbutz cafeteria Age(yrs): Mean(IG)=55.3 Mean(CG)=52.7 Sample size: N(IG)=493 adults and 214 children; N(CG)= 487 adults and 206 children. Male: IG=43%, CG=47%	Health	It was a community-based culinary coaching programme (CCCP). It included 8x90 min coaching sessions with a community steering committee, 22h of kitchen staff training, 12h of pre-school staff training and 30h of education for diners. Control community received no intervention.		Food purchases of legumes, wholegrain products, fruits, nuts, vegetables, MUFA/SFA, processed meats and fish measured before and 12 months after programme initiation.	Intervention cafeteria food improved significantly in all Mediterranean index categories except nuts (legumes, wholegrain products, fish, MUFA/SFA $p<0.0001$; fruits, vegetables $p<0.001$; processed meats $p=0.004$), and in the proportion of ultra-processed and unprocessed or minimally processed foods categories of the NOVA classification (-22% , $p<0.001$ and $+7\%$, $p<0.001$, respectively), compared with the control community.	3
Field experimental design							

Bacon et al. (2018b), UK (133)	Café customers Setting: Cafes Sample size: IG=10 cafes, CG=18 cafes	Environment	The intervention was an 8-week intervention aimed to increase plant-based dish sales by changing the language used to describe plant-based options on restaurant menus. The experiment was conducted in a chain of cafés within Sainsbury's grocery stores in the UK. Three vegetarian versions of meat-based dishes were selected for this experiment.		Sales of plant-based breakfast and lunch dishes assessed at baseline and 8 weeks after dish names were changed.	Changing the breakfast dish "Meat-free Breakfast" name to the alternatives of "Garden Breakfast" (OR=1.13, 95%CI 1.00 to 1.26, $p=0.04$) and "Field-grown Breakfast" (OR=1.19, 95%CI 1.05 to 1.35, $p=0.008$) led to significant increases in target vegetarian dish sales compared to CG. Alternative names: "Feel Good Fry Up" (OR=1.08, 95%CI 0.97 to 1.20, $p=0.149$), "Triple Cheese and Slow Roasted Vegetable Lasagne" (OR=0.99, 95%CI 0.87 to 1.13, $p=0.896$), "Florentine Lasagne" (OR=0.95, 95%CI 0.82 to 1.10, $p=0.504$), "Better Sausages and Mash" (OR=1.07, 95%CI 0.71 to 1.59, $p=0.757$) did not lead to a significant difference in dish sales compared to CG. Two of the three alternative names: "Field-grown Sausages and Mash" (OR=1.52, 95%CI 1.10 to 2.10, $p=0.012$) and "Cumberland Spiced Veggie Sausages and Mash" (OR=1.77, 95%CI 1.18 to 2.64, $p=0.005$), were associated with significant increases in dish sales compared to CG.	2
Friis et al. (2017), Denmark (134)	Adults Setting: FoodScape Lab, University Age(yrs): Mean(Priming)=27.3±6.6 Mean(Default)=25.9±7.1 Mean(Variety)=26.3±6.5	Health	The intervention included three experiments: priming, default and perceived variety. In the default arm, the salad was pre-portioned into a bowl containing 200g of vegetables. Priming arm tailored the environment to accommodate a green ambience of plants, green servings bowls and herbs in the dining area. In the perceived variety arm the pre-mixed salad were divided into each of its components,	Choice architecture Nudge theory	Vegetable intake (the difference in weighed intake (consumption minus wastage) measured in grams using web-based questionnaire and FFQ.	Both the priming condition and perceived variety decreased the meat-based meal component. For the vegetable intake priming had an age-related effect with an 8g/year increase for the group ($p=0.01$). Comparing the effect size of the three nudges (presented as the difference between intervention and control in g) a significant difference was seen between priming and default, with a mean	1

	Sample size: N(Priming)=24 N(Default)=33 N(Variety)=31 Male: 30-42%		to increase the visual variety of vegetables, yet not providing an actual increase in items. Control arm: the food environment was not manipulated.			difference of 201g in total intake and 81g for total vegetable intake.	
Quasi-experimental design							
Dos Santos et al (2020), Denmark, France, Italy and United Kingdom (135)	Adolescents Setting: Foodservice/restaurant Age(yrs): 12-19 Sample size: 360 Male: In Denmark, France and UK- 50%; Italy- 60%	Health and environment	The intervention aimed to influence adolescents to select a vegetable-based dish when this dish was described as “dish of the day” (IG) compared to CG when this strategy was not used. This experiment was implemented in restaurants in 4 European countries: Denmark, France, Italy and United Kingdom.	Theory of Planned Behaviour Nudge theory	Selection of vegetable-based dish (“dish of the day”) measured using questionnaire	The nudging strategy (dish of the day) did not show a difference on the choice of the vegetable-based option among adolescents ($p=0.80$ for Denmark and France and $p=0.69$ and $p=0.53$ for Italy and UK, respectively). However, natural dimension of food choice questionnaire, social norms and attitudes towards vegetable nudging were all positively associated with the choice of the vegetable-based dish. Being male was negatively associated with choosing the vegetable-based dish.	3
Pre-post design							
Craveiro et al (2019), Portugal (136)	Adults Setting: Small-scale farms Age(yrs): Mean(Farmers)=44.5±10.7 Mean(Consumers)=44.5±10.7 Sample size: 36 farmers and 294 consumers. Male: Farmers=42%, Consumers 20%	Health and environment	PROVE was a Portuguese program that empowers small-scale farmers organised into local networks to directly commercialize baskets of locally produced fruits and vegetables to consumers. Farmers received training, handbook, an access to online platform to access consumers. PROVE consumers subscribe to receiving baskets of an agreed range of fruits and vegetables with average weight of 7 kg.	The INHERIT model (INter-sectoral Health and Environment Research for InnovaTion)	Fruits, vegetables and red meat intake measured using FFQ	PROVE consumers were more likely to eat ≥5 portions of fruits and vegetables a day in comparison to the matched sample of Portuguese citizens (average odds ratio: 3.05, $p<0.05$). Also generated an impact on the likelihood of consuming ≤2 portions of red meat a week (average odds ratio: 1.56, $p<0.05$).	2

Resnicow et al. (1992), USA (137)	Children Setting: Elementary school Sample size: 5 elementary schools Longitudinal cohort (n = 1,209/ Post-test only cohort (n = 3,066).	Health	The Know Your Body (KYB) program is a comprehensive skill-based school health education program. It included classroom curriculum, school-wide activities (peer leader training, student health committees, food tasting and health lectures), and environmental modifications (school cafeteria).	Social Learning Theory	Meat intake (XX) assessed using questionnaire at baseline and 3 years post-test.	Students in the post-test only cohort who had high implementation teachers showed significantly ($p<0.05$) lower self-reported intake of meat and desserts, as well as higher health knowledge and self-reported intake of "heart healthy" foods and vegetables than comparison students.	2
Sperber et al. (1996), Israel (138)	Adults and children Setting: Kibbutz community Sample size: 208 adults and 123 children.	Health	The intervention included food policy changes in the central Kibbutz kitchen, health education programs targeting all aged groups and health counselling for individual at risk of coronary artery disease. Meals were usually consumed in communal dining rooms and prepared by kitchen staff. A registered dietitian was hired for 2 days to plan menus and advise where to buy produce with the cooks. Residents also received health education via newsletter, personal letters and mass media messages.		Food purchases measured by a questionnaire at baseline and after 2 years.	Meat intake rich in saturated fat and cholesterol dropped by 80%; red meat intake decreased by approximately 19%. The intake increased for fish (+19.2%), chicken meat (+11.4%) and vegetarian patties (+80%) increased.	3

Study quality

The overall methodological quality for all included studies was 'strong' for 12 studies, 'medium' for 28 studies and 'weak' for ten studies (see Tables 3.3 and 3.4). The quality assessment for each individual study on each individual criterion is provided in Appendix 3 and Appendix 4.

Individual level studies

Of 33 individual level studies, 30 studies aimed to reduce animal-derived foods (mainly red meat) intake due to health concerns (cancer, overweight/obesity, high risk of developing Type 2 diabetes, ischemic heart disease) (90,91,94-121), and only three studies considered both health and the environmental concerns in reducing animal-derived food intake (89,92,93).

Only 17 studies mentioned using behavioural change theory to guide their interventions aiming to reduce meat intake (89, 92, 93, 97, 98, 100-102, 104, 105, 108, 111, 113, 115, 116, 118, 121). Six studies used Social Cognitive Theory, of which two studies were RCTs (98,100). One of them found changes in consumption of red and processed meats and showed trends in more healthful consumption in Intervention group (IG), compared to Control Group (CG), although these trends were not statistically significant from baseline to 6 months (98), and in the other study IG showed greater improvement in reduction in weekly servings of red meat (less than three servings per week) compared to CG (100). One study was a CT and a significant reduction in red and processed meat intake was observed in IG in comparison to CG over 12-month intervention (113). Three studies used pre-and post-study design, and two studies found a significant decrease in the consumption of processed meat from baseline to six weeks with no changes for red meat intake pre- and post- intervention (115,116). One study resulted in significant decreased consumption of red and processed meats over four months (121).

One study used Social psychological theory and Self-determination theory (SDT) (89), which was a RCT and observed positive impact on IG, who consumed significantly less red meat at four weeks. Specifically, IG decrease their red meat intake by 55.11%, while CG increased their meat consumption by 6.14%. Two studies used the Theory of Planned Behaviour (TPB) (92,93). Both of these studies were RCTs and were successful in reducing red meat intake and had positive impact on intentions, instrumental attitudes and anticipated regret in IG compared to CG. A Transtheoretical Model was utilised in two RCT studies (97,104), which showed no effect neither on red meat nor on dairy product in IG compared to CG (97,104).

The following theories/frameworks were used in one study: the study using Health Belief Model (102), was a RCT and revealed a significant decrease in red meat consumption in IG , while it increased in CG over three months; Learning Theory (behaviourism) was used in another RCT study which showed significant decreases in daily meat intake in IG after 6 months (108), theories of experimental learning and Bridges' model of change in a different RCT study (111), revealed red meat intake reduction in IG over 3 months; a pre-post design study using Pender's health promotion model showed decrease in meat servings per week in three weeks period (118).

Educational interventions

Twelve studies used educational approach to reduce red/processed meat intake and purchase. One study used tailored education including self-monitoring techniques and motivational interviewing (91), one study used informative CDs to educate the participants (102), and the rest of the studies used different type of educational strategies such as educational classes, workshops and courses (95,104,105,109,111,112). Of these studies, eight were Randomised Controlled Trials (RCT) (91,95,102,104,105,109,111,112), and four used pre-post study design (115, 117-119). Meat intake was measured in all these studies. Among RCT studies, six found positive impact on reduction in red meat intake in IG (91,95,109,111,112), and follow up varied between 3 months to 6 years. Other RCTs found that daily consumption of red meat was reduced in the IG, but it was not significant in comparison to CG (104), and also no significant changes in red/processed meat intakes was experienced between IG and CG after 8 and 20 weeks (105). Among pre-post study design studies, one study found a significant decrease in the intake of processed meat from baseline to 6 weeks, while, no changes for red meat intake were observed in this study (115). Another study found a decrease in purchases of meat (average dollars/week spent on meat) at baseline to 6 weeks (117). A different study found decrease in meat servings per week over 3 weeks period (118), and the last one showed that intakes of meat and poultry decreased significantly post intervention from baseline to 6 weeks (119).

Counselling interventions

Eleven studies used counselling approach to reduce red/processed meat intake and increase soya intake. The counselling interventions included telephone and in person counselling sessions providing dietary advice. Of these studies eight were RCTs (90,94,96,99-101,106,108,110), one study was a CT (114), and one study was a pre-post study (116). Among

RCT studies, six studies found positive impact on reduction in red meat intake in IG (90,94,96,99,100,110), and follow up period varied between 4 weeks to 1 year. In two other RCTs red/processed meat intake decreased in IG over 12 weeks (101), and 24 months (106). The last RCT experienced significant decrease in daily meat intake after 6 weeks in IG (108). CT study showed that the IG improved their adherence and intake of red/processed meat intake to the guidelines over 12-month program (114). Pre-post study found that processed meat intake decreased pre- to post- intervention (6 weeks). However, no changes for red meat intake were observed (116).

Self-monitoring interventions

Two studies used self-monitoring approach to reduce red meat intake. They were both RCTs and used daily text-messaging (SMS), which focused on anticipated regret and urged them to self-monitor meat intake (92,93). Studies found positive impact on reduction in processed meat intake in IG in one week (92), and red meat intake in IG in 2 weeks (93).

Multicomponent interventions

Eight studies used multicomponent approach to reduce red/ processed meat intake, of which six studies were RCTs (89,97,98,103,107,113), and two studies were pre-post studies (120,121). These eight studies used mixed approaches, among which one study use education and self-monitoring (89), and seven studies used education and counselling approaches (97,98,103,107,113,120,121). Among RCTs, two studies found no intervention effect on red meat and processed meat intake in IG and CG over three months (97), and 20 years (107). One study showed that IG consumed significantly less red meat in total and at 4 weeks (89). One study, which used automated, computer-based voice system, found that changes in intakes of red and processed meats showed trends in more healthful intake, such as lower intake of processed meat, although these trends were not statistically significant in IG compared to CG over 6 months (98), and the last RCT showed that participants in IG had significantly lower red meat intakes compared with CG over 9 years (103). Two pre-post studies showed that IG was associated with decreased meat intake over time for students (120), and a significant decrease in consumption of red and processed meats in 4 months (121).

Micro-environment level studies

Of 17 micro-environmental level studies, eight studies focused on health concerns only when designing the interventions to reduce unsustainable protein intake (126-128, 130, 132, 134,137,138), one study was developed to address the environmental considerations (131), and eight studies considered both health and environmental concerns for reducing unsustainable protein intake (122-125,129-131,135,136). Eleven studies reported using behavioural change theory in their intervention design (122-125,127,128,131,134-137). Of four studies, which used Nudge theory, three were RCTs (122,124,125). One RCT showed that no significant effect of the intervention between IG and CG (122). Two RCTs showed positive impact in red and processed meat reduction and vegetable increase in IG compared to CG over 2-week period (124), and 2 weeks intervention and 1-week post-intervention (125). Another RCT study used choice architecture, which showed no significant difference in reduction in choosing meat-based dishes between IG and CG (127). A different RCT study which used both Social Cognitive Theory and Transtheoretical Model reported a significant reduction in junk food and high-fat meat intake in IG compared to CG after 4-week intervention (128). One CT study used Nudge theory and found that nudge increased the share of vegetarian lunches sold by on average 6% point in IG over 17 weeks (131). One RCT study used Theory of Planned Behaviour (TPB) (123), which found no difference in vegetarian food choice in IG compared to CG. The Quasi-experimental design study used both TPB and Nudge theory, which did not find any difference on the choice of the plant-based option among participants in IG and CG (135). A Field Experimental Design study utilised Choice architecture and Nudge theory, which resulted in the meat-based meal component reduction in IG (134). Finally, a pre-post study design used The INHERIT model (INTER-sectoral Health and Environment Research for InnovaTION) and showed an impact on the likelihood of consuming ≤ 2 portions of red meat a week (136).

Menu manipulation interventions

Of 17 micro-environmental level studies, seven studies used menu manipulation approach in order to reduce meat options or increase choice/sale of plant-based options (122-125,131,133,135). Menu manipulation included adding attractive meat free choices, adding a symbol specifying that less meat intake can save the environment, increasing the visibility of vegetarian portions, and describing the plant-based option as 'dish of the day'. Four studies were RCTs (122-125), one study was Non-Randomised Controlled Trial (131), one study used

a field experimental study design (133), and one study was a Quasi-Experimental Design (135). Of four RCTs, two did not show a difference on the choice of plant-based options in IG compared to CG (122,123), and two showed a positive impact on meat reduction behaviour by choosing more plant-based options in restaurants in IG compared to CG over 2 weeks (124), and over 2 weeks intervention and 1-week post-intervention (125). CT study also showed increase in the share of vegetarian lunches sold by on average 6% point in 17 weeks (131). Field Experimental Design study revealed a significant difference based on some changes on the menu, such as changing the language employed to explain vegetable-based options on restaurant menus (replacing Meat-Free Breakfast with Garden Breakfast), while other menu options did not show any impact neither on vegetable, nor on meat choices (133). The Quasi-Experimental Design found that the nudging strategy (dish of the day) did not show a difference on the choice of the vegetable-based option among adolescents (135).

Choice architecture interventions

Three studies used choice architecture approach, among which two studies were RCTs (127,129), and one study used a field experimental study design (134). Of these studies, one RCT used dining/environmental manipulation, which the Intelligent Buffet was used to register the exact weight of each meal component self-served by each participant (127). The choice architecture in this study involved altering the serving sequence and serving fruit and vegetable components in eight separate dishes. This study found no significant difference in selection of meat dishes between IG and CG. Another RCT used portion size/weight as an approach (129). This study doubled the vegetable portion size and reduced the meat on the plate and resulted in significantly higher vegetable intake (including side dishes) and lower meat intake in IG than CG (129). The third study included three experiments: priming, default and perceived variety. In the default arm, the salad was pre-portioned into a bowl, priming arm tailored the environment to accommodate a green ambience of plants, green colour bowls and herbs in the dining area, and perceived variety arm the pre-mixed salad were divided into each of its components, to increase the visual variety of vegetables, yet not providing an actual increase in items (134). This study found that both the priming condition and perceived variety decreased the meat-based meal component.

Multicomponent interventions

Seven studies used multicomponent approach to reduce red meat intake. Of these studies, three were RCTs (126,128,130), one study was a CT (132), and three studies were pre-post

design studies (136-138). The multicomponent approach included education, labelling, policy, counselling and choice architecture and the studies measured vegetable and meat intake. Of three RCTs, two studies found decrease in ground and processed meats in IG (126), and significantly less junk food and high-fat meat in IG compared to CG (128). One RCT showed that percentage of participants eating ≤ 3 servings per week of red meat did not differ between IG and CG over 18-month intervention (130). CT studies experienced reduction in processed meat before and 12 months after programme initiation (132). Pre-post design studies showed decrease in meat consumption (136-138), after 6 years, 3 years and 2 years respectively.

3.4 Discussion

This systematic literature review investigated the interventions that have promoted sustainable protein consumption (reduction in animal-derived proteins and increase plant-based proteins) and explored how effective these interventions were. Most of individual and micro-environmental level studies demonstrated reduction of unsustainable protein intake, mainly decrease in red and/or processed meat intake. However, only six studies assessed if the preferred behaviour was sustained over time, with most of them following after 3 to 6 months, and only one study followed the result for up to nine years. Evidence shows that longitudinal studies use continual or repeated measure to investigate certain population overtime (139). These studies are specifically practical in evaluating the outcome of interventions over various periods of time (139). Therefore, there is a need for further longitudinal studies to confirm that the reduction in meat intake sustain over prolonged periods of time.

In individual level studies, only three studies targeted other foods and products alongside red/processed meat intake, for example they aimed to increase soya (90), and legume (118) intake and decrease intake in dairy products (109) which showed positive impact on increasing such foods (sustainable protein). This is aligned with previous reviews of studies on red meat consumption (69,83). However, sustainable protein intake is not just about reducing red meat intake, but it also includes the intake of other environmentally sustainable protein, such as legumes, grains, nuts and other meat alternatives (6). Therefore, there is a need for more studies about variety of different sustainable protein.

At individual level, the majority of participants were people, who had a specific medical condition or a risk factor to develop a disease related to meat intake, for example cardiovascular diseases and/or colon cancer and other (90,91,95,96,99-101,103-106,109,111-116,121). This target audience is more likely to change their behaviour in order to avoid the development or reoccurrence of those diseases. These interventions may not show the same effectiveness if applied to the general population. Therefore, there is a need for more interventions aiming to promote sustainable protein intake among the general population.

In individual level studies, some studies provided cooking classes, workshops or books, in order to monitor meat intake or meat purchase (95,113,117,120), and a few participants had admitted to not knowing how to cook. All of these studies resulted in reduce meat purchase or consumption by improving cooking skills. RCT and CT studies showed reduce in animal protein in IG, and pre-post studies also demonstrated decrease in meat consumption over time. Evidence shows that participants might make decisions based on unreliable health knowledge, if they do not receive education regarding fundamental health concepts and how to prepare healthy foods (140,141). Therefore, different types of interventions with focus on experimental learning opportunities would help participants to enhance their skills and choose sustainable diets and maintain them overtime more easily.

Half of micro-environmental level studies increased plant-based foods and decreased meat-based food choices, and the other half tried to make more vegetable-based choices available for health and environmental reasons. All of these studies tried to reduce meat consumption and none of these studies tried to cut meat out of the diet completely, which is the aim of sustainable dietary patterns. Sustainable dietary patterns do not aim to cut meat out of the diet, but it tries to reduce the portion size or the number of days it is consumed. In other words, in order to reach both healthy and environmental outcomes, it is essential to shift the dietary pattern and improve a diet high in vegetable-based and low in animal-based food (6). Therefore, by reducing meat intake we are contributing to sustainable diets no matter how small the contribution is.

The studies in this systematic review recruited mostly adult participants (89-91,94-127,129,130,132-138), and only a few studies have been conducted on children, adolescents or young adults (92,93,108,128,131). There is a need for studies aiming to promote sustainable protein intake among young populations as their dietary behaviours are formed at this stage and will continue into adulthood (31).

The majority of the studies focused on health perspective when designing the interventions. There are some recent studies that focused on interconnection between health and environment, when trying to reduce unsustainable protein intake. While supplying healthy food for people globally, it is also crucial to decrease resource depletion and to reduce climate change (6,142). Therefore, there is a need for further studies which takes into consideration both health and environmental concerns when promoting healthy diets.

3.5 Strengths and limitations

Some strengths are associated with the present study. First, a systematic approach was used and reported following the PRISMA guidelines to synthesise the evidence on the interventions aiming to promote sustainable protein intake. Second, this review included studies from two levels (individual and micro-environmental), which provided a more comprehensive picture on the effectiveness of interventions aiming to promote sustainable protein intake.

This review has some limitations which should be acknowledged. First, most of the included studies have been conducted in high income countries and only a few studies were conducted in low- and middle-income countries (LMIC). This might be due to the fact that sustainable diets concept has received increased attention in the last five years and LMICs have not prioritised it as a significant nutrition and environmental issue due to dealing with other diet related issues such as undernutrition and nutrient deficiencies. In addition, research indicates that meat intake in LMIC has been associated with wealth (143). Thus, rise in income has resulted in significant animal-based food consumption in these countries (144).

Chapter 4 Exploring young Australians' understanding of sustainable and healthy diet: a qualitative study

4.1 Overview

A few studies have explored Australians' knowledge, awareness, and attitudes towards healthy and environmentally friendly dietary patterns. Australians have limited understanding of the impact of their dietary behaviours on the environment (25-27). More specifically, some Australians believed that their diets had an insignificant effect on the environment (29). Also, they have shown more environmentally friendly intentions, which are associated with community's role in preserving the environment, such as considering consumption of less meat and more organic local products, increase in vegetarianism and recycling food waste (29). Therefore, this qualitative study was conducted to explore young Australians' perspectives, motivators, and current practices in achieving sustainable and healthy diet. This section presents methods, results, and discussion of the qualitative study. This qualitative study addressed the following research question:

What are young Australians' understanding of sustainable diets and their perceptions, awareness and current efforts in decreasing unsustainable protein (e.g. red meat) consumption?

The following sub-questions were developed for this study:

- a) What are young Australians' understanding of a sustainable and healthy diet?
Which components of a sustainable and healthy diet do they focus on?
- b) What are they currently doing to achieve a sustainable and healthy diet?
- c) What are the enablers and barriers associated with achieving a sustainable and healthy diets?

4.2 Methods

4.2.1 Study design

The proposed research study adopted a qualitative research approach to answer the research questions posed above. Qualitative approach allows investigators to explore participants' views, feelings, and behaviours which can reveal the perceptions and understanding of the targeted population about the research topic under investigation (145). In this study, a

qualitative research design allowed the researchers to explore in depth young Australians' understanding, attitudes and current practices in achieving sustainable and healthy diet. The ethics online application was completed and submitted. Once ethics approval was granted by Macquarie University, Medicine, Health and Human Sciences Subcommittee, recruitment and semi-structural interviews were conducted. Semi-structured interviews were used as a data collection method. Interviews generated strong data, which delivered deep understanding on participants' experiences, attitudes and opinions (146). Below are the questions that were asked during the interview. The questions were developed by research team to act as probes that could potentially lead to further elaboration of their understanding towards sustainable diets as below:

Demographic questions:

- What is your age, sex?
- What is the highest level of education you have completed?
- What is your employment status?
- What is your occupation?

Sustainable and healthy diet related questions:

- Could you tell me what do you think sustainable and healthy diet is? What constitutes a sustainable and healthy diet? Could you describe me how you think a sustainable and healthy (dinner) plate looks like? (No guidance was given on sustainable and healthy diets).
- In your opinion, which foods have the largest impact on health, on environment?
- In your opinion, how your diet contributes to your health, environment?
- Could you tell me about your meat consumption (e.g. frequency, type of meat)? Did you try to reduce it at any stage of your life, why and how? If yes, what substitutes did you use? Would you be willing to try to reduce your meat consumption? Why yes, no?
- What could motivate you to eat more environmentally healthy diet? E.g. reduce red meat consumption, reduce highly processed food consumption, reduce overconsumption, reduce food wastage etc.
- From where do you get information on your diet?

- What resources would be helpful for you to use for environmentally healthy diet?
- Is there anything else you would like to add?

4.2.2 Participants

Young Australians formed the study sample. Young or emerging adults refer to individuals aged 18 to 25 years old (147-149). All young Australians between 18 to 25 and residing in Australia for at least 12 months were included in this study. The recruitment started in August 2020. A qualitative theoretical sampling strategy was employed for recruiting young Australians (150). Participants were recruited mainly through social media platforms (e.g. Facebook, Instagram, Twitter etc.), noticeboard announcements through Macquarie University Newsletters, councils' notice boards and flyer distribution across Macquarie University and gyms. Recruitment of the sample was conducted once ethics approval was granted. Participants were offered a \$20 Woolworths Gift Card for their participation. We anticipated minimal to no risks from participating in the study, beyond those experienced by participants in their daily lives. Participants were informed that they can withdraw from the study anytime without any penalty. Individual semi-structured interviews took approximately 30 to 45 minutes.

4.2.3 Data collection

All semi-structured online interviews were conducted through online platform- Zoom. Before the interview, a copy of the informed consent form was provided to all participants and participants were asked to schedule the interview with a researcher (the candidate (GS)) indicating time and day most suitable to them. Participants were asked to take a few (n=2-3) pictures of their dinner (either prepared by them or purchased) to facilitate the discussion. The interviewer undertook a training session with the primary supervisor. In addition, one interview was conducted by the principal supervisor with the candidate as an observer. At the commencement of the interview sessions, the interviewees were given an overview of the study; they were reassured that all information would be kept confidential. Recorded data was saved on Macquarie University OneDrive folder protected by password and made available only to the research team. All online interviews were conducted through online platform- Zoom, they were recorded and then all digital recordings were professionally transcribed using Rev.com services.

4.2.4 Data management and analysis

Data analysis was conducted concurrently with data collection to allow both to mutually shape each other and decide on data saturation. Thematic data analysis was used to analyse the data using the manual coding to establish main themes and relationships amongst themes. We used deductive and inductive data coding methods. In the deductive method, COM-B model (see Figure 4.1) (151), and the Theoretical Domains Framework (TDF) (152) were used to guide data coding. The COM-B model includes three constructs: 1) 'Capability' which is explained as people's psychological and physical ability to involve in the activities and includes having the required knowledge and skills; 2) 'Motivation' is explained as the brain operations that activates and conduct behaviour, not just aim and intentional decision-making; and 3) 'Opportunity' is explained as all the details that is outside the people, that cause a behaviour. Theoretical Domains Framework (TDF) includes 14 constructs: Knowledge, Skills, Social/Professional Role and Identity, Beliefs about Capabilities, Optimism, Beliefs about Consequences, Reinforcement, Intentions, Goals, Memory, Attention and Decision Processes, Environmental Context and Resources, Social Influences, Emotions, and Behavioural Regulation. It is a useful framework in categorising enablers and barriers related to behaviour change. These constructs were used in initial coding of the data (see Appendix 5). The principal supervisor and the candidate undertook the coding. The research team met on a regular basis for data coding and draw sub-themes and themes in order to enhance the quality and trustworthiness of data.

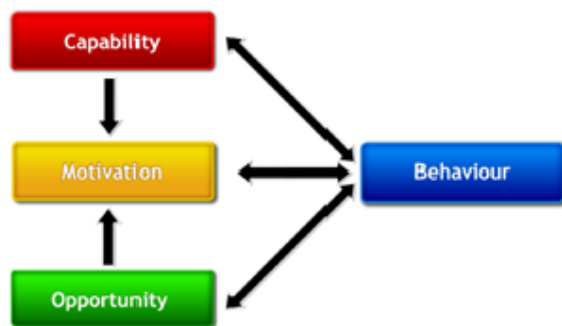


Figure 4.1: The COM-B system- a framework for understanding behaviour (151).

4.4 Results

In total, 22 young Australians participated in this study, when data saturation was reached, since no new information was obtained. Two third of participants were females and aged

between 21 to 25 years (see Table 4.1). Majority of participants (82%) were single, employed either on a part-time or casual basis (68%) and were highly educated (50% with a university degree and 50% current undergraduate students). Furthermore, 59% of participants reported not having any dietary restriction with one third of participants (27%) indicating following either vegetarian, vegan or pescatarian dietary pattern. 18% of participants experienced food insecurity in the last few weeks, mainly due to COVID-19 pandemic and associated loss in income. Finally, nearly two thirds of participants were aware of the sustainable and healthy diet concept but only 45% of participants were trying to practice it in some way (e.g., reduce red meat intake).

Table 4.1- Socio-demographic characteristics of the sample

Socio-Demographic items		N=22 (%)
Gender	Male	5 (23)
	Female	17 (77)
Age	18-20 years	6 (28)
	21-23 years	8 (36)
	24-25 years	8 (36)
Marital status	Single	18 (82)
	Married	1 (5)
	In relationship	3 (13)
Employment status	Unemployed	5 (23)
	Casually employed	12 (54)
	Part-time employed	3 (14)
	Full-time employed	2 (9)
Education	High school	11 (50)
	Undergraduate	10 (45)
	Postgraduate	1(5)
Occupation	Student	5 (23)
	Other occupations	17 (77)
No. of household people/children	1-4 people	20 (91)
	5-8 people	2 (9)
Dietary regimes	None	13 (65)
	Vegetarian/vegan diet	4 (20)
	Pescatarian	2 (10)
	Allergy	1 (5)

Experienced food insecurity in the last few weeks	Did not experience	18 (82)
	Did experience	4 (18)
Awareness and practicing of sustainable and healthy diets	Aware and practicing	10 (45.4)
	Aware but do not practice	5 (23)
	Not aware/ very limited awareness	7 (32)

Themes

Four major themes were developed by analysing 22 interviews associated with young Australians' understanding of sustainable and healthy diets and current efforts in achieving it: i) Understanding of sustainable and healthy diets; ii) Skills and motivation in achieving sustainable and healthy diet; iii) Towards achieving sustainable and healthy diet; and iv) Enablers and barriers in achieving sustainable and healthy diet. These themes, sub-themes, and illustrative quotations are described in detail below.

Theme 1 – Understanding of sustainable and healthy diets

Sub-theme: Foods for health and environmental sustainability

Majority of participants described a healthy diet as being balanced in terms of including all food groups and appropriate distribution of macronutrients (carbohydrates, proteins and fats). They also emphasised that reduction in salt, sugar, unhealthy fats and discretionary foods are important in achieving a healthy diet.

"I'd say a diet that's balanced, and has a good amount of vegetables and fruits included in it, as well as meat, like lean meat and a little water as well, though. Like soft drinks" (P19).

"Healthy is more about making sure that all your food has the right nutrients, and that you're not eating too much foods that have really high amounts of salt or sugar, or unhealthy fats"(P6).

Also, a few participants stated that it is important for them that diet or foods they consume makes them feel good, 'true to your roots' (refers to cultural background) and improves physical and mental health.

"If you want the diet to be sustainable, in my opinion, it has to be something which is true to your roots, I mean, from whichever ethnic background you're from. If that's what you're used to eating from your childhood, you cannot just completely change. If you have been a non-vegetarian your whole life, you cannot turn into a vegan overnight" (P4).

“Healthy is in meeting all the needs of your body. It’s something that is not only physical health, but mental health. You could survive off porridge and potatoes for the rest of your life, but at the end of the day, you’re not going to be happy doing that. So I think a very diet plays into the physical and mentally healthy role. As for sustainable, I sort of see that as cutting back on meat and sourcing things from local producers” (P1).

Participants stated that in order to achieve environmental sustainability, all foods should be consumed in moderation and in appropriate portion sizes (not overconsume foods), increase in vegetables and reduce in processed food and meat intake and reduce food waste. Some participants emphasised that foods should be organic, which are grown without pesticides or fertilisers. In addition, participants mentioned that it is important that foods are ‘fresh’ and preferable locally produced in order to reduce food miles. Finally, a few participants stated that they try to reduce consuming foods which requires a lot of resources to grow or produce, for example nuts (almonds, coconuts) in order to reduce environmental footprint.

“Sustainable diet should be something which is healthy and should be a good amount. I can’t say balanced carbohydrates, proteins, vitamins, everything because it gets really difficult to absorb all the ingredients in one meal. So I would say it should be a balanced and decent amount of most of the ingredients that are really healthy and helpful for our body” (P8).

“Sustainable diet would mean not just what you’re eating, but also where it’s produced, how much packaging it has. And I guess healthy’s sort of along the same lines as that, so if it’s organic, the fat content, sugar content, salt content, things like that. And also how much of it you’re eating. So I think moderation is a big part of sustainable and healthy. Eating healthily would mean to try and consume a lot of vegetables, drinking a lot of water, eating fruit but not too much of it, staying away from processed foods or foods high in sugar, salt, fat, and also trying to have a balanced diet of your proteins and things like that” (P5)

“Sustainability in your diet, to me, is about where does your food come from? And how many miles has it come to travel to you? But then also, whether it’s really sustainable to grow something in that climate” (P6).

Sub-theme: Sustainable diets on the plate

Majority of participants provided the equation for sustainable and healthy diet on the plate (with minor variance between participants): half of the plate should be vegetables or ‘greens’ (referring to leafy vegetables), one quarter of ‘carbs’ (referring to grains such as rice, pasta, bread) and one quarter of protein (referring to meat and alternatives, beans).

“Would be, think about half the plate would be vegetables and then one quarter of it would be pasta or rice carbohydrates and one quarter will be meat, I'm cooking” (P11).

“I'd definitely try for a quarter to a half of vegetables, a quarter of protein, and then a quarter of carbohydrates. Definitely what I aim for. We definitely try to have at least two to three servings of veggies per dinner, except for, of course, when we go out” (P12).

Participants who mentioned meat intake stated that a small portion of meat is needed or switch to more sustainable sources of protein, for example fish (sustainable sourced), chicken, eggs or plant-based proteins.

“I'm not too knowledgeable, but I do know that meat is not very sustainable, especially beef, it takes up a lot of resources. So it would definitely be on the vegetarian side, and I guess equal proportions of carbs, vegetables, and you would need protein as well. So something more sustainable than meat would be protein or lentils” (P15).

“I would usually have one cup of rice or carbs, and then I would have protein as well, so that would be either fish or chicken or eggs if I wanted to. And then the most of it would be veggies. Yeah, veggies. So that's how I would plate out my dinner” (P16).

Interestingly, one participant mentioned that this may not be applicable when going out to eat where health and environmental consideration may be compromised.

“I'd definitely try for a quarter to a half of vegetables, a quarter of protein, and then a quarter of carbohydrates. Definitely what I aim for. We definitely try to have at least two to three servings of veggies per dinner, except for, of course, when we go out” (P12).

Sub-theme: Awareness of the impact of foods consumed on health and environment

Although the participants were not provided with a definition of a sustainable and healthy diet, ten participants were aware of sustainable diets and they were actively practicing it by removing or decreasing meat in their diet. Five participants were aware of sustainable diets, but they were not practicing it, due to either not being ready for a change or the lack of knowledge. Seven participants were either not aware or had very limited awareness of sustainable diets and were not practicing it.

“Impact of different foods [on the environment]? I've heard of it, but I'm not exactly... I don't really understand what's the mechanism behind them” (P9).

“Not really [heard of sustainable diet]. If I had, I didn't take it into notice or maybe I had it in passing and I didn't really value the discussion” (P14).

"So, I specifically know that beef, like cattle is very heavy on the environment in terms of CO2 emissions, I think it is. And a lot of the growing of crops in raising of cattle requires a lot of water" (P20).

Some participants had understanding that some foods require a lot of resources to be produced, for example, they stated that meat and some vegetables (avocados) or nuts requires some intensive resources, and they tried to avoid or reduce consumption as much as possible.

"A movie that I saw last week, about how avocados were taking up a huge amount of the water in Chile, and a lot of people didn't have access to water because of the way that it was being produced for wealthier countries. And then, I know that a lot of food production is made in a way that's not sustainable, is dangerous to the people who live in those areas"(P6).

"I tend to avoid animal-based products, and I guess food crops that require extensive land, water, or land or water use. Particularly almonds, coconuts, quinoa, a few more. But like those kind of food groups I tend to avoid as much as I can"(P7).

More than two thirds of participants (n=16) were aware that animal-derived products contribute to environment negatively, and their knowledge helped them to contribute towards sustainable diets by either cutting meat out of their diet completely or reducing it.

"I am actively trying to cook with less meat and buy less meat because I know that industry produces a lot of greenhouse gases"(P1).

"I do know that meat is not very sustainable, especially beef, it takes up a lot of resources. So it would definitely be on the vegetarian side, and I guess equal proportions of carbs, vegetables, and you would need protein as well "(P15).

Furthermore, a few participants stated that processed foods had negative impact on their health, including some processed meat alternatives available at supermarket.

"So healthy usually it means not buying processed food. Making as much as you can by yourself with as many fresh ingredients as possible. So if I were to eat healthy I would mostly buy fresh fruits and vegetables, make a curry out of that, make my own lentils, make rice by myself. Making it by myself, not processed, basically"(p15).

In addition, some participants emphasised that foods we consume go beyond health. They stated that food is also about mental health, community and society of which we are part of.

"Healthy is in meeting all the needs of your body. It's something that is not only physical health, but also mental health" (P1).

"I do think people are generally slowly understanding that nutrition is not simply about the individual itself, but it also has a credit application to the practical world, from both a community as a society as a whole"(P7).

Theme 2- Skills and motivation in achieving sustainable and healthy diet

Sub-theme: Food preparation and cooking skills

Cooking was a distinct skill among half of the participants. It was measured by self-reported cooking skills or their ability to cook. Participants increased their cooking skills mainly when they changed their dietary behaviours, for example they became a vegetarian, wanted to eat healthier or reduced meat intake, as they needed to cook for themselves. However, a few participants reported having basic or no cooking skills or not being interested in cooking, which had a negative impact on them preparing/eating healthier foods.

"I've been cooking for myself for most of my life, because, well, I'm vegetarian." (P6).

"Because I'm not a very good cook. And when I was living by myself, I didn't really know what to cook"(P17).

Some of the participants, with cooking skills, reported having good food preparation and planning skills. They prepared meals in advance, so they could eat healthy if they had some time pressures. In addition, some participants reported learning how to cook from their mothers, home economics classes at school or themselves.

"When I cook, usually I cook for two days at one time, especially if I'm really busy. So if I cook for two days at one time, it helps me not to eat unhealthy like noodles and stuff. That really helps, I guess"(P15).

"In my year 11, 12, I have studied home science. And in home science, we used to learn all about food preparation meals, what should we eat, what shouldn't we eat. And that was the time I really get into like all the food. And that was really interesting subject for me. And we should have cooking practicals as well. And we have learned all about meal preparation, what should we eat, how should we eat, and how should we design our plate and stuff like that. So I have learned my first basic base of knowledge of food and diet and information was from my home science subject"(P8).

Sub-theme: Motivated to eat healthy for the future

Some participants reported that they were motivated to eat healthier as it gave them energy and helped them to be active and 'fresh' in the future and also, they did not want to suffer from a disease later in life and they want to maintain a healthy lifestyle when they get older.

"Knowing that in the future my health is going to be pretty dependent on how I choose to live my life now. I know that the older you get, the more difficult it is to maintain a healthy lifestyle if you haven't started younger"(P6).

"When I'm eating healthy, I think of, oh, it's for my long term health because I don't want to be sick when I'm old and that's about it"(P9).

"It has effects on your energy levels. So I prefer that I'm like more energetic than tired all the time. I know straight off, right faster to get tired, straight away" (P19).

About one third of participants were motivated to avoid or eat less processed foods for health reasons. They were also motivated to replace processed meat with fresh fruits and vegetables. Furthermore, some participants were motivated to eat less meat just for health reasons, stating that eating less meat is healthy for their body, including skin and digestive system, with some participants indicating that they were motivated to eat less meat for environmental reasons. However, one participant reported not being motivated to reduce meat intake at all, as eating meat was joyful for them.

"So usually it means not buying processed food. Making as much as you can by yourself with as many fresh ingredients as possible. So if I were to eat healthy I would mostly buy fresh fruits and vegetables, make a curry out of that, make my own lentils, make rice by myself. Making it by myself, not processed, basically"(p15).

"Red meats, I feel like aren't as good for my health or my digestion than chicken or fish is, so I'll try and have those more. Tofu is a big component"(P2).

"I try avoiding beef, even though I eat beef all the time, but I do eat beef a little less because I know that beef cultivation is still harmful towards our environment and I'm very against animal abuse"(P10).

Sub theme: Feeling good when eating for health and environment

The majority of participants stated that they felt good physically and/or mentally when they ate healthy food. Some participants stated that switching from red meat to white meat or less meat in general made them feel better. Moreover, about half of the participants reported that they felt good if their eating decisions contributed to the environment as well.

"I feel really good when I don't eat a lot of meat. I felt really nothealthy, but very like light and sluggish and not so drained"(P3).

"I feel really bad mentally if I eat like chicken or pork or beef, maybe like two to three consecutive days. It happens only if I'm out. So, if I'm with my family living, we have the home cooked meal, which is always vegetarian. But, if I'm visiting uni and I'm meeting people, so I might consume something

which has non-veg in it, so I would feel really bad. And maybe psychologically for the environment and also for my body that I've consumed a lot of meat. So, what I would usually do that I won't eat meat for next month"(P8).

"Just the fact that I'm very passionate about sustainability and the environment. It's one of the things that I care the most about. I guess it's just empathy for nature, and, yeah, knowing that I have an impact and I can do something, I feel like I should. I have that sense of responsibility"(P13).

Furthermore, some participants reported that they felt bad or guilty if they ate less healthy food. However, some participants stated being frustrated if they were being criticised on what they eat or they could not enjoy the food they like. In addition, they did not like it when their diets were restrictive.

"I don't want to be in a position where I feel guilty about foods that I'm eating, or be overly conscious about things like that"(P6).

"So, I do feel better. It's part of the mind as well, you feel guilty when you eat junk food, but you do notice it in your energy levels. I don't feel as much bloated" (15).

"I guess when I get criticism from other people, whether they're right or not, or whether they got their sources from somewhere, which I may or may not know. And I guess sometimes being criticised what I eat. That may be a bit of a frustration. Because it's a negative connotation of being a vegan is some sort of green hippie shenanigans. And I guess the social aspect can be a bit rough. And I guess if I was younger than might have deferred me from continuing or thinking about sustainable practice. But luckily university helped me understand that it's just important to just critically think and look at both side of the arguments and decide from there"(P7).

Interestingly, some participants believed that most people do not have enough knowledge on sustainable and healthy diet and if they knew more about it, they would switch to healthier and more sustainable food choices. However, one participant was less positive stating that people do not care about environment, all they think is 'price tag'.

"If people are told more about healthy diets, they would really consider taking it. But there's also a limitation in what people eat, depends on what schedule they have. So people can really embark on a healthy diet when they don't have the time to prepare"(P14).

"No one cares about sustainability, no one really cares about like where the food is coming from. Everybody is looking at the price tags and everybody's looking at the marketing words, the high words"(P10).

Theme 3 – Towards achieving sustainable and healthy diets

Sub-theme: Reducing intake of less healthy foods

Over half of participants indicated that they were trying to reduce processed/junk food, as well as focus on reduction of unhealthy foods including unhealthy fats, refined carbs (sugar), salt and canned fish with some participants trying to reduce intake of less healthy foods, in order to stay in normal Body Mass Index (BMI).

"I've been trying to eat less canned fish just because of reports I've heard of microplastics and heavy metal in them, the accumulation in them"(P1).

"I am trying to eat foods that don't have a lot of sugar content, a lot of bad fats in them. So for example, maybe you choose olive oil over butter or something like that. Have avocados instead"(P2).

"My weight. I know that the BMI range that I'm in, it's not in the normal side, it's slightly overweight, so I am trying to cut down my food or trying to incorporate more healthier choices"(P4).

Sub-theme: Reducing animal-derived and resource intensive foods

About two thirds of participants indicated that they were trying or have reduced animal derived foods, such as red meat, dairy and eggs. Also, some participants mentioned they were actively trying to reduce resource intensive products, including animal-derived products, as well as some plant-based foods, for example nuts and vegetables. Some participants stated that they were reducing meat intake in their diet, but they were not able to cut meat out of their diet completely. However, some stated that if they ate more meat than usual in one week, then they reduce it in the following week. This was the way of 'balancing it'.

"So, I don't eat much dairy. I don't eat much red meat, and I try to eat a lot of fish. And I don't often have egg by itself, but sometimes egg is included in preparation for my foods"(P17).

"I guess quinoa, it's quite resource intensive compared to good old white rice or brown rice, which is not as extensive from my understanding"(P7).

"I heard that actually planting avocados will harm the environment. I'm not exactly sure, but I mean, it's another reason for me to reduce eating avocados because it seems avocados is quite pricey and it's another reason to reconfirm that, oh, I should reduce the intake of avocados and try to replace it with other sources and then more sustainable sources"(P9).

Furthermore, some participants were also concerned about packaging and plastics and stated that they were trying to reduce foods that have lots of packaging.

"I'm definitely someone who's very conscious of packaging and things like that. I tend to not use packaged items if I can. And on the environment as a whole"(P20).

"I never cut myself off red meat completely. I've reduced my intake of it over time, but it's not necessarily that I really consumed a lot more. So it never really had a big effect. So let's suppose I was

consuming it four times a week. I cut it down to once or twice a week, but didn't have it that big of an effect on my personal physique or my mental state, nothing at all"(P10).

Theme 4- Enablers and barriers in achieving sustainable and healthy diet

Sub-theme: Healthy and environmentally sustainable food cost more

Half of the participants stated that healthy and sustainable food cost a lot more than less healthy and/or sustainable food options. They stated that buying or preparing healthy and sustainable food such as plant-based options/alternatives, fresh vegetables or dining at a restaurant (e.g. a vegan restaurant) were much more expensive. Some participants stated living on 'a student budget'. Therefore, they focused more on price of the food and often bought discounted options or products on a special offer.

"Vegan restaurants, they can obviously those, I guess, vegan substitute stuff can be pricey" (p7).

"I would say that it is very hard to maintain a healthy and sustainable diet, because even if you do wish to eat healthier, more sustainable, it is usually more expensive, and as students, it is very hard to maintain that"(P15).

"There's a lot of factors so based on what's on special, on discount on the market. And also based on what's available in my fridge and also based on how much time do I have to prepare the meals"(P9).

"As a student on a student budget, I had to cut down on fish, so that's when the major change happened" (P4).

It was apparent that Socioeconomic Status (SES) had an impact on healthy/environmentally sustainable food options. For example, some participants reported that their families were financially secure so they could afford healthier foods. Apart from SES, some participants reported that they grew up in a health-conscious family, so they had previous knowledge about healthy food choices. In addition, some participants stated that having a proper job and/or nutrition related education had an impact on making healthy and informed food choices.

"I know that I come from a very privileged background. So, I know I have the funds to eat healthy to my standard of healthy, which is quite nice. And I have the access to the food that I want. There's no limitations on where I can get it from or ... There's four supermarkets I can access very easily. I don't have to worry about that. And I think that I just have minimal barriers to eat healthy"(P12).

"I have a bachelor's degree in nutrition and dietetics. So that would be the main form, I guess. So I do participate in CPD, which is through dietician connection and through the DA. So a lot of, hopefully, evidence-based practice and through peer-reviewed research"(P12).

Some participants lost their jobs due to COVID pandemic and faced financial problems. Therefore, at this stage their priority was on price rather than health and sustainability aspects when choosing foods.

"Last few months with COVID, yeah, that I lost my job and everything. I got help from the uni. I got food bank and all of that"(P13).

"I'm pretty sure when I moved back to Sydney, when this COVID thing settles, and I have a proper job in Sydney, I have made a promise to myself that I'll cook for myself. It doesn't matter if I'm living alone, and I will eat properly just like I eat properly when I'm here with my family"(P8).

Sub-theme: (Un)Availability of healthy and environmentally sustainable food

About one third of participants stated that there was a lack of availability of vegetarian food options or they were way more expensive than non-vegetarian options when dining out in restaurants or cafes. Therefore, some of participants were choosing meat-based meals when dining out. Interestingly, one participant (now unemployed) reported that she witnessed the increase in some fast-food places offering options for vegetarians and vegans and people's enthusiasm to purchase them.

"When I go out to eat in restaurants, most restaurants in Sydney aren't very vegetarian friendly, so they'll have some vegan friendly menus that have some substitutes for meat"(P15).

"And I see that a lot of people are turning vegan and vegetarian at least. They completely say no to any animal product whatsoever and that's really nice. Because I used to work at Mad Mix. It's like a Mexican restaurant place kind of thing. And they used to have like a lot of vegan and vegetarian options. And people really encourage and they were like, "Yeah, we want vegan options." They were not tempted by any animal products or anything. They were really motivated to control diet"(P8).

Furthermore, some participants reported eating less healthy or environmentally sustainable foods when dining out with family and friends. Also, the majority of participants were eating what was available at home in the fridge or what they parents prepared. In some instances, the meals were healthy and sometimes it was less healthy.

"So sometimes when you're out with your family or friends and having a lot of unhealthy foods because I'm a human, So definitely I feel like eating them"(P9).

"When I go out and I'm socializing with friends, it's a bit hard to pick the healthy option"(P16).

"I'm trying to eat less sugar. It's not necessarily working, but I am aiming to eat less sugar, and sometimes my mom will sneak a few vegetables into my plate, something like sliced carrots and stuff,

and so I try and make an effort to eat more of those, get second helpings of those as well. But I don't think the healthiness of foods really regulates what I eat as much as it should."(P18).

"What's available in the fridge because I don't really like to go out to eat. So if there's anything at home that I can eat, I'll just eat it. So I guess availability of food at home"(P16).

Some participants stated that they were trying out meal kit delivery services, as it was easy, healthy and environmentally friendly (due to reduced food miles). In addition, some participants stated that there was some options available for vegans at the markets but it was vegan junk food, and reported that there was lack of local farmers markets to buy fresh fruits and vegetables.

"I have considered the new meal kits that are coming out like HelloFresh, or I think there's Marley Spoon as well, the ones which come with pre-packaged stuff. They have claims saying that meals can cost up to like less than \$10 a meal, if you've given whatever plan or saying things like, it has a lesser carbon footprint than going to the grocery store and stuff. So I have considered trying those new meal kits and stuff, just because they seem to have good cost-effective, and environmental, and healthy benefits"(P18).

"Also it depends on where I buy my foods. Let's say if for whatever reason, I need to travel out to the countryside or out to the central coast area, where there might not be a major supermarket or that provides, or a general local farmers' market that provides affordable food and vegetables and fruits and grains and such"(P7).

Sub-theme: Positive and negative role modelling

Some participants stated that family members/relatives and/or friends had impact on them in consuming a healthy and sustainable diets, and some participant reported that their families were very strict on healthy food intake, and some reported having a doctor in the family who was encouraging healthy diets. Interestingly, some participants reported having vegetarian friend or a family member had an impact on their decisions about meat intake. However, some participants reported that some of their family meals being not very healthy or environmentally friendly, but they ate it because it was prepared for them and they did not need to cook it by themselves.

"And because my friends are vegetarian vegan as well, so I don't eat red meat around them"(P17).

"It's usually my uncle because he's a doctor and he keeps telling us that we shouldn't eat chips. We shouldn't unhealthy snack. He gave us all the healthy options of snacking. Sometimes he bring flavored yogurts as a sweet dish for us after dinner, or he bring baby carrots and baby cucumbers for us, if we want to eat something. And we have a juicer in which you bring all sorts of vegetables and

oranges and apples and pears and everything for healthy juices. So I would say my source of dietary information is my uncle"(P8).

"I am trying to eat a lot less meat. I know that it's hard because I grew up in a very meat heavy family(P1).

Furthermore, some participants mentioned that cultural factors had an impact on meat intake. For example, they or the family were practicing certain religion or being born in a certain country where vegetarianism was more popular.

"As occasionally, I have to follow a vegetarian diet for a few days in a year for religious purposes, because I was raised Hindu and I'm still living with my parents who practice Hinduism. So I have to be vegetarian sometimes, but mostly I eat most things"(P18).

"Since my parents don't allow meat to be cooked in the home, in the kitchen, we do use a soy mince replacement, if we're trying to make something with beef mince or anything"(P18).

Sub-theme: Availability of information sources and its impact on food choices

Participants reported looking for food and nutrition related information on variety of sources such as online through social media and some used more reputable governmental sources. Moreover, some participants stated that they trusted what family and friends say about healthy eating. Also, some participants believed that advertisements often encouraged unhealthy food intake. Interestingly, one participant stated that social media impacted on eating more meat, as they followed fitness influencers and they were encouraging an increased intake of meat as main source of protein. In addition, some participants stated that they got some food and nutrition related knowledge at school and university, therefore, they knew how to critically evaluate the resources. Finally, some participants reported that public health campaigns have been influential in choosing a healthy diet.

"Anything that's coming from a government source or a university source. If it's in terms of my own research, I would usually read from a book or an article or some sort of trusted website, like usually not really blog posts. I might get ideas from it, but then I do more research on it later"(P5). "I probably could learn more, but I trust my parents, because they brought me up"(P17).

"So I try my best to look up on Google. So I know what information, what websites present. So it's something presented in Forbes. I would, I would more likely to be believing it, but then something presented like other reps that I've never heard of. Or if the website seems very shade, you're sketchy. I usually don't mind"(P10).

"But luckily university helped me understand that it's just important to just critically think and look at both side of the arguments and decide from there"(P7).

"It's a lot of public health campaigns but eat the rainbow, so making sure you have a good variety of predominantly 80% of fresh produce"(P3).

Some participants reported that they would like more recipes to be available on how to cook sustainable and healthy meals. They stated that not knowing how to cook sustainable and healthy meals was a barrier for them to consume such diet.

"First it was the recipes. I'm not too sure how to incorporate vegetables on this much amount of vegetables into my meals"(P11).

"There's not a variety of like recipes for me, for example, tofu, I only know couple of recipes. Um, but yeah, I think that's the biggest barriers for me"(P21).

4.5 Discussion

This study aimed to explore young Australians' understanding of sustainable and healthy diets and their current efforts in achieving them. This is a novel research, as no study has investigated young Australian's perception and understanding of sustainable and healthy diets and what they are currently doing to achieve them. This qualitative study has revealed that nearly two thirds of young Australians were aware of some aspects of sustainable and healthy diet, but less than half of participants were trying to make healthy and sustainable food choices. Meat and other animal-derived food intake were the most often mentioned aspects of sustainable and healthy diet. Also, participants had positive attitudes and motivation for consuming less animal derived foods for health and environmental reasons with some participants actively trying to reduce it. It is not surprising, as the most recent climate change protest in Australia revealed that young Australians are concerned about global warming and they are ready to tackle this problem (30). Moreover, young people tend to have more motivation to reduce meat intake for health and environmental reasons, compared to other life stages (e.g., adults and elderly) (153). In addition, some participants emphasised that they were trying to reduce foods that are resource intensive products including animal-based foods, and some plant-based foods, such as nuts and some vegetables. However, participant's knowledge and awareness about sustainable diets was not comprehensive. They focused only on a few aspects of sustainable and healthy diet and also discussed it more from health aspect than environment.

Some participants reported that even though they would be interested in eating more healthy and environmentally sustainable foods, costs associated with such foods and lack of

availability of these foods are major barriers. It is not unexpected finding, as according to Australian Bureau of Statistics in 2017-18 only 51.3% of Australians aged 18 and over consumed recommended serves of fruit every day (54), and only 4% of young Australians consumed adequate serving of vegetables (59). In addition, 34% of Australians spent on take away foods, which are often high in sugar, salt and saturated fat (22). Although half of the participants stated that buying or preparing healthy and sustainable food is expensive, studies have shown that healthy foods do not cost more than that of unhealthy foods per serving (154,155). The reason behind the participant's assumption of higher price of healthy and sustainable food might be the lack of cooking skills in preparing such meals, as many participants reported that they did not know how to cook plant-based foods. Adequate level of cooking skills and confidence in cooking are linked to healthier eating pattern (156). However, the time spend in cooking at home has decreased in the past 30 years, due to increase in working women and advance in cooking-related technology (157). Therefore, interventions with experimental learning opportunities, for example; interventions targeting increase in cooking skills and confidence, might be a good approach to increase young Australians' food literacy including motivation and confidence in cooking plant-based meals. In addition, public education and campaigns need to be put into effect, to deliver information, cooking skills and recipes. This information should be designed and presented differently to attract various groups of individuals. It is also important to provide opportunities to practice this behaviour by making sustainable and healthy food more available and affordable.

Socio Economic Status (SES) of participants played an important role in sustainable and healthy eating. Being from a wealthy and financially secured family has an impact on participant's affordability of healthier foods. In addition, having a proper job or nutrition related education or being from a healthy-conscious family had an impact on making positive food choices in participants. Evidence shows that higher occupational status and social level is linked to higher expenditure on healthy foods in comparison to people from lower SES background (158).

The participants used various sources of information, in order to be informed of nutrition related information. The information gathered mainly from Internet, followed by family and friend advice, and used knowledge gained from school and/or health campaigns. Internet has been recognised as the major source of information, on what to eat, in Australia and it has increased sharply since 2004 (159). Australians use Internet to gain information on healthy

food preparation, getting recipes, and gain cooking skills to eat healthier foods (159). Therefore, it might be useful to develop strategies and educate young adults on how to use more reputable and reliable sources, when searching information on the Internet.

Family members, friend and relatives had significant impact the participants food choices. Vegetarian family members were a role model for some participants and impacted the sustainability of their food choices. Having vegan friend or a doctor in the family played a significant role in healthy and sustainable food choices for some other participants. Research shows that children who had parental role modelling in consuming vegetables and fruits were more likely to consume daily servings of fruits and vegetables in comparison to those children who did not (158). Therefore, parental involvement in interventions could be implemented to improve children's dietary behaviour. These interventions can be conducted with parent's presents in educational interventions or training classes or it can be a family counselling on dietary behaviour.

4.6 Strengths and limitation

This study has several strengths. Participants residing in Australia were recruited, but our participants were from different cultural backgrounds, for example Indian, Latin American, Japanese and other. This allowed the exploration of the impact of cultural aspects on their perceptions of healthy and sustainable diets. Furthermore, online program Zoom was used to interview the participants which enabled us to recruit participants from different geographical locations across Australia. In addition, a Theoretical Domains Framework was used in analysing the data, which provided strong theoretical basis for this research and allowed to build up on understanding of behaviours impacting on consuming healthy and sustainable diets. In addition, this research included participants at different behaviour change stages, who were aware and practicing some of the aspects of sustainable and healthy diet and who were either not aware or not practicing it. This allowed the exploration of barriers and enablers at different stages of behaviour change.

This study is also subjected to some limitations, which should be acknowledged. The participants were highly educated individuals with either having an undergraduate University degree or currently enrolled students. Also, majority of our participants were females. This may not reflect the views of general young Australian population. However, gender (female) and education level have an impact on food and nutrition knowledge and healthy food

behaviours (160-161). Also, this study explored young Australians' views, therefore the generalisability of our study may be limited. However, young people around the world demonstrates the increased interest in environmental issues (30), therefore the experiences, barriers and enablers in achieving such diet might be similar.

Chapter 5 Conclusion and future research

Our current food choices and dietary behaviours can have a significant negative impact on the global burden of diet-related non-communicable diseases (NCDs) and the environment leading to global warming. Therefore, there is a need to move to sustainable and healthy diets in order to reduce the risk of development of NCDs and the negative impact on the environment. This thesis explored young Australians' understanding of sustainable and healthy diet including motivation and current practice in achieving it and synthesised the evidence on the interventions implemented to promote sustainable protein intake.

The findings of a systematic literature review indicate that a comprehensive approach targeting individual level (e.g., educational, self-monitoring and multicomponent interventions) and micro-environmental level (e.g., increase the availability and visibility of plant-based food options) could be an effective strategy in promoting sustainable protein intake. However, the development and evaluation of interventions targeting general population longitudinally are needed. Furthermore, a qualitative study with young Australians showed that they are motivated in consuming diet which is healthier and environmentally sustainable, however, they identified many barriers such as lack of availability of such foods, low cooking skills, time and financial constraints. Moreover, they reported that role modelling played a significant role in their dietary behaviours. Therefore, there is a need for interventions that incorporate education and experiential learning opportunities to increase their food literacy including cooking skills. In addition, there is a need to make sustainable and healthy diet more available as key to improving diet quality, while ensuring that the nature has enough resources for future generation.

Future Research:

This research contributed to the understanding of young Australians' perspective and understanding of sustainable and healthy diet and their current attempts in achieving it. Also, it synthesised the evidence on the interventions aimed to promote sustainable protein intake. However, further research is needed to shift our current unsustainable diets to more healthy and environmentally sustainable:

- Most participants from a systematic literature review were people with certain medical conditions or risk factors in developing diseases related to high meat intake. These participants may have deeper motivation to decrease red meat intake in comparison to general population. Therefore, there is a need for development and evaluation of interventions targeting general population with less awareness of sustainable and healthy diets.
- Although majority of studies showed positive changes in reducing red meat intake, most studies did not follow up if this behaviour sustained over time. Therefore, there is a need for longitudinal studies to evaluate if interventions are successful in sustaining the new behaviour.
- Moreover, majority of participants in a qualitative study were aware of some aspects of sustainable and healthy diets, and they showed a better understanding of healthy diets. Also, they showed intentions and motivation in practising sustainable and healthy diets but identified many barriers impacting on their behaviour. Therefore, there is a need for development of interventions to address these barriers in adhering to sustainable and healthy diet. In addition, the majority of participants were female, and were highly educated with either having an undergraduate degree or currently enrolled students. Therefore, there is a need for exploring the awareness of sustainable and healthy diets in more diverse groups, such as less educated people and among men, in order to increase the generalisability of the findings.

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Appendices:

Appendix 1: PRISMA Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	29
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	29
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	29
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	29
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	30
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	30
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	31
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	31
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	31

Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	32-33
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	33
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	56
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	33
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	33
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	56
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	56
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	33
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	56
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	56
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	56-63
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	56-63
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	56
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	56-63
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	61

Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	63
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	61
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	61

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

For more information, visit: www.prisma-statement.org.

Appendix 2: Search strings

Search strings

▼ Search History (18)					
<input type="checkbox"/>	# ▲	Searches	Results	Type	Actions
<input type="checkbox"/>	1	meat/ or meat products/ or meat proteins/ or poultry/ or beef/ or red meat/ or pork meat/ or seafood/	60697	Advanced	Display Results More ▼
<input type="checkbox"/>	2	(meat or meatless or animal derived or animal or poultry or pork or beef or seafood) ti,ab.	572746	Advanced	Display Results More ▼
<input type="checkbox"/>	3	or/1-2	596580	Advanced	Display Results More ▼
<input type="checkbox"/>	4	exp plants/ or crops, agricultural/ or plants..mp. or nuts.mp. or legumes.mp. or edible/ or edible grain/ or vegetables/ or vegetable based.mp. or vegetar*.mp. or vegan*.mp. or flexitarian*.mp.	906712	Advanced	Display Results More ▼
<input type="checkbox"/>	5	(plant based or edible plant* or vegetable** or grain) ti,ab.	97242	Advanced	Display Results More ▼
<input type="checkbox"/>	6	or/4-5	959196	Advanced	Display Results More ▼
<input type="checkbox"/>	7	and/3,6	42436	Advanced	Display Results More ▼
<input type="checkbox"/>	8	exp Diet/ or exp Food/ or exp proteins/	7273825	Advanced	Display Results More ▼
<input type="checkbox"/>	9	(food or diet or diets or protein* or sustainab*).ti,ab.	3616680	Advanced	Display Results More ▼
<input type="checkbox"/>	10	or/8-9	8357029	Advanced	Display Results More ▼
<input type="checkbox"/>	11	(reduc* or intake* or substitut* or consumption or "dietary change").mp.	4179927	Advanced	Display Results More ▼
<input type="checkbox"/>	12	or/10-11	10702681	Advanced	Display Results More ▼
<input type="checkbox"/>	13	and/7,12	35213	Advanced	Display Results More ▼
<input type="checkbox"/>	14	((randomized controlled trial or controlled clinical trial) pt. or randomized.ab. or randomly.ab. or trial.ab.) not (exp animals/ not humans.sh.)	1149812	Advanced	Display Results More ▼
<input type="checkbox"/>	15	(intervention or program*) ti,ab. not (exp animals/ not humans.sh.)	1263932	Advanced	Display Results More ▼
<input type="checkbox"/>	16	or/14-15	2216139	Advanced	Display Results More ▼
<input type="checkbox"/>	17	and/13,16	2953	Advanced	Display Results More ▼
<input type="checkbox"/>	18	limit 17 to english language	2784	Advanced	Display Results More ▼

Appendix 3: Quality assessment of individual level studies

Author(s) (year), country	Selection bias	Design	Confounders	Blinding	Data collection methods	Withdrawals and drop outs	Overall
Randomised controlled Trials (RCT)							
Amiot et al., 2018 Canada	2	1	2	2	3	1	2
Archarya et al. 2004 USA	2	1	1	2	2	3	2
Beresford et al., 2006 USA	2	1	3	2	3	1	3
Carfora et al., 2017a Italy	2	1	3	2	2	2	2
Carfora et al., 2017b Italy	2	1	3	2	2	1	2
Celis-Morales et al., 2017 Ireland, The Netherland, Spain, Greece, UK, Poland and Germany	1	1	3	2	2	2	2
Carmody et al., 2008 USA	2	1	3	2	3	3	3
Dalgard et al., 2001 Denmark	3	1	3	2	3	1	3
Delichatsios et al, 2001a USA	1	1	1	2	2	3	2
Delichatsios et al, 2001b USA	3	1	2	2	2	1	2
Emmons et al, 2005a USA	2	1	1	2	2	1	1
Emmons et al- 2005b USA	2	1	1	2	2	1	1
Grimmett, et al, 2015 UK	2	1	3	2	2	2	2

Hatami et al, 2018 Iran	2	1	3	2	1	1	2
Jaacks et al, 2014 USA	2	1	1	2	2	3	2
Johansen et al, 2009 Norway	2	1	2	2	2	3	2
James et al, 2015 Australia	3	1	1	2	1	2	2
Lee et al, 2018 China	2	1	1	2	2	1	1
Matthews et al, 2019 Finland	2	1	3	2	2	3	3
Merrill et al, 2009 USA	2	1	1	2	1	1	1
Saffari et al, 2014 Iran	2	1	1	2	3	1	2
Sacerdote et al, 2005 Italy	1	1	3	1	2	1	2
Shai et al, 2012 Israel	2	1	3	2	3	1	3
Zuniga et al, 2018 USA	1	1	1	2	3	1	2
Non-randomised controlled Trials (CT)							
Schiavon et al, 2014 Brazil	2	1	2	2	2	2	1
de Liz et al, 2018 Brazil	2	1	3	2	2	2	2
Pre-post design							
Hawkes et al- 2012 Australia	2	2	NA	2	1	3	2
Hawkes et al, 2009 Australia	2	2	NA	2	1	1	1
Flynn et al, 2013 USA	2	2	NA	2	3	2	2

Lessem et al- 2019 USA	3	2	NA	2	1	1	2
Maryuyama et al, 2017 Japan	2	2	NA	2	2	1	1
Ring et al, 2019 USA	2	2	NA	2	1	1	1
Spees et al, 2016 USA	2	2	NA	2	2	1	1

Appendix 4: Quality assessment of micro-environmental level studies

Author(s) (year), country	Selection bias	Design	Confounders	Blinding	Data collection methods	Withdrawals and drop outs	Overall
Randomised Controlled Trials (RCT)							
Attwood et al. (2020), UK	2	1	1	2	3	2	2
Bacon et al. (2018a), UK	2	1	3	2	2	1	2
Campbell-Arvai et al. (2014), USA	1	1	3	2	2	1	2
Gravert & Kurz (2019), Sweden	2	1	3	2	3	3	3
Herbert et al. (1993), USA	2	1	1	2	2	2	1
Kongsbak et al. (2016), Denmark	2	1	1	2	2	3	2
McClain et al. (2013), USA	2	1	1	2	1	3	2
Reinders et al. (2017), Netherlands	2	1	1	2	3	NA	2
Sorensen et al. (2005), USA	3	1	1	2	2	1	2
Non-randomised controlled Trials (CT)							
Kurz (2018), Sweden	2	1	2	2	2	NA	1
Polak et al. (2019), Israel	2	1	1	3	2	3	3
Field experimental design							
Bacon et al. (2018b), UK	2	1	2	2	2	3	2
Friis et al. (2017), Denmark	2	1	2	2	2	2	1
Quasi-experimental design							
Dos Santos et al (2020), Denmark, France, Italy and United Kingdom	2	1	2	2	3	3	3
Pre-post design							
Craveiro et al (2019), Portugal	2	2	NA	2	2	3	2
130-Resnicow et al. (1992), USA	1	2	NA	2	2	3	2
Sperber et al. (1996), Israel	2	2	NA	2	3	3	3

Appendix 5: Theoretical Domains Framework (TDF) and selected illustrative quotes

TDF construct and the number of participants mentioned it	Selective quotes
1-Knowledge (An awareness of existing of something). 22 participants.	<p><i>"I am actively trying to cook with less meat and buy less meat because I know that industry produces a lot of greenhouse gases"(P1).</i></p> <p><i>"Sustainable diet would mean not just what you're eating, but also where it's produced, how much packaging it has"(P5).</i></p> <p><i>"for me personally, a sustainable, healthy diet is one where I can reduce my food waste, reduce my plastic consumption, eat a wide variety of whole foods, as well as incorporate some discretionary items and be satisfied at the end of the day"(P12).</i></p> <p><i>"Environmentally sustainable diets would be, not maybe getting takeout containers every day of the week, or buying things in bulk. So, you're not going to the grocery store every day of the week. So not using your car, not making seven trips every week, that sort of thing. So, thinking of environmentally sustainable practices, how to incorporate them into your eating as well. Hope that makes sense."(P18).</i></p> <p><i>"So, I specifically know that beef, like cattle is very heavy on the environment in terms of CO2 emissions, I think it is. And a lot of the growing of crops in raising of cattle requires a lot of water. I know that's the things that come to mind. And in terms of the environment, I think it's a lot to do with the process as well. If you're growing a crop, how the land is treated and the actual growing process and harvesting and things like that. I don't really know much at all, to be honest"(P20).</i></p>
2-Skills (An ability or proficiency acquired through practice). 12 participants.	<p><i>"then I became a vegetarian, so that changed pretty rapidly. I wasn't a great cook back then, so I probably just ate a lot of carbs and not a lot of vegetables, and wasn't particularly healthy. So, I gradually learned how to cook, and cooked better food for myself"(P6).</i></p> <p><i>"I prepare most of my, try preparing as much as I can by myself and whatever I've sent you I have prepared myself"(P10).</i></p> <p><i>"when I cook, usually I cook for two days at one time, especially if I'm really busy. So, if I cook for two days at one time, it helps me not to eat unhealthy like noodles and stuff. That really helps, I guess"(P15).</i></p> <p><i>"If I prepare it from home, like I'm going to work. If I prepare food that obviously makes me eat healthier. Cause I don't buy food when I'm out, so it's all from home"(P19).</i></p> <p><i>"I'll cook mostly for myself if I don't want to eat what everyone else is eating"(P20).</i></p>
3-Social professional role and identity (A coherent set of behaviours and displayed personal qualities of an individual in a social or work setting). 13 participants.	<p><i>"I've got an Asian background and I guess brown rice and things like that are things that are healthier"(P2).</i></p> <p><i>"it has to be something which is true to your roots, I mean, from whichever ethnic background you're from. If that's what you're used to eating from your childhood, you cannot just completely change. If you have been a non-vegetarian your whole life, you cannot turn into a vegan overnight. A sustainable diet would be something which comes from your roots"(P4).</i></p> <p><i>"my first preference is chicken. My second preference is ham and I ignore beef because of the religious reasons that Indians don't eat beef. But if something comes really good in a beef patty, then I won't say no to it. But I would obviously look for other options and avoid beef as long as I can"(P8).</i></p>

	<p><i>"I'm a Bangladeshi, We Bangladeshi's are usually very big fans of fish. I don't like fish myself to be honest, my culture likes a lot of fish. I don't like fish at all. The only kind of fish that I eat are sea fish"(P10).</i></p> <p><i>"Probably just the habit, the habit of in Mexico, there weren't many options. It was all a lot of meat, and telling people about it, and yeah, that was more of a challenge, like people accepting that you're not going to eat whatever"(P13).</i></p>
<p>4- Beliefs about capabilities (Acceptance of the truth, reality or validity about an ability, talent or facility that a person can put to constructive use). 0 participants.</p>	
<p>5-Optimism (The confidence that things will happen or the best or that desired goals will be attained). 4 participants.</p>	<p><i>"I just take everything that I read with a grain of salt. I just take information that I've heard multiple times more seriously, than things that I've heard once or twice"(P6).</i></p> <p><i>"I don't know. I just trust it [information source]. I've never thought it like that, that why should I trust it? I just do. Real plant products, they just have a why that you should trust them. I don't know. I just do"(P8).</i></p> <p><i>"The information that I get from Google, I trust most of it because I look at the website itself, I think in other websites where they're not, they don't give you false information"(P10).</i></p> <p><i>"not everything that they state is a 100% correct. Same goes for our grocery stores not every product label is a 100% accurate. There's a lot of loopholes and people make use of it. So, it's important to keep an eye out on the news, that's what I believe"(P10).</i></p> <p><i>"I guess, applying some criticality to it, seeing who is saying it, why would they be saying it, and if it aligns with other things I've heard. So if the government came out tomorrow saying, smoking is great or maybe not smoking, but like sugar is really good for you, to have as much sugar as possible, I'd be like, "Well, what's happening here?" (P18).</i></p>
<p>6- Beliefs about consequences (Acceptance of the truth, reality or validity about outcomes of a behaviour in a given situation). 16 participants.</p>	<p><i>"I don't think the environmental issues should be pushed to the individual. I think it's the corporations, it's the entire meat industry that should be held accountable for environmental change. I know that my food choices support that regime, but if I were to change it, then I don't believe that the whole industry would change"(P1).</i></p> <p><i>"it's not just for the physical aspect but more the mental aspect, because the better you eat, the higher in nutrients you are, which means that you're better able to process information and remember, and it regulates mood"(P5).</i></p> <p><i>"knowing that in the future my health is going to be pretty dependent on how I choose to live my life now. I know that the older you get, the more difficult it is to maintain a healthy lifestyle if you haven't started younger"(P6).</i></p> <p><i>"I try avoiding beef, even though I eat beef all the time, but I do eat beef a little less because I know that beef cultivation is still harmful towards our environment and I'm very against animal abuse"(P10).</i></p> <p><i>"I think eating healthy would like it makes your life like your lifestyle much more productive, having junk food makes you lazy, because I've experienced from eating, eating junk I end up not doing anything any work done"(P22).</i></p>
<p>7-Reinforcement (Increasing the probability of a response by arranging a dependent relationship</p>	<p><i>"knowing that in the future my health is going to be pretty dependent on how I choose to live my life now. I know that the older you get, the more difficult it is to maintain a healthy lifestyle if you haven't started younger"(P6).</i></p>

or contingency, between the response and a given stimulus). 1 participant.	
8-Intentions (A continues decision to perform a behaviour or a resolve to act in a certain way). 8 participants.	<p><i>"[need some explanation here what was the question?] not so much eggs, because I usually go through cycles of either I want to eat them or I don't"(P6).</i></p> <p><i>"But I would like it to maintain, I guess, the environment, the qualities of our unique Australian environment to be maintained as much as I can, or much as I wish. And I do like to minimize the impact of what I eat, to allow our environment to flourish for the future, for not only myself and the current generation, but also for future generation to appreciate the biodiversity and the environmental diversity that we have in Australia, and not just Australia but worldwide too"(P7).</i></p> <p><i>"Environmental effect is something that I personally take very seriously. It has altered my diet quite a bit. I preach altering your diet for environmental issues. So I also run, I have a foundation back home in Bangladesh where we encourage children to be more sustainable in their movements. We educate them about sustainability as well"(P10).</i></p> <p><i>"I think, I need to take care of my body, it's the only one I have, as well as taking care of it internally for my immunity and general healthiness, as well as how I look outside appearance-wise. I don't want to have a beer belly by the time I'm 30. I want to try and stay as healthy looking as possible"(P18).</i></p> <p><i>"But now I tend to be more mindful about like how my body works, and I only eat when I'm truly hungry basically just listening to my body more"(P21).</i></p>
9-Goals (Mental representations of outcomes or end states that an individual wants to achieve). 7 participants.	<p><i>"I do a meal plan at the start of the week or just before I go shopping, and that helps me save a bit of money"(P1).</i></p> <p><i>"my weight. I know that the BMI range that I'm in, it's not in the normal side, it's slightly overweight, so I am trying to cut down my food or trying to incorporate more healthier choices"(P4).</i></p> <p><i>"I'm pretty sure when I moved back to Sydney, when this COVID thing settles, and I have a proper job in Sydney, because I don't have proper work in Sydney. I work in Hong Kong. So if I get a proper job in Sydney, I have made a promise to myself that I'll cook for myself. It doesn't matter if I'm living alone, and I will eat properly just like I eat properly when I'm here with my family"(P8).</i></p> <p><i>"It's very important to be mindful of the macronutrients. I count my calories daily; I try to stay in a calorie deficit if I can. That's what I'm trying to do at the moment, because I'm cutting my weight"(P10).</i></p> <p><i>"number one, it's also appearance. If I'm going to be very honest with you, it's about appearance. Secondly, it's about keeping our system clean because I noticed a big change in my body because I was a smoker, to be honest. And before I started working out, when I wasn't doing my, when I was doing my cardio. So when I was walking on the treadmill or running on the treadmill, it took a big toll on my body. I was also eating very, not clean. So I was eating very dirty. I was eating out of carbs I was eating a lot of bad protein. I was eating fatty foods and had a big effect on my body which I personally realized once I started working out every day. And that's why I decided to make the switch and I encourage everyone to make the same switch"(P10).</i></p>
10- Memory, attention and decision processes (The ability to retain information, focus selectivity on aspects of the environment and	<p><i>"There are all these foods that I really liked when I was a child, that I wasn't allowed to eat when I was a child, as well. So, it can be really, really tempting to just be like, "Oh, I'm just going to treat myself." But then if it becomes every week thing, then it's not treating yourself. That's just part of what you're eating"(P6).</i></p> <p><i>"when I was in year 10, I was really fat and I didn't really care about what I was eating. I used to go to our school canteen and eat all sorts of junk foods and I gained a lot of weight. But</i></p>

choose between two or more alternatives). 2 participants.	<i>in year 11, I really stretched myself out. I did a lot of workout and I eat healthy and I lost about 10 KGs of weight"(P8).</i>
11- Environmental context and resources (Any circumstance of a person's situation or environment that discourages or encourages the development of skills and abilities, independence, social competence and adaptive behaviour) (person's situation impact on food or environmental situation impact on food). 22 participants.	<p><i>"going out to eat, sometimes meat options are the majority of the options that are available. So when I go out to eat, for example, meats' probably more of a popular option than when I am at home"(P2).</i></p> <p><i>"a lot of my friends are really busy; they all work more hours than I do. And so, the idea of them cooking when they get home, it's really difficult. Whereas, because I do most of my work from home, I have more time to cook"(P6).</i></p> <p><i>"I used to love cakes a lot and yeah, and muffins and all that whip cream. So sometimes you just feel tempted to just going back to all that and it's easy to get it. It's easy, it's even affordably cheaper to buy it as compared to when you want to do a high protein diet, where you have to get your meat, you have to put in your vegetables, you have to put in your carbohydrate. You can just have a cake and eat, that's very easy if you ask me. It's so different from having to cook everything else to make a proper dinner or a problem now with all the nutrients"(P14).</i></p> <p><i>"It's hard for me to stick to a diet. Unfortunately, since the effects aren't immediate and they aren't incredibly noticeable all the time, it's hard for me to stick to a diet and keep eating in a way that I should be, or I feel like I should be eating"(P18).</i></p> <p><i>"I tried to prepare as much as possible (food) because It's quite expensive outside but I make, make sure once a week, I go out and I like I eat outside"(P22).</i></p>
12-Social influences (Those interpersonal processes that can cause individual to change their thoughts, feelings or behaviours). 21 participants.	<p><i>"when I was obviously much younger, my mom cooked everything for me"(P6).</i></p> <p><i>"as I got older, as I didn't cook at the time, my mom was the chef. As she got more easy with work, the selection of food has been the variety, I guess, slimmed down considerably to something that's more quick and convenient"(P7).</i></p> <p><i>"Most recently me and my sister have been watching documentaries on how the meat industry works. And I guess the nature of how they're doing it isn't really good for the environment and stuff like that. We're trying to be more sustainable in where we eat. So that's, I guess the reason why we've shifted towards more vegetarian options, but at the same time, we also know that there's probably better health benefits from that as well "(P2).</i></p> <p><i>"I think it's pretty similar, especially between my sister and mum. Probably the only person that's a bit different would be dad. He's not really concerned about healthy eating. But I think amongst us girls, it's probably quite similar"(P5).</i></p> <p><i>"my uncle, one of them is a doctor, so he really motivates us to eat healthy food and do healthy snacking. So our snacks usually at home is salad. We cut some carrots and cut some tomatoes and put some salt and pepper in it and that's our healthy snacking"(P8).</i></p>
13- Emotion (A complex reaction pattern, involving experiential, behavioural, and physiological elements, by which the individual attempts to deal with a personally significant matter or event). 19 participants.	<p><i>"my mental health definitely plays a role in it. There are days or weeks where I'm just not motivated to do much. And it's hard to think to yourself, well, I'm going to prepare a healthy meal"(P1).</i></p> <p><i>"I feel really bad mentally if I eat like chicken or pork or beef, maybe like two to three consecutive days. It happens only if I'm out. So if I'm with my family living, we have the home cooked meal, which is always vegetarian. But, if I'm visiting uni and I'm meeting people, so I might consume something which has non-veg in it, so I would feel really bad. And maybe psychologically for the environment and also for my body that I've consumed a lot of meat. So what I would usually do that I won't eat meat for next month"(P8).</i></p> <p><i>"Eating healthy brings me joy and I feel good about eating healthy and it's something that relates to my health as well"(P9).</i></p>

	<p><i>"I think it's very linked for me to just feeling good, because, for example, when I was eating all the food bank stuff, because it's not fresh, I was feeling more lethargic and more heavy. So, first thing is it makes me feel good and that it's fresher"(P13).</i></p> <p><i>"So I do feel better. It's part of the mind as well, you feel guilty when you eat junk food, but you do notice it in your energy levels. I don't feel as much bloated. Say if I eat a pizza, I would feel bloated after that, but after eating a healthy meal, I don't feel as bloated. And say if I had a pizza, I wouldn't feel hungry for a very long time, and it disrupts my cycle"(P15).</i></p>
<p>14- Behavioural regulation (Anything aimed at managing Or measured actions). 22 participants.</p>	<p><i>"I never go shopping hungry because I find that I want instant satisfaction and if I go on full stomach, then I'm not going to pick up the pre-packaged or processed bullshit"(P1).</i></p> <p><i>"I refuse to buy wine that's been imported from overseas just because of the carbon footprint that it has to get it into Australia, when we have really good wine here in Australia"(P3).</i></p> <p><i>"I was told that acne is directly related to the proportion of dairy that I consume, which is why I'm trying to cut down dairy. But cutting that down has been a huge problem for now, because I have to restrict not just milk, but milk products as well, so that is, cheese, yogurt and cream cheese, or bakery products or anything that even has a certain amount of dairy I have to cut down on. That has been a problem because I like my coffee a lot"(P4).</i></p> <p><i>"I sometimes try to be careful about how much additional fat I add to things. If I'm cooking with butter or oil, to just be careful about how much I'm using. Especially when I'm frying, doing a stir-fry with vegetables and stuff, if I feel I'm using too much oil, to maybe just put in a little bit of water, instead of adding more oil"(P6).</i></p> <p><i>"restricting my carbohydrate intake. So this is one of the thing that I'm still struggling because I do love carbs, but because my physical activity is not as much as I used to have since young"(P9).</i></p>

Appendix 6: Advertisements used to recruit participants



Are you aged 18 to 25 years, living in Australia for at least 12 months? Are you willing to share your views and experiences on sustainable and healthy diets via an online interview? We offer \$20 Gift Voucher for your participation!

Please email golsa.saberi@hdr.mq.edu.au OR rimante.ronto@mq.edu.au OR fill a short EOI form (see QR code) and we will contact you shortly!



Appendix 7: Consent form

Department of Health Systems and Population
Faculty of Medicine and Health Sciences
MACQUARIE UNIVERSITY NSW 2109
Phone: +61 (2) 9850 2301
Fax: +61 (2) 9850 6410
Email: rimante.ronto@mq.edu.au



Chief Investigator: Dr Rimante Ronto

Participant Information and Consent Form

Exploring young Australian's understanding and current practices on sustainable and healthy diet

You are invited to participate in a study about your understanding and current practices on sustainable and healthy diet. The purpose of the study is to explore in depth young Australians' understanding, attitudes, and current practices in achieving sustainable and healthy diets. The mentioned aim will help to inform the development of evidence-based interventions and policies.

The project is jointly conducted by five investigators: **Dr Rimante Ronto, Golsa Saberi, Dr Elizabeth Fox, Dr Julia Carins and Dr Keren Papier**. The Chief Investigator for this study is Dr Rimante Ronto, Lecturer in Public Health, Department of Health Systems and Populations. If you have any questions, Dr Rimante can be contacted either via email: rimante.ronto@mq.edu.au or phone: 02 9850 2301.

This study consists of an individual online interview to be conducted over online platform such as Zoom and/or Microsoft Teams. The interview will last approximately 30 to 45 minutes, during which we will ask you about your understanding of sustainable diet and your current dietary practices. In addition, we will ask you to send 2 to 3 pictures showing your dinner meals either prepared by you or purchased in the last three days prior to the interview. These pictures will be used to facilitate the discussion. The interview will be recorded. You will be able to review your answers before data analysis. Interview transcripts will be deidentified during data analysis and reporting.

Any information or personal details gathered in the course of the study are confidential, except as required by law. No individual will be identified in any publication of the results. *Chief investigator Dr Rimante Ronto and research team are the only persons having access to your personal data.* A summary of the results can be made available to you on request by simply noting it at the end of your interview session. Data collected and analysed in this study might be published in peer-reviewed academic journals and presented at national and international conferences, however, your personal information will remain confidential.

Your involvement in this study would contribute to insight on young Australian's knowledge, attitudes and current practices in achieving sustainable and healthy diet. There are no significant risks to you associated with participation in this project. Should you feel discomfort please free to discontinue your participation in the research.

Participation in this study is entirely **voluntary**: you are not obliged to participate and if you decide to participate, you are free to withdraw at any time during the interview without having to give a reason and without any consequence. However, once data is deidentified, you will not be able to withdraw your consent as we will not be able to identify which answers are yours. At the end of interview, you will be eligible to receive a **\$20 gift voucher**. Please note, you will be able to keep the voucher if you decide to withdraw from this study. **If you agree to participate in this study, please sign this form below and return it by email to:**

Golsa Saberi (golsa.saberi@hdr.mq.edu.au), Master of Public Health Research Student.

I, _____ (*participant's name*) have read/ *have read to me* and understand the information above and any questions I have asked have been answered to my satisfaction. I agree to participate in this research, knowing that the interview will be recorded, and I can withdraw from further participation in the research at any time without consequence. I have been given a copy of this form to keep.

Participant's Name: _____

(Block letters)

Participant's Signature: _____ Date: _____

Investigator's Name: _____

(Block letters)

Investigator's Signature: _____ Date: _____

The researcher will contact you with further details regarding time and date.

The ethical aspects of this study have been approved by the Macquarie University Human Research Ethics Committee. If you have any complaints or reservations about any ethical aspect of your participation in this research, you may contact the Committee through the Director, Research Ethics & Integrity (telephone (02) 9850 7854; email ethics@mq.edu.au). Any complaint you make will be treated in confidence and investigated, and you will be informed of the outcome.

Appendix 8: Ethics approval

Medicine & Health Sciences Subcommittee

Macquarie University, North Ryde

NSW 2109, Australia



04/08/2020

Dear Dr Ronto,

Reference No: 52020793218854

Project ID: 7932

Title: Sustainable diets interviews

Thank you for submitting the above application for ethical review. The Medicine & Health Sciences Subcommittee has considered your application.

I am pleased to advise that ethical approval has been granted for this project to be conducted by Dr Rimante Ronto, and other personnel: Mrs Golsa Saberi.

This research meets the requirements set out in the National Statement on Ethical Conduct in Human Research 2007, (updated July 2018).

Standard Conditions of Approval:

1. Continuing compliance with the requirements of the National Statement, available from the following website: <https://nhmrc.gov.au/about-us/publications/national-statement-ethical-conduct-human-research-2007-updated-2018>.
2. This approval is valid for five (5) years, subject to the submission of annual reports. Please submit your reports on the anniversary of the approval for this protocol - 4 August yearly. You will be sent an automatic reminder email one week from the due date to remind you of your reporting responsibilities.
3. All adverse events, including unforeseen events, which might affect the continued ethical acceptability of the project, must be reported to the subcommittee within 72 hours.
4. All proposed changes to the project and associated documents must be submitted to the subcommittee for review and approval before implementation. Changes can be made via the [Human Research Ethics Management System](#).

The HREC Terms of Reference and Standard Operating Procedures are available from the Research Services website: <https://www.mq.edu.au/research/ethics-integrity-and-policies/ethics/human-ethics>.

It is the responsibility of the Chief Investigator to retain a copy of all documentation related to this project and to forward a copy of this approval letter to all personnel listed on the project.

Should you have any queries regarding your project, please contact the [Faculty Ethics Officer](#).

The Medicine & Health Sciences Subcommittee wishes you every success in your research.

Yours sincerely,

Dr Mark Butlin

Chair, Medicine & Health Sciences Subcommittee

The Faculty Ethics Subcommittees at Macquarie University operate in accordance with the National Statement on Ethical Conduct in Human Research 2007, (updated July 2018), [Section 5.2.2

04/08/2020

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The Medicine & Health Sciences Subcommittee wishes you every success in your research.

Yours sincerely,

Dr Mark Butlin

Chair, Medicine & Health Sciences Subcommittee

The Faculty Ethics Subcommittees at Macquarie University operate in accordance with the National Statement on Ethical Conduct in Human Research 2007, (updated July 2018), [Section 5.2.22].