Communicating for impact: Tailoring nutrition messages to influence dietary behaviour

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ABSTRACT

Poor diet quality is a factor associated with the prevalence of non-communicable diseases among Australian adults. To improve diet quality, brief online dietary feedback interventions have been developed, but, to date, have had modest effect. To enhance intervention effectiveness, a potential first step is identifying the dietary target that can maximise overall diet quality improvement. The second step can be making dietary feedback more influential by framing nutrition messages. Since the influence of differently framed nutrition messages may vary between individuals, tailoring the message frame may be more effective than using one generic message for everyone. Therefore, this thesis aimed to design and test a brief online dietary feedback intervention with tailored nutrition message frames and enhanced behavioural support, for improving Australian adults' diet quality.

The thesis aim was addressed through four studies. First, a secondary dietary pattern subgroup analysis was used to identify the priority target. Next, a randomised controlled trial with a nested crossover trial was designed to test a brief online dietary feedback intervention: *Shifting My Nutrition Score in 28 Days*. The crossover trial tested the effectiveness of four nutrition message frames, using participants' intention to change as the outcome. The messages were framed as positive, negative, majority or minority descriptive norm messages. The message associated with a participant's highest intention was delivered as the tailored message. The randomised controlled trial tested whether a tailored nutrition message, with enhanced behavioural support, was more effective than a generic message used in standard practice, in influencing dietary behaviour. Last, participant characteristics as predictors of intervention effectiveness were analysed.

The secondary analysis showed that 81% of the sample ($n = 216{,}045$) did not comply with the Australian Dietary Guidelines for discretionary choices, regardless of population subgroup. Thus, this food group was chosen as the priority dietary target for intervention. The crossover trial revealed that nutrition message frames increased intention from baseline; however, the difference in effects between the message frames was limited. The *Shifting My Nutrition Score in 28 Days* intervention showed limited difference in the effect between the tailored and generic nutrition messages on discretionary choice intake. However, the intervention achieved a significant one serve reduction in discretionary choice intake ($n = 1{,}441$; $\eta^2 = 0.28$, $p < 0.001$). Exploratory analysis revealed that having a lower diet quality at baseline was associated with a greater likelihood of a one serve or more reduction in discretionary choice intake (OR 1.57, 95% CI [1.47, 1.68], $p < 0.001$).

To the best of this PhD candidate's knowledge, this is the first study to incorporate nutrition message frames, individually tailored to influence intention, into a novel, evidence-based, brief online dietary feedback intervention. The original contribution to knowledge of this thesis is that it may not be necessary to tailor nutrition message frames and provide enhanced behavioural support for improving the diet quality of a sample with high baseline intention. Extending this new knowledge may allow researchers to design and deliver other influential messages, within practical and effective tailored interventions, to continue improving Australian adults' diet quality.

DECLARATION

I certify that this thesis does not incorporate without acknowledgment any material previously submitted for a degree or diploma in any university; and to the best of my knowledge and belief, does not contain any material previously published or written by another person except where due reference is made in the text.

Signed..

Date........15 December 2021........

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ABBREVIATIONS

ADGs	Australian Dietary Guidelines
ANOVA/ANCOVA	Analysis of (co)variance
BCTs	Behaviour Change Techniques
BCW	Behaviour Change Wheel
BMI	Body Mass Index
COM-B	Capability, Opportunity, Motivation and Behaviour
CONSORT	CONsolidated Statement of Reporting Trials
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DGI	Dietary Guideline Index
RCT	Randomised Controlled Trial
EPHPP	Effective Public Health Practice Project Quality Assessment Tool for Quantitative Studies
SEIFA	Socio-Economic Index for Areas
SFS	Short Food Survey

GLOSSARY

Behaviour Change Techniques	The smallest, reproducible components (referred to as the 'active ingredients') of an intervention to bring about behaviour change.
Dietary behaviour	The behaviours that lead to diet quality.
Diet quality	The level of compliance of the overall diet with the Australian Dietary Guidelines (ADGs).
Diet components	The components of the diet that together determine diet quality.
Discretionary choices	The ADG term for a group of 'non-core' foods and beverages high in saturated fats, added sugars and/or sodium (or alcohol), and often high in energy (kilojoules).
Generic nutrition message	A message communicating dietary advice, commonly using language from the ADGs, without tailoring.
Nutrition message framing	A communication approach for dietary advice, using a theoretical framework: by using a positive or negative, or a majority or a minority descriptive norm frame.
Majority or minority descriptive norm framed messages	Messages communicating information on the dietary behaviours of the majority, or the minority, of the population.
Positive or negative framed messages	Messages communicating the positive, or the negative, health outcomes associated with a dietary behaviour.
Priority dietary target	The diet component that scores the lowest within an overall diet quality score and thus needs intervention priority.
Segmentation	The degree to which a population is divided into increasingly more defined, homogenous subgroups.
Shifting My Nutrition Score in 28 Days	A 28-day brief online dietary feedback intervention that delivers nutrition messages through two emails, 14 days apart.
Tailored nutrition message frames	Messages that communicate dietary advice, framed using a theoretical framework, and tailored to an individual's highest baseline intention score.

THESIS OVERVIEW

This thesis is structured as seven chapters, including four studies: 1) a secondary analysis, 2) a crossover trial nested within 3) a randomised controlled trial, and 4) an exploratory analysis.

Chapter 1 provides context to the thesis, including a broad overview of the literature regarding the diet quality of Australian adults. An argument is shaped around the need to enhance the effect of dietary feedback interventions to maximise diet quality improvement. The chapter then critiques the evidence on nutrition message framing. Finally, a synthesis of systematic reviews and applicable theories inform the development of a novel intervention that aims to improve diet quality.

Chapter 2 reports on a secondary analysis using the CSIRO Healthy Diet Score survey data, which aimed to identify the differences in the score of overall diet quality and its components against dietary guideline compliance, between population subgroups. The key outcome from the chapter is the identification of discretionary choices as the priority dietary target for intervention. The chapter reports the methods, results, and discussion of this secondary analysis.

Chapter 3 presents the design methods of the brief online dietary feedback intervention that aims to improve discretionary choice intake. Detail is provided on how the randomised controlled trial with a nested crossover trial was designed to test the effectiveness of nutrition message framing; and to determine whether tailored nutrition messages are more effective than generic messages, on discretionary choice intake reduction. The methods for the process-evaluation, and the exploratory analysis to identify predictors of intervention effectiveness, are also described.

Chapter 4 reports findings from the crossover trial, regarding which nutrition message frame is more effective for increasing the intention to reduce discretionary choice intake. A discussion of these results is presented to guide ongoing research in this field.

Chapter 5 presents the findings of the brief online intervention to address the main thesis aim. Using the randomised controlled trial results, the effectiveness of tailored nutrition messaging with enhanced behavioural support on reducing discretionary choice reduction is presented. The process-evaluation results are presented to describe participants' satisfaction with the intervention. The discussion places the findings within the wider context of the evidence.

Chapter 6 showcases the exploratory secondary analysis to determine the predictors of intervention effectiveness. Two post-intervention outcomes are presented: a reduction in one serve of discretionary choice intake and compliance with the Australian Dietary Guideline recommendation for discretionary choices. A discussion of these results considers future implications for tailoring online interventions to achieve significant and sustainable improvement in dietary behaviour.

Chapter 7 provides an overall discussion of the thesis, and the original contribution to knowledge it provides to the evidence. Key findings from the developed intervention are reinforced, before consolidated findings are discussed in the context of the broader dietary intervention literature. The overarching strengths and limitations are discussed, and implications and future directions for research are outlined, leading to the conclusion of the thesis.

CHAPTER 1 INTRODUCTION, LITERATURE REVIEW AND THESIS AIM

1.1 Overview

Diet quality is a key modifiable risk factor for the prevention of chronic disease. However, many Australians have poor diet quality. Given the increasing prevalence of chronic disease in the country, this thesis aimed to design and test a brief online dietary feedback intervention for improving the diet quality of Australian adults. Thus, the next section of this chapter introduces the concept of diet quality, its definition and how it can be assessed. Diet quality assessment tools that have been developed into large-scale surveys are then summarised. The potential of these surveys to become interventions that deliver feedback messages to improve diet quality is also outlined. Then, a three-part literature review is presented to identify research gaps (see Figure 1-1), which if addressed, could improve the effectiveness of large-scale diet quality assessment and feedback interventions to improve diet quality. Part one, in section 1.3, discusses whether diet quality differs between population subgroups. This knowledge is important in developing large-scale feedback interventions to prioritise specific dietary targets that can maximise diet quality improvement. Part two, in section 1.4, introduces health communication, specifically message framing, as an important component of large-scale feedback interventions to encourage change in dietary behaviours. This section presents a narrative review on the effectiveness of nutrition message framing and introduces a novel approach of tailoring such nutrition messages. Part three, in section 1.5, reviews features associated with effective nutrition interventions delivered online. Section 1.6 discusses the role of theory. This chapter concludes with section 1.7, by summarising the evidence gaps and research questions, and section 1.8, by presenting the thesis aim and objectives.

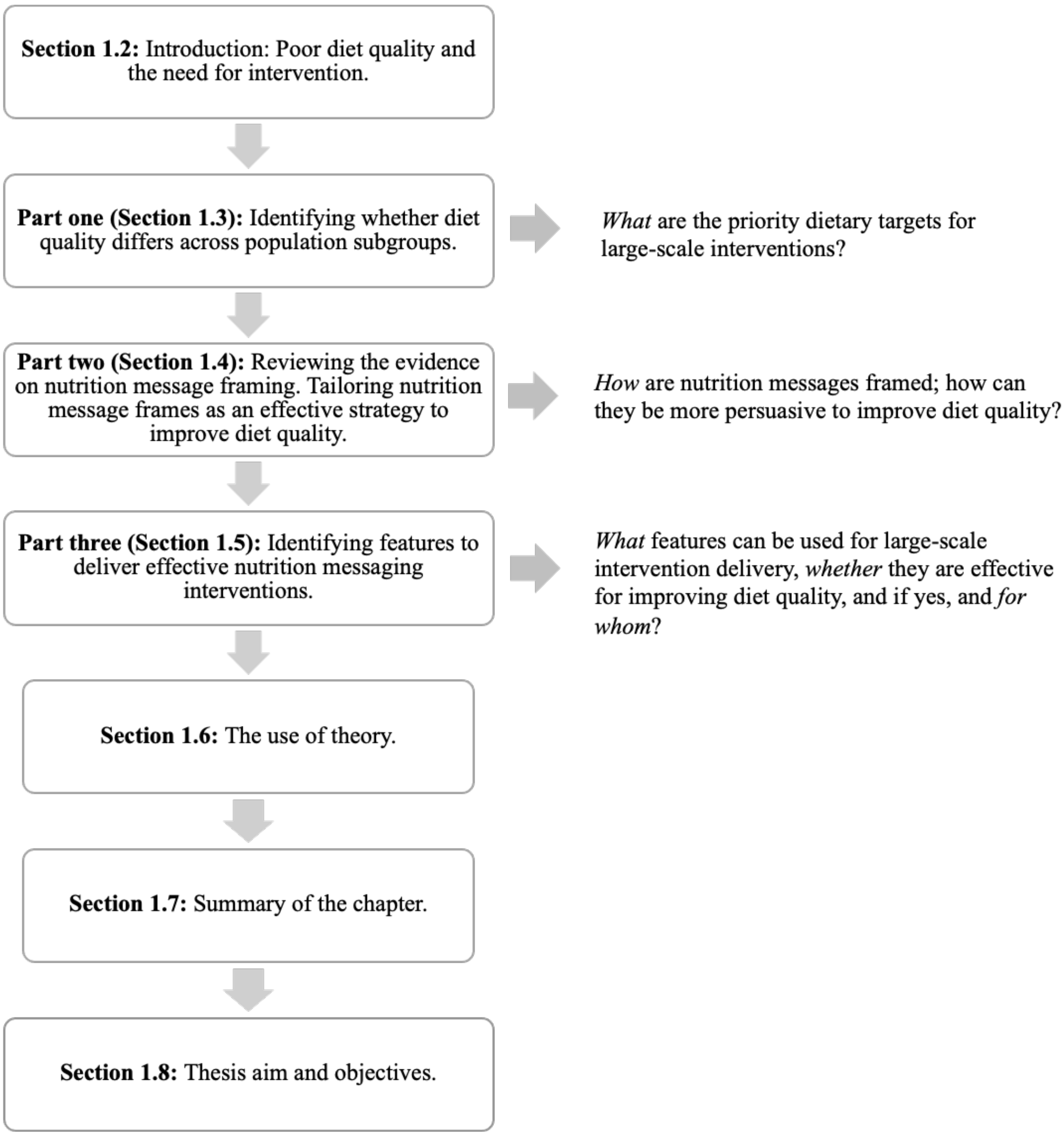


Figure 1-1: Summary of the sections and three-part literature review in Chapter 1.

1.2 Introduction

This section provides background information on diet quality, including its association with disease, the diet quality assessment tools that have been developed into large-scale surveys and the potential of these surveys to become successful interventions.

1.2.1 Diet quality and its association with disease

Poor diet quality is a factor associated with non-communicable diseases (1) and accounted for 11 million (22%) adult deaths worldwide in 2017 (2). In Australia, poor diet quality accounted for 7.3% of the burden of total non-communicable diseases in 2015 (3) and was also associated with overweight and obesity (4). The 2017–2018 National Health Survey found that more two-thirds (67%) of Australian adults were living with overweight or obesity (5). Thus, improving diet quality is a key strategy in reducing the risk of non-communicable disease and the rates of overweight and obesity (3).

Single components of a diet can predict the risk of non-communicable diseases as well as overweight and obesity (6). However, the association between single components and health risks may not account for the collinearity of, or interplay between these single components that make up overall diet quality (7). A growing body of evidence demonstrates the detrimental effects on health of diet quality, that is characterised by the low intake of nutrient-rich foods, such as fruits, vegetables and wholegrains, and the high intake of energy-dense, nutrient-poor foods, such as foods high in saturated and trans fats, added salt or sugars, and low in fibre (1, 2, 8-11). Therefore, the *whole of diet* needs to be considered in attempting to reduce health risks. This perspective of considering the whole of diet is consistent with global dietary guidelines that provide recommendations to both support nutrient adequacy and reduce the risk of non-communicable diseases (7). The next section discusses diet quality definitions in relation to dietary guidelines.

1.2.2 Diet quality definition

Diet quality can be defined as compliance with national dietary guidelines developed for a particular population and context (12). In the case of Australia, optimal diet quality is defined as eating in compliance with the Australian Dietary Guidelines (ADGs), which consider nutrient intake adequacy and food variety within core food groups that are associated with non-communicable disease prevention (10). The ADGs recommend the daily intake of five core food groups, with the number of serves adapted to age and gender, height, weight, physical activity levels, and pregnancy or breastfeeding needs (10). On average, the recommended intake of the core food groups is as follows: vegetables and legumes/beans (five serves); fruit (two serves); grain foods, mostly wholegrain and/or high cereal fibre varieties (five serves); lean meat and poultry, fish, eggs, tofu, nuts and seeds, and legumes/beans (two serves); and milk, yoghurt, cheese and/or alternatives, mostly reduced fat (two to three serves) (10). The ADGs also recommend the use of unsaturated 'healthy' fats for spreads and oils, or approximately 30 g of nuts and seeds, and water as the main drink. Last, it is recommended to limit the intake of non-core food and drinks that are high in saturated fat, added sugars, added salt, and alcohol, termed 'discretionary choices' (10)—the term is presently under review (13). Thus, high diet quality reflects high compliance with dietary guidelines, whereas poor diet quality reflects suboptimal compliance.

1.2.3 Current compliance with the Australian Dietary Guidelines

Compliance with the ADGs has been poor, as indicated by national dietary intake data from the 2011–2012 National Nutrition and Physical Activity Survey, collected via 24-hour dietary recalls from more than 12,000 individuals (14). Since the data for 2012 can be considered outdated, they are still of value as they are obtained from the largest and most comprehensive health survey ever conducted in Australia. The data showed that the majority of Australian adults are not meeting the recommended daily intakes of all core food groups (14). Between 1995 and 2011–2012, the estimated number of serves per 10,000 kilojoules consumed had increased for lean meat and poultry, fish, eggs, nuts and seeds and legumes/beans, did not change for fruit, grain foods or dairy, decreased for vegetables and legumes/beans and decreased slightly for discretionary choices (15). The more recent 2017–2018 National Health Survey (5), provides data on select diet components—fruit, vegetable and sugar-sweetened beverage intake—from a representative sample (n = 21,315). The survey results showed that only about 7.5% met the guideline for vegetable serves, and only 5.4% met both the fruit and the vegetable serve guidelines (14). Intakes of discretionary choices were in large excess of the recommendations, contributing 35% of daily energy intake for adults in every age group (14, 15). Evidently, recommendations on the serves of individual diet components (i.e. food groups) are not being met. In addition to improving recommendation rates of single diet components, the collinearity between single diet components must be considered since these together influence overall diet quality (16). Some methods of diet quality assessment will be discussed next.

1.2.4 Diet quality assessment

Overall diet quality can be assessed against compliance with national dietary guideline recommendations (17-20). A hypothesis-driven approach or an a priori approach can be used to estimate overall compliance with dietary guidelines, with preliminary knowledge of the disadvantages and benefits of specific foods, to calculate diet quality indices (6, 16, 21, 22). Then, these indices can be used to compare overall diets across population subgroups, to identify the key determinants of diet quality, to investigate associations with health risk factors and outcomes and to examine the effects of interventions on overall diet quality (11, 23).

Several indices have been developed to assess the diet quality of the intakes of Australians (24-26). One is the Dietary Guideline Index (DGI), developed in 2008 (24). The DGI uses 15 food-based indicators to assess the quantity, quality and variety of core food groups and discretionary choices consumed by individuals, resulting in a score ranging from 0 to 150 (24). Studies using the DGI have demonstrated that, as expected, higher DGI scores are associated with dietary guideline compliance, the intake of key nutrients, demographic factors, self-assessed rating of health status, health behaviours, such as smoking and physical activity practices, reduced energy (kilojoule) consumption, lower Body Mass Index (BMI) and lower risk of hypertension and type 2 diabetes (4, 8, 9, 24, 27, 28). The DGI has been applied to food intake data measured via 24-hour recalls (9), food frequency questionnaires (27) and a validated Short Food Survey (SFS) (29). Thus, the DGI is a useful tool to conceptualise diet quality in terms of overall dietary guideline compliance.

1.2.5 Current interventions that aim to improve overall diet quality

Two online diet quality assessment tools have been developed for use with Australian adults, which can also be used as brief feedback interventions to improve overall diet quality (30, 31). One tool is the CSIRO Healthy Diet Score (30), a one-point-in-time web-based survey that the Commonwealth Scientific and Industrial Research Organisation (CSIRO) has developed. The survey uses the validated SFS to collect dietary information from individuals (29). Then, the survey provides feedback in terms of an overall diet quality score based on a dietary assessment using the DGI (24). A higher diet quality score indicates higher compliance with the ADGs. In addition to this score, the survey calculates the scores of all diet components and provides a report on the three lowest-scoring components, because improvements to these three scores are more likely to improve that individual's overall diet quality (30). The other tool has a similar design: the Healthy Eating Quiz (31), a one-point-in-time web-based survey, based on the validated Australian Recommended Food Score (25, 31). This quiz scores and gives feedback on individuals' overall diet quality against compliance with the ADGs but does not assess discretionary choice intake. It provides a report with the overall diet score and feedback on all diet quality components. These examples highlight that brief online dietary assessment and feedback tools can also serve as an intervention strategy to improve diet quality, which can reach large populations in an efficient way.

The CSIRO Healthy Diet Score and the Healthy Eating Quiz are available nationally. The CSIRO Healthy Diet Score data have been used to monitor and evaluate diet quality and diet component scores of the population (30) and to identify whether diet quality varies between population subgroups (4, 32). The Healthy Eating Quiz has also been used to monitor and evaluate the diet quality of Australian adults (31) and has been developed into a randomised controlled trial (RCT) protocol: AIM4Me (33). The RCT is aimed at young adults (aged 18–24 years) to test whether the current Healthy Eating Quiz feedback report on overall diet quality is an effective intervention strategy for improving diet quality or whether additional intervention is needed (33). Nonetheless, there is an absence of evaluation data on the effectiveness of the brief feedback that these tools provide, in improving the diet quality of Australians.

International studies have evaluated the effect of online dietary feedback interventions. In Kuwait, a food frequency questionnaire 'EatWellQ8' (34) assessed diet quality using the Alternative Healthy Eating Index (35). Similarly to the CSIRO Healthy Diet Score, EatWellQ8 delivered feedback suggestions on the three lowest scoring components that are more likely to improve overall diet quality. In an RCT, the impact of dietary feedback based on the dietary assessments were compared with the effect of using general healthy eating guidelines (control) on diet quality (34). Preliminary results showed that the feedback intervention was associated with a significantly higher increase (12%) in the overall diet quality score after 12 weeks compared with the increase (4%) for the control (34).

To evaluate further whether feedback messages on baseline dietary assessment are effective for improving diet quality, a large pan-European study was performed. The 'Food4Me' study was conducted to test the delivery of three feedback approaches (36). The control group (Level 0) received general healthy eating guidelines; the Level 1 group received feedback on baseline dietary assessment (using the Healthy Eating Index (37)); individuals in the Level 2 group received additional information, that is, their phenotype data; and those in the Level 3 group received their genotype data as well. The feedback was provided on three discrete nutrient-related components with the highest priority for diet quality improvement (38). The results indicated that providing feedback on dietary assessment was more effective at improving diet quality than the general guidelines given to the control group (39, 40). Specifically, there was a decrease in red meat consumption (−5.48 g or by 8.5% from baseline, $p = 0.046$), and in nutrients found in discretionary choices, such as saturated fat (−1.14% of energy or by 7.8%, $p < 0.0001$) and salt (−0.65 g or by 8.9%, $p = 0.002$); and increased consumption of folate (29.6 mg or by 11.5%, $p = 0.048$), leading to higher Healthy Eating Index scores (by 1.27 points or 2.6%, $p = 0.010$) (39) and improved adherence to the Mediterranean diet score (range: 0–14) for the intervention groups (5.48 $\pm$ 0.07) compared with the control (5.10 $\pm$ 0.05, $p = 0.002$) (40). Given these modest effects on diet quality, researchers have called for well-designed feedback messaging interventions, tested using RCTs, focussing on a broader range of dietary outcomes and more support for behaviour change, in order to enhance the effects of current intervention efforts (41).

In summary, results from international research have indicated that providing dietary feedback messages on baseline diet quality assessment results in modest improvement in diet quality. Therefore, exploring ways to evaluate and enhance the effect of feedback on diet quality in an Australian context, using well-designed interventions, is warranted.

1.2.6 Intervening in overall diet quality, one diet quality component at a time

To enhance the effect of feedback interventions that aim to improve diet quality, the feedback should provide realistic, applicable information. An overall diet quality score may not provide enough information on which diet components constitute the overall diet. Therefore, to ensure that diet quality scores and the associated information can be used to intervene in practice, single component scores should be explored (42, 43). In these situations, it is useful to move from an overall diet quality perspective back to a disaggregated single component approach. The single components, which are usually food groups, can be then identified as *priority dietary targets* for intervention. In line with this view, a study on the Healthy Eating Index (44) proposed that single component scores within overall diet quality should be examined. The study showed that an identical total diet quality score can result in two different dietary patterns. It depicted two dietary patterns, each with a total score of 50 points out of 100. One dietary pattern had a higher vegetable intake but lower total protein food intake, whereas the other pattern had lower vegetable intake but higher total protein food intake (44). Thus, this evidence portrays the importance of examining the components comprising overall diet quality scores.

In addition, overall diet quality scores could predict how single diet components score. Higher overall diet quality scores have been associated with higher scores for fruit and vegetable components, whereas low overall scores have been associated with lower component scores for core food groups and discretionary choices (30, 45). Therefore, the additional information contained within an overall diet quality score range demonstrates the need to examine single diet components, and not solely depend on overall scores. Thus, an individual's overall diet quality score could be used to deliver a feedback intervention that targets priority diet quality components.

1.2.7 Approaches to enhancing the effect of current interventions

As aforementioned, providing feedback on baseline dietary assessments can be effective in improving diet quality (39, 40). A key question that remains for interventions aiming to improve overall diet quality is how to enhance the nature of the feedback provided. As described, feedback has been provided using approximately five approaches. The first feedback approach is to provide a report on the overall diet quality score, based on the diet quality assessment (30, 31). The second is to provide a report on a single component or a collection of diet quality components that are likely to maximise overall diet quality improvement (36, 38). The third approach is to provide additional information on phenotype data, and the fourth approach is to provide information on genotype data (39, 40). Last, the fifth approach is to combine all the other approaches, resulting in a detailed report that includes feedback messages on diet, phenotype and genotype (39, 40). The effect of these approaches on diet quality improvement has been promising (36, 38-40). However, explanations about the need to add phenotype and genotype data in feedback are unconvincing (41).

In this regard, the delivery of different, more complex feedback has been examined (39-41). As mentioned in section 1.2.5, the Food4Me study, in testing the effectiveness of providing feedback on the overall diet quality score and three diet quality components, also examined whether providing phenotype and/or genotype data would enhance intervention effects. The results indicated that the provision of any feedback beyond information on the diet quality components most likely to improve overall diet quality did not contribute added benefits towards improving overall diet quality (39, 40). A larger body of evidence on feedback interventions strengthens the Food4Me results. A recent systematic review of 11 nutrition feedback messaging trials indicated that there was limited evidence to support the added benefits, for dietary behaviour change, of delivering additional feedback on genotype data compared with feedback based only on a baseline dietary assessment (41). The large-scale collection of individuals' phenotype and genotype data can be expensive, and feedback based on this complex information may not result in added effect on dietary behaviour compared with feedback on baseline dietary assessments (39, 40). Therefore, another avenue to explore is the way in which the feedback itself is communicated.

The current approach to communicating feedback is by using messages from the ADGs (10). For example, the CSIRO Healthy Diet Score delivers the following feedback when the discretionary choice intake exceeds guideline recommendations: '*Eat fewer discretionary foods… known as "extra foods". Extra foods include cakes, biscuits, pastry, … sugar-sweetened beverages, alcohol and similar foods. It is recommended that you eat these foods only sometimes and in small amounts.*' (30). Similarly, the Food4Me study communicated feedback using messages from a variety of reputable European government sources, such as the British Dietetic Association; for example, '*you can increase your intake of Vitamin C by eating more fruit and vegetables – aim for at least 5 a day*' (38). In contrast, the Healthy Eating Quiz provides feedback using different messages that communicate health outcomes (31). For example, in giving feedback about the lean meats food group, the message provides information on the positive and the negative health outcomes of meeting, or not meeting, the guideline recommendation for this food group. The message provided in this case: '*The amino acids found in lean red meat… are essential parts of our bodies including the skin, heart, lungs and eyes. …are excellent sources of protein and minerals such as iron and zinc.'* This section of the message provides the positive health outcomes, whereas '*Low iron levels can lead to tiredness, reduced ability to work and less resistance to infection*' explains the negative health outcomes. Last, both the CSIRO Healthy Diet Score and the Healthy Eating Quiz provide descriptive social comparisons regarding the diet quality score. For example, the individual receives information on how other people of the same gender and age group score on overall diet quality (30) or single diet components (31). The effect on diet quality of the current approaches to communicating feedback has not yet been evaluated. However, a communication technique termed nutrition message framing has been associated with behaviour change at a population level (46).

Nutrition and health information, including feedback, can be communicated using different message frames. First, the general term 'health messages' can apply to persuasive messages designed to change any behaviour within the context of health (47). For example, a nutrition health message provides information about the likely health outcomes of a healthy dietary behaviour, such as, 'vegetable intake can improve our health'. Conversely, message 'framing' is a theoretical grounded communication approach for framing the health outcomes differently. The most common approaches to framing messages are stressing positive outcomes (positive frame) or negative outcomes (negative frame) (48, 49). This approach to messaging can be likened to the feedback provided by the Healthy Eating Quiz example given in the earlier paragraph. Further, providing social norm description in feedback, as in the approach of currently available dietary feedback interventions, also influences dietary behaviours (50, 51). Given that message framing has been associated with behaviour change at a population level (46), using different nutrition message frames could be more persuasive for influencing dietary behaviour change, and could enhance the effectiveness of current feedback interventions. Section 1.4.2 expands on this topic; it explores *how* nutrition messages are framed and their potential effect on improving diet quality (Figure 1-1).

A further consideration for communicating feedback is exploring aspects to tailor the nutrition message frame. For influencing a change in health behaviour, information in interventions should not only address how the message is framed, but how the message is tailored using unexplored population characteristics, such as demographic or psychosocial data (52, 53). This approach could further build on how messages are communicated in dietary feedback interventions and may enhance the effectiveness achieved in comparison to non-tailored 'generic' messages. Evidence for the need to examine the tailoring of nutrition message frames is presented in section 0. For the purposes of this thesis, interventions that assess diet quality and deliver non-tailored generic messages, as dietary feedback, such as the CSIRO Healthy Diet Score, will be termed 'current standard practice'. Another aspect that needs consideration is how to deliver tailored nutrition message frames efficiently, on a large scale.

Traditionally, larger-scale interventions have been delivered via mail-outs or multiple intensive contacts (54-59), but the reach and effect of these efforts has been small (59). In a rapidly changing environment, people are often short on time (60), while public health resources for disease prevention are scarce (61). As a solution, a brief, online approach for intervention can be used (58, 59, 62) to deliver tailored nutrition messages effectively and at scale to improve diet quality. The literature on brief online approaches to nutrition interventions is synthesised in section 1.5 to understand the features that can be used for developing an intervention, *whether* they are effective and *for whom* (Figure 1-1).

1.2.8 Summary of the introduction

The introduction discussed the current public health issues associated with poor diet quality and established a working definition of diet quality as poor compliance with dietary guidelines. Currently, diet quality assessment survey tools have been developed into large-scale surveys, with the primary intention of monitoring population diet quality. Recently, these tools have also been used as brief feedback interventions, aimed at providing feedback on both overall baseline diet quality and key diet quality components (food groups) that, if changed, would likely improve overall diet quality. The development of these surveys into feedback interventions has demonstrated some improvement in diet quality. Calls have been made for additional evidence, through using robust study designs and including behavioural support, on the effectiveness of brief online feedback interventions. In doing so, there is the potential to explore different approaches to communicating feedback within these brief interventions. For example, it can be examined whether delivering feedback using different nutrition message framing or tailored nutrition messaging could enhance the effectiveness of current practice. However, to improve the diet quality of the population, delivering feedback on different diet components to each individual may not be feasible. Hence, assessments of the diet quality of population subgroups can identify the key components most likely to maximise the improvement of overall diet quality. These key components, which are usually food groups, can become priority dietary targets, as a starting point for developing a large-scale nutrition messaging intervention. This concept is discussed in the next section, part one, of the three-part literature review.

1.3 Part One: Identifying Priority Dietary Targets for Improving Diet Quality

Diet quality feedback has been delivered in the form of a total diet quality score and/or the scores of diet quality components, which are usually the food groups that are likely to improve the total score. The benefit of delivering additional feedback on single component scores is that it facilitates more focussed, practical behaviour change. Therefore, it is worth identifying whether there are diet quality components that are likely to maximise diet quality improvement. If yes, could the components be identified based on the characteristics of a population? This process may allow dietary feedback to be *targeted* at population subgroups for a feasible large-scale intervention. Therefore, part one of this chapter explores how the diet quality of population subgroups differs, to understand which characteristics should be used to identify *what* the priority dietary targets are for a large-scale intervention (Figure 1-1).

1.3.1 Understanding how population subgroups differ in their diet quality

To understand how diet quality differs between population subgroups, the current evidence on how subgroups comply with dietary guidelines will be reviewed. Since interventions use baseline diet quality assessment to deliver dietary feedback, baseline diet quality can be used as a characteristic for subgrouping a population. In addition, gender, age and weight status can be used, considering that the ADGs use these population subgroups to adapt recommendations (10).

1.3.1.1 Gender

In the average Australian population, the dietary guideline compliance rates between genders differs slightly. The 2011–2012 national data showed that more female adults (5%) than male adults (3%) met vegetable serve recommendations (14). In contrast, for fruit serves, more males (29%) than females (23%) met the recommendation (14). A slightly higher average proportion of males met the ADG recommendations for the remaining core food groups. The compliance rate of males and females for grain foods or ‘grains’ was 35% and 25%, respectively; for lean meat and poultry, fish, eggs, tofu, nuts and seeds, and legumes/beans or ‘meat’, 18% and 10%, respectively; and for milk, yoghurt, cheese and/or alternatives, or ‘dairy’, 14% and 6%, respectively (14). In short, apart from vegetable intake, males are more likely than females to comply with the ADGs.

For discretionary choices, the percentage of total energy consumed from this food group was 36% for males, and slightly lower, 33%, for females (14). Specifically, the 2017–2018 national data showed that males were twice as likely as females to consume sugar-sweetened beverages daily (12% v. 6%, respectively) (5). A 2019 study using the 2011–2012 national data found that 60% of the Australian adult population that exceeds discretionary choice consumption of three serves daily had a mean intake of five daily serves (63). A higher proportion of males (54.7%) than females

(45.3%) consumed more than 47% of their energy from discretionary choices (63). This finding demonstrates that, on average, males' intake of discretionary choices is higher than that of females.

However, dietary assessment studies that use diet quality indices have revealed some differences from the national data. In the original DGI study, overall diet score, that is, overall compliance with dietary guidelines, was higher for females (99.6 out of 150) than for males (91.0, $p < 0.05$) (24). Females also had higher scores than males for vegetables, fruit, wholegrains and saturated fat intake. Unlike national data, DGI scores showed that females had a higher intake of discretionary choices (24). A study using a diet quality index adapted from the DGI (RESIDE-DGI) also showed that a higher diet quality was associated with being female (72.0 out of 100), rather than male (66.4, $p < 0.001$) (64). Further, in a study examining diet quality using the Healthy Eating Index for Australian Adults, females scored higher than males on eight out of 11 diet components (45). Specifically, females scored higher for dairy, lean meat and alcohol, resulting in a significant positive association between the total score and being female ($\beta = 3.2$, $p < 0.001$) (45). In two commercialised online dietary data collection surveys using a collective sample of over 250,000 Australian adults (in 2017), females also had significantly higher diet scores (three more points out of 100) than males (30, 31). Similarly, data from a sample of 3,690 adults in the United States (US) showed a higher overall Healthy Eating Index score for females than for males (65). Thus, diet quality index data indicate that females are more likely to comply with overall dietary guidelines.

In summary, national survey data demonstrate that males are more likely than females to meet recommendations for all food groups, except vegetables and discretionary choices. However, studies that assess overall diet quality showed that females had better diet quality. One reason for this discrepancy could be that the data collected via research studies or commercialised surveys may not be representative of the whole Australian population. Moreover, the data are likely to be influenced by bias, given that those who completed the surveys did so voluntarily. Therefore, they are likely to have a stronger interest in nutrition than those who have not completed the survey. Conversely, the 2011–2012 National Nutrition and Physical Activity Survey (14) and the 2017–2018 National Health Survey (5) used complex approaches to sampling and therefore collected data from a representative sample. Nonetheless, this conflicting evidence requires further diet quality assessment to understand the compliance of females and males with dietary guidelines and the dietary targets to be prioritised by gender. This information can help to identify the most likely priority dietary targets that will maximise the improvement of overall diet quality.

1.3.1.2 Age groups

The 2011–2012 national data showed that compliance with the guidelines for most core food groups was higher amongst older age groups than younger age groups. As regards to vegetable intake, more adults in the age groups of 51–70 years and 71+ years (approximately 6% in each group) met the recommendation than did younger adults aged 19–50 years (1.7%) (14). Similar trends were observed for fruit intake—more individuals in the 51–70 (33%) and 71+ (40%) age groups than those in the 19–50 (20%) age group met the recommendation (14). In contrast, dairy intake differed substantially between older and younger age groups: 20% of the 19–50 age group met the recommendation, as against 6% of the 51–70 and 1% of the 71+ age groups. Relative to the other age groups, more adults in the 51–70 age group met the recommendation for meat, whereas more individuals in the 71+ age group met the recommendation for grains (14). Thus, generally, more older adults than younger adults met the recommendation for core food groups.

In addition, the proportion of energy consumed from discretionary choices was lower for older age groups than for younger age groups. Discretionary choices comprised slightly more of the total energy intake of adults aged 19–30 years (36% of energy intake) than that of adults aged 31–50 (35%) and 71+ (34%) years (14). The total energy intake from discretionary choices of those in the 51–70 age group was the least (33%). Specifically, the 2017–2018 data showed that younger adults aged 18–24 were more likely to consume sugar-sweetened beverages, with 61% consuming these at least once per week, as against 19% of those aged at least 65 years (5). Similar trends were found in secondary analyses of the 2011–2012 national data (63, 66). Younger adults were more likely than other age groups to eat an average of 10 serves daily of discretionary choices. Secondary analysis of age differences between individuals consuming less discretionary choices (less than one serve daily) and consuming more discretionary choices (more than five serves), showed a higher proportion of the 19–50 age group in the higher consumption group (63). Evidently, older adults consume less discretionary choices in comparison to younger adults.

Significantly, the results of diet quality index studies were similar to these national data. The DGI score has been positively associated with age (24). Older adults (aged > 50 years) had higher overall diet quality scores than younger adults (aged 18–29) (24) In addition, there were gender differences within age groups. For males, regression analysis showed significant inverse correlations in the 18–29 age group between diet score and gender ($\beta = -7.03$ [−9.16 to −4.91]), more so than for females ($\beta = -3.14$ [−5.07 to −1.20]). For the 50–64 age group, correlations were smaller but positive ($\beta = 0.08$ [−1.86 to 2.02] for males; and $\beta = 3.77$ [1.91 to 5.64] for females) (24). Similarly, analysis using the alternative DGI tool showed that higher diet quality was associated with older age—the mean score for those aged less than 42 years was 68.1 (of 100), and it increased to 71.7 for those aged more than 53 years ($p < 0.001$) (64). A study that used the Healthy Eating Index for Australian adults indicated that the total score was independently associated with older age, with each score per unit change of the covariates (β) increasing by 3.4 from the 25–34 age group, to the 65–74 age group ($p < 0.001$) (45). As for findings based on the CSIRO Healthy Diet Score, those aged at least 51 years had a higher mean diet score (61.0 points or more, out of 100) than those aged up to 50 years (less than 57.3 points) (30). Similarly, another study has documented higher diet quality scores for those aged 45–75 years than for those aged 16–44 years ($p < 0.001$) (31). Consistent with Australian data, studies from the US (65) and Germany (67) and other international studies (68) also found significant positive associations between diet quality and age. Thus, diet quality data consistently show that the dietary behaviours of older adults are healthier than those of younger adults.

In summary, diet quality is positively associated with age. Regardless, there are inverse correlations, with older adults not as likely as younger adults to meet the recommendations for dairy. In addition, there are gender differences within age groups, such that older female adults are more likely to have healthier diet quality than males in that age group. However, since it is important to understand what comprises overall diet quality, further assessment of diet quality components by population subgroups of age is warranted. Examining the interaction of both gender and age subgroups when assessing diet quality components will also be important in attempting to further define priority dietary targets for large-scale interventions.

1.3.1.3 Weight status categories

Weight status can be categorised using the BMI (69). The BMI can be used to broadly categorise populations into underweight (<18.5 kg/m^2), healthy weight (18.5–24.9 kg/m^2), overweight (≥ 25.0 kg/m^2) and obesity (≥ 30.0 kg/m^2). BMI is only one measure of obesity; therefore, other measures, such as the percentage of body fat, the waist circumference or the waist-to-hip ratio have been used (70). The prevalence of overweight and obesity in Australia has steadily increased, up from 57% in 1995 to 67% in 2017–2018 (5). Almost 56% of females and 70% of males among the adult population are classified with overweight or obesity, and the annual increase in rate is the highest among males aged 20–24 years and females aged 20–29 years (5). A diet consistent with the ADGs is recommended to maintain a healthy weight (71), which demonstrates that weight status is correlated with diet quality. Therefore, it is important to uncover how diet quality differs between weight status categories in order to prioritise dietary targets.

Given the lack of nationally representative data that show the variations in diet quality according to weight status, this thesis reviews the results from diet quality index studies on the relationship between diet quality and weight status. An inverse association has been found between diet quality and having overweight or obesity status. The 2008 DGI study showed that diet quality had a significant inverse association with the waist-to-hip ratio for males ($\beta = -0.02$, $p < 0.001$) and females ($\beta = -0.02$, $p = 0.003$), and a positive association with BMI for females only ($\beta = 1.20$, $p = 0.008$) (24). In 2009, the highest diet quality scores of DGI were inversely associated with abdominal obesity (OR 0.68, 95% CI [0.48, 0.96]), but only among males (72). Hendrie et al. showed a stepwise increase in the likelihood of being classified with overweight or obesity with a decreasing diet score, using the DGI tool (4). Low diet quality scores were associated with nearly triple the odds (OR 2.99, 95% CI [2.88, 3.11] $p < 0.001$) of having overweight or obesity (4). In another dietary assessment tool using DGI, those with the highest diet quality scores were less likely to have obesity (males: OR 0.64, 95% CI [0.45,0.92] *p*-trend = 0.014; females: OR 0.68, 95% CI [0.48,0.96] *p*-trend = 0.025) and central adiposity (males: OR 0.68, 95% CI [0.48, 0.97], *p*-trend = 0.030; females: OR 0.53, 95% CI [0.37, 0.77], *p*-trend = 0.001) (9). In reference to older adults with overweight or obesity, similar inverse relationships with diet quality have been observed (27). A study using the Healthy Eating Index for Australian adults confirmed that the overall diet score is independently associated with obesity in reference to healthy weight ($\beta = -2.7$, $p < 0.001$) (45). Last, the examination of five common overall diet quality measures in association with weight in a pan-European sample showed that all diet scores were inversely associated with BMI and other adiposity measures, such as the waist-to-height ratio and waist circumference (73). Evidently, there is an inverse relationship between overall diet quality scores and weight status.

In addition, key diet components that contribute to overall diet quality scores have been assessed by weight status. Compliance with national guideline recommendations for discretionary choices and fruit has been significantly lower among individuals with overweight and obesity than among those with a healthy weight (4). Sui et al. showed significant associations between high intakes of discretionary choices and lower fruit intake among people with higher BMI values (66). Specifically, the intake of sugar-sweetened beverages and alcohol was strongly and positively associated with BMI ($\beta = 6.6$, $p < 0.001$) (66). Regarding fruit, the Healthy Eating Index for Australian Adults study confirmed that the component score was significantly lower for the obesity group (3.1 ± 0.3) than for the remaining groups (the average of the underweight, healthy weight and overweight BMI group scores = 3.5) (45). Specifically, people in the healthy weight range had higher mean scores for grains, fruit, discretionary choices, fat and alcohol, whereas the obesity group scored higher for lean meat (45). These results may indicate that only particular components of diet quality and their compliance with guidelines, may be associated with weight status.

In summary, diet quality indices have shown consistent inverse associations between weight status and diet quality. Further, associations between the intake of some diet components—such as fruit and discretionary choices—and weight status have been found, such that those with overweight and obesity are more likely to eat less fruit and more discretionary choices than are those with a healthy weight status. Moreover, within weight status categories, there are diet quality differences based on gender and age, which suggests that examining the interaction of weight status with other demographic characteristics may lead to the identification of more defined priority dietary targets for a large-scale intervention.

1.3.1.4 Overall diet quality

As mentioned in section 1.2.6, differences in diet quality component scores can be explored within overall diet quality scores in population studies. Variations in the methods of scoring these components mean there are many ways to achieve a higher overall diet score (30, 45). However, there are no national data that indicate how component scores differ between high and low overall diet quality scores. Diet quality assessment tools, such as the CSIRO Healthy Diet Score (4, 30) and the Healthy Eating Quiz (31), have examined differences in diet components between subgroups of demographic or weight status characteristics. However, the tools have not yet been used to assess diet quality components by baseline diet quality. Defining subgroups of the population by diet quality scores can be a method to identify dietary targets that need priority in large-scale interventions.

1.3.1.5 Summary of the differences in diet quality by population subgroup

Part one of this chapter explored differences in diet quality and dietary guideline compliance of populations sub-grouped by their gender, age, weight status and baseline diet quality score characteristics. Nationally representative data have indicated that, compared to females, males are more likely to meet the recommended guideline serves of all food groups, except for vegetables and discretionary choices. However, diet quality indices have indicated that females have better overall diet quality. This conflict may be explained by the differences in the national versus survey samples used for data collection. In addition, diet quality tends to improve with age, and gender was found to influence this association. For example, older female populations are more likely to comply with the dietary guidelines than were older males. Last, people classified with overweight or obesity are more likely to have poor diet quality than are those in the healthy weight range. Moreover, gender and age also influence the association between weight status and diet quality. This information portrays that diet quality has been analysed by subgroups that are defined by one characteristic alone, such as gender, age groups and weight status categories. Some evidence indicates there is an interaction between all these subgroups, revealing that a diet quality analysis may need to be conducted on more complex subgroups using multiple characteristics.

1.3.2 Gap to address: Finding priority dietary targets within overall diet quality

As discussed in the previous section, the evidence on the dietary targets that need to be prioritised for population subgroups is limited. In particular, there is limited literature on how diet quality differs by population subgroups defined according to multiple characteristics, using gender, age and weight status. Therefore, the evidence gap relates to understanding whether diet quality components likely to improve overall diet quality (thus, *priority dietary targets*) differ between more defined population subgroups.

To understand the variation in diet quality component scores in a population, segmentation can be used, where individuals are placed into increasingly defined subgroups based on similar characteristics (74, 75). This analysis may inform which dietary targets, for which population, result in the most effective impact on diet quality improvement. It may also inform whether more complex segmentation will result in more focussed targeting of diet components. In this regard, the national diet data may be outdated, given that the latest comprehensive diet survey was in 2011–2012 (14). To complement these data, other large databases can be used that have collected more recent self-reported dietary intake data using validated questionnaires (30). Thus, further assessment of diet quality component scores, using updated data, may help in identifying priority dietary targets for intervention focus.

In summary, identifying priority dietary targets for different population subgroups may be a sound strategy for interventions that aim to deliver feedback that can maximise overall diet quality at the population level. Diet quality is known to differ by population characteristics, such as gender, age and weight status. Thus, using segmentation, populations can be increasingly defined and feedback on diet quality components may become more targeted. This approach would inform interventions on the dietary targets to prioritise for different population subgroups, which may increase the potential of maximising overall diet quality improvement. Finding priority dietary targets could then allow testing other intervention strategies, such as communication, for changing the behaviours associated with those dietary targets.

1.4 Part Two: Framing Nutrition Messages for Effective Dietary Behaviour Change

The previous section highlighted the importance of identifying dietary targets that can most likely lead to improvements in overall diet quality, by population subgroup. Interventions that provide feedback on certain dietary targets have shown promising results in terms of improving dietary behaviour and diet quality (34, 36). In addition to providing feedback to improve dietary behaviours associated with these dietary targets, it is important to ascertain methods to communicate such feedback effectively. A communication technique termed message framing is used in health and nutrition communication (47). This communication technique, when used in health campaigns, has been associated with behaviour change at the population level (76, 77). Thus, message framing is a potentially effective communication technique to deliver dietary feedback. Part two of this chapter will introduce the topic of health and nutrition message communication and will review the current evidence on *how* nutrition messages can be framed and tailored, and what is their potential effect in terms of diet quality improvement (Figure 1-1).

1.4.1 Introduction to health and nutrition messages

Communicating health messages is a crucial part of behaviour change interventions (46) and is among the World Health Organisation's 'Best Buys' for non-communicable disease prevention and control (78). Health messages have been used successfully for communicating the health outcomes associated with health-related behaviours, such as stopping smoking for reducing the risk of lung cancer or getting vaccinated for gaining population immunity (79). Nutrition has become an important health behaviour to address in public health messages in the past 30 years (80). Currently, nutrition messages are widely used as part of population dietary behaviour interventions, such as campaigns (76, 77).

Nutrition messages that provide dietary advice are highly accessible. Interventions aiming to increase awareness about dietary guidelines specifically, disseminate nutrition messages using posters, handouts and public service announcements, through work, education and community settings; and on a larger scale, through mass media, such as television, radio, newspapers and billboards (81). To complement these population health strategies, interventions have recently been developed for difficult-to-reach individuals in the population, to communicate messages and raise awareness on the ADG recommendations (10). As mentioned in section 1.2.7, diet quality assessment surveys, such as the CSIRO Healthy Diet Score, provide feedback messages as a strategy to improve populations' diet quality score (30). The current feedback messaging within the CSIRO Healthy Diet Score provides information, guided by the ADGs, on *what* behaviour needs to change to improve a diet quality score. For example, feedback messages are provided on the recommended amount of core food groups; for instance, ‘eat two serves of fruit and five serves of vegetables’. Further, feedback messaging provided by the Healthy Eating Quiz (31) communicates the positive or negative health outcomes associated with dietary behaviours; for example, ‘fruit and vegetable intake is associated with better heart health’, or ‘too many discretionary choices can increase diabetes risk’. However, until date, the impact of these feedback messages has not been evaluated (30, 31). Moreover, the messages considered in the studies that have evaluated the impact of feedback messages on diet quality, such as the Food4Me study, usually address how to increase nutrient intake, such as ‘increase your intake of Vitamin C by eating more fruit and vegetables’, and the effect sizes of these messages have been modest, improving overall diet quality by about 2.6% (36). Thus, although nutrition messages have been used as part of dietary feedback interventions aiming to improve diet quality, studies are yet to reveal, and compare, the effectiveness of the different nutrition messaging approaches.

In addition, the process of message development, selection and evaluation has rarely been reported in the literature (81). These gaps may lead to inconsistency and less clarity and credibility in the communication process, resulting in unknown or small effects on diet quality (82). To enhance the effect of dietary feedback in improving diet quality, nutrition messaging development needs to be evidence based and have a robust theoretical grounding. Hence, researchers have recommended developing and testing new, evidence-based ways to communicate nutrition messages (76, 77, 81, 83). Identifying how nutrition messages influence various people may enhance the effect of interventions on improving diet quality (76, 77, 81, 83). In addition to communicating *what* behaviour needs to change—for example, ‘eat more vegetables’—incorporating a *how* or *why* aspect may make behaviour change more practical (84). A *how* or *why* aspect could be derived from evidence-based and theoretically grounded nutrition message framing research (76, 85). Therefore, designing and evaluating the impact of framed messages, and testing their effect when delivered via a dietary feedback intervention, should be considered.

In summary, this section provided an introduction about health communication and its important role in behaviour change interventions. Few dietary feedback interventions have collected data to evaluate the effectiveness of their communication efforts in improving diet quality. Further, the approach to nutrition messaging in interventions is not informed by theory or evidence. A challenge that remains is developing nutrition messages, including feedback messages, that effectively influence a change in dietary behaviours. A potential avenue is using nutrition message framing. Therefore, it is worth exploring the current evidence on nutrition message framing and its effectiveness in improving dietary outcomes. This exploration can provide a base for future dietary interventions, by informing how to develop salient, practical nutrition messages that are scientifically and theoretically grounded. The next section reports a narrative review conducted to evaluate nutrition message framing and to understand whether there is a nutrition message frame that can be most effective for improving dietary behaviour.

1.4.2 Narrative review: Impact of nutrition message framing on dietary intention and behaviour

This section will report a narrative review on the literature that has evaluated nutrition message framing. First, nutrition message framing will be defined with detailed examples. Then, an overview of message framing studies will be reported and their effect on different dietary outcomes will be synthesised. The review will identify key gaps and limitations that need to be addressed in future nutrition message framing research and development.

1.4.2.1 Definitions and effectiveness of nutrition message framing

Messages can be framed using theoretically grounded communication strategies that not only address *what* to do to improve behaviours, but also *how* and *why*. Messaging framing influences people's decision-making and behaviours (48, 49, 86). It has been used successfully for influencing individuals to reduce alcohol intake, and smoking, and increase cancer examination and sunscreen use (85). In the past decade, message framing research has developed in the field of nutrition (76, 85).

Nutrition message framing can be theoretically designed in many ways. The most common nutrition message framing approach is to deliver a positive or gain-framed message, which focusses on the benefits *gained* by following, or not following, the information in a message, while a negative or loss-framed message portrays what is *lost* by adhering, or not adhering, to the message (87). This messaging framing construct is based on attribute framing from the prospect theory (49). The findings in the wider health behaviour literature have supported the use of loss-framed messaging for encouraging risk-detection behaviours, such as cancer screening, and have revealed that gain-framed messages can be more effective for promoting prevention behaviours, such as healthy eating and physical activity (48, 49, 88). There are other ways to deliver messages within positive and negative framing, such as through goal framing. A summary of message framing definitions and some examples are shown in Table 1-1. In this thesis, hereafter, any message that communicates a healthy outcome will be termed a 'positive' message, whereas any message that communicates an unhealthy outcome will be termed a 'negative' message. In summary, considering the array of ways in which nutrition message frames can be presented, there are inconsistencies in the effects of different messages on people's behaviour (48). Thus, a better understanding of the effects of different message frames is needed.

Overall, the findings on the effect of nutrition messages using positive or negative framing have been inconclusive to date. A Cochrane review evaluated the effects of attribute (positive v. negative) framing and goal (gain v. loss) framing of health information, on persuasion and behaviour outcomes, on a range of audiences, such as the public, professionals and policymakers (89). The Cochrane review included 35 studies; it focussed on a variety of health behaviour outcomes, such as sunscreen use, cancer screening, alcohol use and smoking, and included three studies on dietary behaviours (lowering dietary cholesterol, salt and fat and increasing fruit and vegetable intake). These three studies were conducted before 2006, on a university-aged student population, and their outcomes were psychological measures, such as the intention to change after exposure to the message (89). These studies revealed very small effects on persuasiveness—the pooled standardised mean difference was −0.06 (95% CI [−0.18, 0.06], $I^2 = 73\%$), which corresponded to a 0.1 point difference on a 10-point Likert scale (89). In addition, the authors concluded that the evidence was low in quality based on the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach (90). This review was conducted more than 10 years ago (89) and its results may now be too outdated for drawing conclusions.

Another 10-year-old meta-analysis, which included studies conducted before 2005, found substantial variability between message framing effects on a variety of health behaviours (85). The effect found between positive messages and prevention behaviours, such as skin cancer screening, was small ($r = 0.083$, $p = 0.002$). However, message framing on dietary outcomes showed overall weak and insignificant effects ($r = -0.014$, p = n.s.) (85). The authors concluded that the lack of effect on dietary outcomes could be because these studies did not examine measures of actual behaviour (85). Evidently, these reviewed studies may now be outdated. Contemporary ways of delivering nutrition messages may have improved their effect. In the past decade, the use of message framing in the nutrition field has increased, with the aim to examine how message framing influences the dietary behaviours of people, and these investigations range from low-scale experimental research to larger-scale approaches, such as health campaigns (91). However, to the best of this PhD candidate's knowledge, no recent review has been conducted to strengthen the evidence on the effects of positive and negative messaging on dietary behaviours.

In addition, other constructs or theories have been used to inform the ways in which messages can be framed to influence behaviour. For example, social norm description in messages has been shown to influence dietary behaviours. People eating in pairs tend to influence and match each other's intakes (50). The use of social norms, such as descriptive, injunctive and subjective norms, in messages (definitions and examples are shown in Table 1-1) has been found to somewhat motivate people to improve their dietary behaviours through intention. In their review, Robinson et al. mainly focussed on the impact of descriptive norm messaging (51). Two types of descriptive norms were tested. In a high-intake (majority) norm approach, messages portrayed that the majority of people had a high consumption of a healthy or unhealthy food, whereas in a low-intake (minority) norm approach, messages portrayed that the majority of people had low dietary intake of healthy or unhealthy food. Robinson et al. reviewed 15 experimental studies, of which 14 sampled university students (51). The results showed that both high- and low-intake norms had a moderate overall effect ($Z = 2.98$; $p = 0.003$; $SMD = 0.45$, 95% CI [0.15, 0.74]) on influencing dietary behaviours related to unhealthy snack intake (51). For example, when participants saw information indicating what most people eat, this message significantly increased the likelihood of participants making similar choices (51). Evidently, nutrition messages that communicate social norms show potential in their ability to influence a change in dietary behaviour. However, there are limitations associated with the conclusiveness of these findings.

To date, reviews of the impact of message framing on health behaviours have included a wide range of target behaviours. This aspect makes it difficult to conclude how effective nutrition message framing approaches are in influencing the health behaviour of interest, in this case, dietary behaviour. Further, the identified reviews were published between 2011 and 2014 and included studies conducted in 1980–2013. Thus, there is merit in conducting a review that includes contemporary literature on nutrition message framing. Therefore, the following section aims to review more recent literature on the effectiveness of a wide range of message frames in improving dietary outcomes (intention or behaviour). Reviewing this literature will increase the understanding on which types of messages are most influential on different aspects of diet quality, and the key gaps that need to be filled in future nutrition message framing research.

Table 1-1: Messaging terminology and examples of positive, negative and social norm messages used in different contexts

Message type	Definition and example of message	
Attribute/Consequence frame[1] The positive v. negative description of a specific attribute of a single item or a state	Positive: the presentation of a desirable attribute	Negative: the presentation of an undesirable attribute
Examples[1]	There is a higher chance of being disease-free with a healthy diet	There is a lower chance of being disease-free with an unhealthy diet
Goal/Action frame[1] The description of the consequences of performing/not performing an act, as a gain (positive) v. a loss (negative)	Gain (Positive): to attain a desirable outcome	Loss (Negative): to attain an undesirable outcome
Examples[2]	When you eat a lot of fruits and vegetables: Better health Improved physical stamina Improved concentration Lower blood pressure Lower cholesterol level	When you eat less fruits and vegetables: Worse health Worsened physical stamina Worsened concentration Higher blood pressure Higher cholesterol level
Self-discrepancies and event frame: Advantage/disadvantage of compliance/noncompliance	Advantages of compliance (enjoying gains and/or avoiding losses): this frame stresses the desirable consequences but receives less attention	Disadvantages of noncompliance (suffering losses and/or losing out on gains): this frame focuses on the undesirable outcomes and engenders extensive cognitive elaboration
Examples[3]	(a) ‘Why is less junk food good for you?’; (b) the presented benefits are ‘obtaining better sleeping patterns, lowering your risk of being overweight, cutting your risk of getting high blood pressure and increasing your stamina’; and (c) the action cue is ‘Eat less junk food, you will enjoy the health benefits!’	(a) ‘Why is junk food bad for you?’; (b) the presented losses are ‘failing to obtain better sleeping patterns, escalating your risk of being overweight and raising your risk of getting high blood pressure’; and (c) the cue to action is ‘Eat less junk food, otherwise, you may suffer the health costs!’
Social norm – descriptive: The current dietary behaviours of society	Majority (high-intake norm) Healthy v. unhealthy	Minority (low-intake norm)
Examples[4,5]	‘Research has shown that 80% of university students eat sufficient fruit’ ‘Most people have a salad for lunch’ v. ‘Most people have a burger for lunch’	‘Only 27% of university students eat sufficient fruit’
Social norm – other	Injunctive norm: behaviours approved by society	Subjective norms: the perceived behaviours of others

Note:
[1]Adapted from Akl EA, et al. (89); [2]adapted from Dijkstra A, et al. (92); [3]adapted from Yan C (93); [4]adapted from Stok FM, et al. (94); [5]adapted from Robinson E, et al. (95).

1.4.2.2 Method of narrative review

A search of Ovid Medline was conducted to identify experimental quantitative studies in the nutrition communication literature that have investigated the effectiveness of different types of messaging in improving dietary outcomes (intention or behaviour), and where applicable, effectiveness based on different sample characteristics (i.e. demographic or psychosocial variables). Search terms included anything that relates to messaging (i.e. communicat* or messag* or information), and target outcome (i.e. intak* or consum* or eat* or diet*). Reference lists of selected articles, relevant prior reviews, meta-analyses and theses were reviewed. Literature published within the past 15 (2005–2020) years was included for relevance.

The studies included in the review were experimental in design, with an outcome of intention related to dietary behaviour, or dietary behaviour itself, and were conducted on adults aged 18 years or older. The included studies were also limited to those published in English.

Data extraction was focussed on the study sample, design, experiment setting, message type, theory (where reported), diet outcome focus (i.e. food, food group or nutrient) and key results regarding message effectiveness in improving outcomes from baseline to post-intervention. Cohen's *d* (96) effect sizes were calculated for those studies with adequate reporting of results and sample sizes. Effect sizes already reported in studies, such as Cohen's *d*, eta-squared (η^2) and partial eta-squared values (ηp^2 or partial *r*), were also used when studies adequately reported them, to compare effects between studies with similar experimental designs (97). The *d* effect sizes are based on the difference between observations, divided by their standard deviation values. The *r* effect sizes describe the proportion of variance that is explained by group membership (i.e. a correlation (*r)* of 0.5 indicates 25% (r^2) of the variance is explained by the difference between groups). Eta-squared (η^2) is part of the *r* family and an extension of r^2 that can be used for more than two sets of observations (98). The magnitude of the intervention effect (effect size) was determined as the following. For Cohen's *d*, 0.01 = very small, 0.2 = small effect, 0.5 = medium, 0.8 = large, 1.2 = very large and 2.0 = huge effect (99). For η^2 related to analysis of variance, 0.01 = small, 0.06 = medium and 0.14 = large; or η^2 related to regression, 0.01 = small, 0.13 = medium and 0.26 = large (97). An effective messaging intervention was defined as one where the change in improving the dietary outcome (intention or intake) was positive and statistically different from baseline or when compared with control.

The study quality was assessed using the Effective Public Health Practice Project Quality Assessment Tool for Quantitative Studies (EPHPP) (100). The tool assesses quality ratings defined as weak, moderate or strong, identified using six component ratings: selection bias, study design, confounders, blinding, data collection method and study drop-outs. Studies with a weak rating on two or more domains were categorised as weak quality; studies with one weak domain rating were regarded as moderate quality; and studies with no weak ratings were categorised as strong quality.

1.4.2.3 Summary of study characteristics

The following section provides a summary of results, such as target outcomes (target behaviour, and food or food group), and the types of messages identified from the studies. Results are described in narrative form.

1.4.2.3.1 Study characteristics

In all, 34 experimental studies were identified that met the inclusion criteria. A detailed summary of these studies is provided in Appendix 2. More than half (*n* = 18) of the studies were published in the past 5 years. About one-third of the studies (*n* = 12) were conducted in the US (62, 93, 101-110), 11 in Europe (111-115) (of which six were conducted in the Netherlands (92, 94, 116-119), and one in Australia (120).

More than half of the studies (*n* = 19) were conducted in an experimental laboratory setting (92-95, 103-105, 111-113, 115, 116, 119, 121-126). Of the 15 conducted in a 'real-world' field setting, five were community interventions (62, 101, 106, 109, 120, 127); four were conducted in a food service or retail setting (two in a restaurant/canteen (116, 128) and two in a grocery store (108, 129)); four were conducted online (110, 114, 117, 118); and the others (*n* = 2) were conducted at an outdoor festival (102), or as part of a national omnibus survey (130). The majority of studies were between-subject designs (*n* = 28) with most as pre-/post-test design (*n* = 19). Five of the studies were designed as RCTs (62, 111, 112, 120, 125).

Most of the studies (*n* = 21) included a university student population. Of these, 19 reported the sample age, which ranged between 19 and 27 years. Of the studies that recruited participants from the general population (*n* = 13), and those that reported a sample age (*n* = 12 of 13), the range was between 29 and 60 years. Most of the study samples were female, and 21 of the studies had a sample consisting of nearly two-third (65%) females. Sample sizes were generally varied. For all but one study (*n* = 33), sample sizes ranged between 60 (62) to 1,585 (129), with 19 of these studies including less than 200 participants. One study (108), which was conducted in a supermarket and only collected data on 971,706 grocery transactions, did not report participant sample size or demographic characteristics.

The EPHPP components were largely assessed as weak (101-103, 105, 108, 114-116, 121, 122, 128-130) and moderate quality (92-95, 104, 106, 107, 110, 111, 117-120, 125, 131) (62, 109, 112, 113, 126). One reason for this quality assessment was that there were key sources of bias, including participant selection, which resulted in the lack of a representative population. Other reasons were that the samples were mostly young females, and experiments were conducted in laboratory settings. Moreover, the studies lacked transparency in reporting participant group allocation and lacked control conditions in the experimental designs. There was a common absence of controlling for confounders or the lack of reporting of these for statistical adjustments. Reporting of between-group sample numbers and their outcome value differences was unclear, making it difficult to calculate effect sizes. Most studies also used unvalidated, unreliable dietary data collection methods. In the real-world field studies, intervention integrity regarding the testing and the reporting of potential contamination was not evident, which may have led to the overestimation of the results.

Table 1-2: Summary table of narrative review study characteristics

Characteristic of study		Number of studies (%) *N* = 34
Year	2006–2019	34 (100)
Country	US	12 (35)
	Europe	11 (32)
	UK	9 (26)
	Australia	1 (3)
	Other	2 (3)
Design	Randomised controlled trial	5 (15)
	Between-subject pre-/post-test	19 (56)
	Between-subject post-test	9 (26)
	Within-subject pre-/post-test	1 (3)
Setting	Laboratory	19 (56)
	Community	5 (15)
	Food service or retail	4 (12)
	Online	4 (12)
	Other	2 (6)
Sample (*N* range: 60–1585)*		
Age by population	University student population (age range: 19–27 years)	21 (62)
	General population (age range: 29–60 years)	13 (38)
Gender	Over 65% female	21 (62)

Note:
*One study was conducted in a supermarket; it collected data on 971,706 grocery transactions (not individuals) and did not report participant sample size or demographic characteristics (108).

1.4.2.3.2 Diet outcome focus

Fifteen of the 34 studies included dietary intake as their main outcome (62, 94, 95, 103-107, 110, 119, 120, 122, 123, 125, 131), with all studies measuring these outcomes using self-reported food questions related to the food/food group, such as dairy (104) (Table 1-3). In measuring food intake, a few studies used one or two items from previously validated food frequency questionnaires (62, 95, 103, 111, 113, 122), whereas the remainder used single self-reported measures without reporting the source, validity or reliability. None of the studies measured overall diet quality. Six studies had intention to eat as the main outcome (92, 102, 115, 117, 126, 130), and another six had both intention to eat and actual intake as the main outcomes (109, 111-113, 118, 121). Three other studies, which were mainly conducted in food settings, had purchasing or spending as an outcome (108, 128, 129). The remaining four studies had other psychological measures as the outcomes, such as association with food (93), attitude (114), appetitive (116) or diet motivation (101).

The studies presented findings for a variety of outcomes related to foods, food groups and nutrients (Table 1-3). Twelve studies had both fruit and vegetables as the targets (62, 92, 94, 103, 106, 109-111, 113, 120, 122, 130). Three only focussed on fruit (117-119), four on vegetables (108, 125, 128, 129), and one study on dairy foods (calcium) (104). The type of discretionary choice focussed on in the studies were varied. One study's outcome was non-specifically termed as 'junk food' (93), one focussed on candy (116), one study defined 'high-calorie snacks' as chocolate, crisps, cake, pastries, biscuits and other unhealthy sweet or savoury snacks (121), one focussed on dessert (105) and one on snacks with or without a nutritional warning, such as cereal bars, cookies and pastry (123). One study focussed on burger choice (in comparison to salad) (107), and another on chocolate chip cookies, ready salted crisps and chocolate finger biscuits (131). Discretionary choice meal food, such as sausages, breadsticks, tortilla chips (95) and processed meat (112) were focussed on in two studies. Others included cookies, candy bars, chips (119), snack cereal bars (126) or a Big Mac burger (115). In the remaining studies, the outcome focus was on general healthy eating (101, 102).

Table 1-3: Number of studies focussing on foods/food groups or behaviours associated with food intake

Outcome	Number of studies (%) *N* = 34 (100)
Behavioural measure	
Intention	6 (18)
Intake	15 (44)
Intention and intake	6 (18)
Purchasing/spending	3 (9)
Other psychological measures (i.e. attitude)	4 (12)
Food/food group	**25 (74)**
Fruit	3 (9)
Vegetables	4 (12)
Fruit and vegetables	12 (35)
Dairy	1 (3)
Discretionary choices:	5 (15)
Candy (confectionary foods)	1
High-calorie (kilojoule) snacks (sweet and savoury)*	1
Desserts	1
Meal food (i.e. sausages, breadsticks & processed meat)	2
Dietary behaviour (choice)	**9 (26)**
(no clear food group target)	
Meal choice:	3 (9)
Salad v. burger	
Side of vegetables	
Meal with vegetables	
Snack choice:	4 (12)
Healthy (i.e. fruit) v. unhealthy (i.e. sweet/savoury snack)	
General healthy eating	2 (6)

1.4.2.3.3 Nutrition message framing

Among the 34 identified studies, as detailed in Appendix 2, most studies predominately examined a comparison in effect between positive or negative framing (*n* = 15 studies) (Table 1-4), a construct that derives from attribute framing in the prospect theory (49). Social norm messages were examined in 35% of the studies (*n* = 12), in which messages presented descriptive, injunctive, liking and provincial norms. Of the social norm conditions that fall under the descriptive norm construct (132), eight studies examined messages framed as majority norms (95, 107, 119, 125, 128-131) or 'what most people are doing', whereas one study compared majority norms with minority norms (94) or 'what the minority of people are doing'.

There were seven other studies that did not use the aforementioned messaging constructs in their experiments. Instead, the messaging approach investigated was regarding complexity or simplicity, effects of an image of food in the presence or absence of a health message, risks/planning, self-referencing, and body image/appearance constructs were investigated. Studies were compared between groups; compared with a control condition, which was often an implicit positive health message (observed in seven studies); or compared with a non-nutrition message. There were many overlaps with messaging comparisons and the types of messages investigated for each study are presented in the detailed summary table of the studies in Appendix 2.

In regard to theoretical constructs or frameworks, 18 studies reported investigating a theory or using it to guide the research (Table 1-4). The most commonly used theory was the prospect theory, reported in eight studies (102-104, 111, 116, 117, 121, 122).

Table 1-4: Message types used in the 34 identified studies, with or without a theory or framework

Message construct	Terms used	Theory used	Number (% of total), *N* = 34 ***Number within construct using theory, N = 18***
Positive/negative	Gain, loss, positive, negative, advantage, disadvantage		15 (44)
	Studies using theory/framework	*Prospect theory* *Regulatory fit theory* *Regulatory focus theory* *Heuristic-systematic model framework*	*11*
Social norm	Descriptive, injunctive, liking, provincial		12 (35)
	Studies using theory/framework	*Theory of planned behaviour* *Theory of reasoned action* *The focus theory of normative conduct + identity theory*	*3*
Other messages			7 (21)
	Studies using theory/framework	*Theory of planned behaviour* *social cognitive theory* *Health action process approach* *The associative and propositional evaluation model* *The associative and propositional evaluation model*	*4*

Section 1.4.2.3 has summarised the study characteristics, the outcomes (target behaviours and food or food groups) and the types of messages identified in the literature. The next sections discuss the results of the studies in detail. First, the literature on positive and negative messaging is reviewed to identify their effects on dietary intention or behaviours.

1.4.2.4 Main results of messages framed as positive and negative

Among the 15 studies that examined positive (gain) and negative (loss) messaging, Cohen's *d* effect sizes could only be calculated for those that provided sufficient detail about their sample and results. Effect sizes were reported in some studies, and these were also interpreted in this review. For the studies with intention as an outcome, Cohen's *d* effect sizes were mostly of small to medium magnitude (range $d = 0.27 - 0.77$). Eta-squared values were medium to large (range $\eta^2 = 0.03–0.13$). Among the studies with intake as an outcome, Cohen's *d* effect sizes were again mostly small to moderate (range $d = 0.33 - 0.57$). Eta-squared values were small to medium (range $\eta^2 = 0.02–0.07$). Partial eta-squared (ηp^2) values ranged from 0.16 to 0.33, indicating that the statistical models of the studies explained a moderate level of variance (98). Five studies did not provide sufficient detail for effect size calculations and nor did they report their effect sizes (105, 106, 111, 122, 123).

The messages had mixed effects. Five of the studies found that a negative message led to a marginally higher, but not significant, increase in intention (111, 118) and intake of fruits and vegetables (103), and reduction in discretionary choices (93, 121) than did a positive message. Conversely, three studies found that a positive message had a more favourable effect than a negative message on general healthy eating outcomes (101, 122) and led to less unhealthy behaviour among people who follow weight-loss diets (105). Five studies found mixed results regarding message type effectiveness in improving dietary outcomes. These findings depended on the message framing approach, such as the presence or absence of health outcomes (92, 116) or the behaviours of participants at baseline (104, 111, 118). The latter studies had weak reporting quality, with little room to interpret and compare their results.

The baseline characteristics of individuals appeared to have moderated the significance of message impact on the outcomes for core foods, such as fruit and vegetables. One study (103), on adjusting for baseline gender, anger, anxiety and baseline fruit and vegetable intake, showed that the effect of the negative message in increasing fruit and vegetable intake (1.4 serve increase) was more significant than the effect of the positive message (0.6 serve increase, $p < 0.05$, partial $\eta^2 = 0.33$) and only when participants had a high baseline state of fear. This finding represented an association between emotional factors and message persuasion. Baseline intention and consumption behaviours also moderated the effect of messages.

The higher intention to eat fruit and vegetables, after receiving a negative message, was associated with a higher baseline intention and being less motivationally oriented/prevention-focussed (111), and a higher than average baseline fruit intake (118). Another study, which investigated the effect of matching messages to participants' regulatory focus, that is, the motivational system that drives behaviour (106), found that those who were more promotion-focussed and received the positive message (i.e. 'eating more fruit and vegetables for optimal health') were more likely to eat more fruit and vegetables, than those who were prevention-focussed ('eating more fruit and vegetables to protect health'), and vice versa, meaning the negative message for those who were prevention-focussed were more likely to improve dietary behaviour. The two studies did not report outcome values other than the adjusted regression coefficient (111) and odds ratios (106), which made it difficult to interpret their results.

Participants who already had healthy dietary behaviours, or more interest in health at baseline, increased their intention to improve dietary behaviours following negative messages, as opposed to those without baseline healthy behaviours, on whom these messages had no effect (117). Specifically, intention to eat fruit was significantly higher when a negative message was combined with short-term consequences than when it was combined with long-term consequences (d = 0.48) (117). This relationship between baseline interest and the effect of message framing was also noticed by the aforementioned study groups (111, 118), which found that those with high intentions at baseline who improved their dietary behaviours were more receptive to negative messaging. Conversely, Gerend and Shepherd (104) who investigated message effects on the consumption of a calcium-rich diet, found that among participants with relatively low baseline dietary calcium intake (1 SD below the mean), exposure to the positive message led to higher intentions than did exposure to the negative message. Other key moderators of the effect of positive messages on fruit and vegetable intake were found. Baseline autonomy (122) and having an 'approach' rather than 'avoidance' orientation for healthy behaviours (101), moderated the messages' effects.

Of note, the mHealth intervention by Cohen et al. resulted in more engagement from participants receiving the positive message than from those receiving the negative message (8% difference in engagement rate) (101). Dijkstra et al. (92) found no significant effect between a positive and negative message in terms of presence or absence of health outcomes. However, when the message became personalised using the participant's name, the positive message produced a higher intention to increase fruit intake in comparison to the negative message (92). In one study, the acceptance of the positive message did not translate into engagement. Although positive messaging was more accepted by participants (mean acceptance score: positive = 5.8 ± 1.29 v. negative = 5.0 ± 1.61), negative messaging produced more engagement (mean = 0.6 ± 2.93 v. 1.9 ± 1.37, for the positive and negative messages, respectively, and intention (mean = 5.2 ± 1.26 v. 6.0 ± 0.82, respectively) towards healthier dietary behaviours (all *p-values* < 0.01) (102).

For discretionary choices, Yan (93) found that the negative message largely influenced the intention of only the participants who were ambivalent (i.e. had mixed feelings about discretionary choices) (d = 0.77), and did not affect those who already had an opinion on the topic (p = 0.87). High heteronomy, also known as the motivation by external factors, was a key moderator of the intervention effect on high-calorie snacking among overweight participants, with the negative message (2.8 mean serves post-intervention) being moderately more effective than the positive message (3.8 mean serves, p = 0.04, η^2 = 0.07) (121). In a somewhat different type of study (123), which examined the effects of message frames against those of control messages on participants choosing a particular snack, participants found the positive message to be significantly more credible than the negative message. Although there was no significant difference between the effects of message frames on snack choice, participants who were exposed to either positive or negative nutrition messages selected products featuring nutritional warnings for sugar significantly less often (40%) than those in the control group (66%, p = 0.039). Participants in the control group selected foods that featured warnings for sugar and saturated fat more often than participants in the intervention group (123).

1.4.2.5 Main results of messages framed using social norms

Twelve studies investigated the effect of social norm messages. The most common social norm message that was investigated used the descriptive norms construct (132). Cohen's *d* effect sizes could only be calculated for the studies that provided sufficient detail about their sample and results. Effect sizes were reported in some studies, and these were also interpreted in this review. Cohen's *d* effect sizes were mostly of moderate to large magnitude among the studies with intention as an outcome (range $d = 0.49–1.56$). Partial eta-squared (ηp^2) values were between 0.003 and 0.02, indicating that very little variance was explained by the models. Among the studies with intake as an outcome, Cohen's *d* effect sizes were again mostly moderate to large (range $d = 0.25–1.00$). Eta-squared values were also medium to large (range $\eta^2 = 0.19–0.42$). Four studies did not provide sufficient detail for effect size calculations and nor did they report effect sizes (107, 108, 128, 129).

Of the 12 studies, nine tested social norm messaging against another type of message, mostly a control (neutral) or a health message. Seven studies found significantly moderate to large effects of messaging interventions as against the control conditions (95, 107, 108, 120, 128, 130, 131), whereas two studies did not find significant differences between the conditions (110, 119). Of the remaining studies, two (94, 133) investigated descriptive norms: the difference between the majority norm approach, which portrays what most people are doing, and the minority norm approach, which portrays what less people are doing; and one study tested the effect of the descriptive majority norm message in a within-group, no-control study design (129).

Baseline characteristics and behaviours moderated the significance of social norm messaging effects. For fruit and vegetable intake, one study found that males (baseline intake of 3.3 serves/day), but not females (3.7 serves/day), were influenced by a majority descriptive norm. Men's fruit intake in the descriptive norm condition increased to approximately four serves compared with no change in the control condition, $p = 0.001$ (130). Two studies found that the effect of messages was only significant for those with lower than average baseline healthy food intake (95, 129). Both experiments by Robinson et al. found that the majority norm message led to significantly more consumption of vegetables than did the health message (Experiment 1 mean: 67 g ± 46.7 v. 32 g ± 32, respectively, $p < 0.05$). All Cohen's *d* effect sizes were large in magnitude (95). Thomas et al.'s (125, 129) studies in the restaurant setting found that majority norm messages were associated with an increase in the overall purchase and consumption of vegetables; however, only individuals whose consumption of vegetables at baseline was low increased their consumption of broccoli only, compared with the control condition ($p < 0.05$) (125). These results were confirmed by two other studies in the restaurant setting (116, 128). Nevertheless, the percent increase in vegetable consumption, was not sustained post-intervention for the social norm intervention (22.1%; OR 0.59, 95% CI [0.46, 0.75]), but was sustained for the health intervention (48.1%; OR 0.83, 95% CI [0.67, 1.02]) (128).

Similarly to Robinson et al. (95), Verkooijen et al. (119) found that the majority norm message affected only consumers whose intake of fruit at baseline was low (mean increase = 0.37 serves, $p = 0.008$). However, since they found a similar pattern in the no-message control condition, the authors concluded that the effect of the descriptive norm message on these consumers was merely a result of statistical regression to the mean (119).

Stok et al. (94), who examined differences between majority and minority norms, found in their first experiment that participants receiving a majority norm message reported higher fruit intake intentions than did those receiving a minority norm message (mean serves = 3.89 ± 0.97 v. 3.53 ± 0.72, respectively), but this effect became significant when participants strongly identified with the referent group in the message ($p = 0.028$). In their second experiment, the majority norm message had a significant effect on fruit intake change (mean increase of 0.3 fruit portion) in the cases of both high- and low-referent identification messages; however, minority norm with the high-identification message led to significantly less fruit consumption (mean decrease of 0.3 fruit serve, all p-values < 0.04).

Similar findings for reducing discretionary choices were observed, in which descriptive majority norm messages were more effective than control messages. In both studies by Robinson et al. (95, 133), the descriptive norm condition participants selected snacks with significantly less calories (5.6 g ± 9.3) than the health condition participants (24.2 g ± 21.3, $p < 0.05$); however, the injunctive norm condition had no significant effect compared with the health condition, $p = 0.23$ (95). In addition, those who read messages about the positive health effects of selecting fewer discretionary choices (i.e. 'reducing junk food intake is good for your health') or descriptive norm messages (i.e. 'students eat less junk food than you might realise') consumed fewer high-calorie snack foods than did those who read control messages (30 ± 21 g v. 23 ± 20 g v. 42 ± 38 g, respectively, $p < 0.05$).

1.4.2.6 Main results of other types of messages

Seven studies investigated the effect of other types of messages that are discussed in detail in the next paragraph. Cohen's *d* effect sizes could only be calculated for the studies that provided sufficient details about their sample and results. Cohen's *d* effect sizes were mostly of small to moderate magnitude among the studies with intention as an outcome (range d = 0.18–0.51). Among the studies with intake as an outcome, Cohen's *d* effect sizes were small to moderate (range d = 0.20–0.68) and one study's standard deviation value differences resulted in very large Cohen's *d* effect sizes (range d = 2.17–3.33) (62). Two studies did not provide sufficient detail for effect size calculations and nor did they report effect sizes.

Of the seven studies, four tested messages against a control condition (62, 112-114) but only two found significant effects of the intervention (62, 112). Two studies involved messages related to body image and appearance (114, 134). One study (134) compared an appearance-based message (i.e. 'eat better for your waist') to a health message (i.e. 'eat better for your heart'), and the other (114) compared an appearance- and health-based approach to a control. Appleton et al. (134) found the appearance-based message to be more influential on immediate fruit selection than the health message, controlling for previous fruit consumption and fruit liking (β = 20.21, p = 0.01). This effect became non-significant at follow-up (β = 20.15, p = 0.10). Mattavelli et al. (114) found that a baseline positive attitude towards green vegetables led to higher, but non-significant, positive attitude scores among participants who read the appearance- or health-based message, compared with the control group.

Two studies investigated the effect of messages on fruit and vegetable intake using baseline characteristics, such as the need for cognition (i.e. the level of interest in an issue) (109) or baseline intention for healthy eating, using the health action process approach theory (113). The first study (109) found that regardless of the level of need for cognition, participants reported a higher intake of fruit and vegetable serves after a complex message (using statistics to portray risks associated with better health) than did those who received a simple message (mean serves = 4.03 ± 1.50 v. 3.75 ± 1.31, respectively, $p < 0.06$). Participants with a higher baseline need for cognition reported higher intakes than did those with a lower need for cognition (mean serves = 4.24 ± 1.55 v. 3.96 ± 1.48, respectively, $p < 0.01$). Godinho et al. (113) found that fruit and vegetable intakes were not significantly different between groups at follow-up (the change value from baseline not reported). However, baseline intention was somewhat influential for the effect of the message, in that following the 'fear' message, non-intenders had greater self-efficacy than those exposed to the 'planning' or control messages. High intenders had increased self-efficacy following the 'planning' message, whereas no change was observed following the 'fear' or control conditions. Similarly, for discretionary choice outcomes, Carfora et al. (112) found significant reductions in processed meat intake (1.74 ± 1.84 g) compared with a control (3.29 ± 2.61 g), $p < 0.008$, $\eta p^2 = 0.06$. This result was mediated by baseline psychological characteristics, such as regret, attitude and intention.

Last, one study (115) tested the effects of presenting an image of a burger displayed with, and without, a health message ('for your health, eat at least five fruits and vegetables per day'). The findings showed that the presence of the health message with the image of the burger diminished participants' choice of a healthy snack significantly (18% chose a healthy snack when exposed to the image with the health message, compared with 35% who chose a healthy snack after seeing the image without the message, $p = 0.032$).

1.4.2.7 Discussion of the narrative review

This narrative review explored published experimental literature that has investigated the effectiveness of differently framed nutrition messages in improving dietary outcomes such as intention and behaviour. Of the 34 studies included in this review, five found that a negative message leads to marginally better dietary outcomes than a positive message (93, 103, 111, 118, 121), whereas three studies found a positive message to have a more favourable effect (101, 105, 122). Most studies, especially those investigating positive and negative framing, did not compare with control conditions, since they only aimed to identify the message frame that had a greater effect on dietary outcomes among the frames they compared. Seven studies found moderate to large effects of social norm messages, particularly descriptive majority or minority norm messaging against the control conditions (95, 107, 108, 120, 128, 130, 131). The outcomes of the remaining studies were inconclusive owing to the variability of the types of messages tested. Since no studies have examined the effects of positive, negative and descriptive norm messages together, there is merit in testing and comparing the effects of these message frames.

In regard to descriptive norms, four of the reviewed studies found that majority descriptive norms were effective at increasing vegetable (95, 125, 129) and fruit intake (94). One study tested the effect of a minority descriptive norm and found this framing to be less effective than a majority norm in increasing fruit intake (94). However, since only one study has compared these two norms, it is important to conduct further research on how minority norm messaging could also influence other dietary behaviours. Moreover, recent research suggests that communicating about trending minority norms that indicate what is increasing in popularity can exert more influence than communicating about what is already popular (majority norm), even when only a minority of people perform the behaviour (135). This evidence suggest that descriptive norm message framing requires more testing in order to allow stronger conclusions to be drawn about this communication technique.

The current narrative review could not conclusively identify the nutrition message frame that has the most impact on dietary outcomes. Prior systematic and meta-analytic reviews have also found variability, inconsistency and inconclusive results between studies examining positive and negative (85, 89) or social norm (51, 136) messages. There are limitations associated with the inconsistency in this area of research. One limitation is the use of attitudes and intentions as proxy measures for the effect of message framing on behaviour. Using attitudes and intentions as the final outcome may be misguided, and the resulting conclusions may provide an incomplete picture of the effect of message framing on actual behaviour (85). In another review, 95% of descriptive norm studies on diet have been tested on college-aged, female students and have focussed on particular foods or food groups with measurements that do not provide sufficient information to apply the findings on the impact of the overall diet quality (51). Thus, knowledge about this research area could be improved by testing the effect of nutrition message framing on dietary behaviour by using a more generalisable sample.

Almost all significant effects in the reviewed studies were moderated by one or more individual characteristics. These included gender, weight and a baseline psychological measure, which was most commonly intention, or a baseline dietary behaviour measure. A recent Australian report discussed that people are more attracted to messages framed in terms of creating something good, rather than stopping something bad, that is, messages directing them to ‘increase’ or ‘eat more’ core foods instead of ‘banning’ and ‘reducing’ discretionary foods (137, 138). Likewise, a 2015 review analysed 43 studies and showed that ‘don’t’ messages work less effectively than ‘do’ messages (87). Negatively framed messages were more effective in influencing experts—such as dietitians and physicians—who were highly involved and knowledgeable in the area (87). However, the general public who did not know much about nutrition was more accepting of a positive message that highlighted the benefits of eating healthy foods (positive), than warning against the harms of eating unhealthy foods (negative) (87). As a further example, the disadvantage frame (negative) presented by Yan (93) was most persuasive when individuals were motivated, and if the topic was personally relevant and/or the risk of behaviour was high and frightening. In contrast, the advantage frame (positive) was most persuasive among people who lacked motivation, and if the topic was of low relevance and/or the risk was low (93). Yan’s argument in 2015 (93) echoes that of Kahneman and Tversky in 1984 (139), who implied that positively framed messages would be more effective in trying to persuade people to adopt risk-avoiding behaviour and negatively framed messages would be more effective in encouragement to adopt risk-seeking behaviour. Consequently, the literature, together with this narrative review, show that by identifying the target audience, one can predict whether a positive, a negative or a social norm message will be more effective. Thus, message framing may have to be tailored to different participant characteristics.

Tailoring messages frames for different participants may be crucial in achieving diet quality improvement. People may read the same message, but their unique prior experiences may mean that they are interpretating the message differently. A more recently published study tested the idea that those with unhealthy dietary behaviours, but who are highly knowledgeable about healthy eating, would need more carefully constructed messages if presented with images of discretionary choices (140). The findings indicated that for individuals who were more averse to discretionary choices, the messaging needed to be relevant with strong arguments; however, those with less knowledge and with unhealthy dietary behaviours, were less averse and responded well to positive messages about healthy eating, even when presented with an image of discretionary choices. Interestingly, if the message for highly knowledgeable individuals was not relevant or argumentative, viewing the discretionary food images activated their desire to consume the discretionary food, leading to an unintended ‘boomerang effect’ (140). The unintended effect has been identified in multiple other behaviour change interventions (141). To avoid this effect, evidence suggests that tailoring nutrition messages to appropriate audiences is warranted. This approach will be discussed further in section 0.

Next, the limitations of the reviewed studies should be considered. Regarding dietary behaviour, this review found that there was a vague focus on ‘overall’ healthier eating or examining an undefined food group, such as ‘junk food’. Typically, unvalidated measurement tools were used for dietary measurement, leading to little room to compare, specifically interpret or replicate studies. This finding reveals the need for future research to use validated and reliable tools when measuring a dietary behaviour, and to use a specific, consistent definition for foods. In this regard, it is important to remain up to date on food group terminology, since both the ADGs (142) and the term ‘discretionary choices’ are currently under review (13). Regardless of food group definitions, the reviewed studies only focussed on several dietary outcomes. Of the 34 studies, 35% tested the impact on fruit and vegetable outcomes, whereas 15% examined discretionary choices as an outcome. Therefore, the exploration of the effect of message framing approaches for discretionary choices has been limited. As discussed in part one of this chapter, identifying which food groups need to be prioritised for interventions may advance the understanding on the food groups, and for whom, that messaging interventions should focus on.

A second limitation of the reviewed studies is that none was considered of strong quality against the EPHPP (100). It is acknowledged that the Cochrane Collaboration ‘GRADE’ appraisal tool is commonly used in experimental studies, such as controlled trials, quasi-RCTs and crossover studies. It is well established that bias associated with these study designs includes failure to conceal allocation, failure to blind, loss to follow-up and failure to appropriately consider the intention-to-treat analysis (90). However, since the current review included a range of study designs, with and without controls, with most being laboratory based and some being cohort studies, it was decided that the EPHPP tool was most suitable for assessing the methodological quality of a range of study types. Many of the EPHPP and GRADE criteria are similar, including those for the level of randomisation, allocation and blinding, and therefore, both quality appraisals would likely have resulted in similar scores. As a sensitivity consideration, two of the reviewed studies were chosen randomly to assess their quality using both quality assessment tools (102, 114).

Both studies were rated weak on using the EPHPP tool as well as on using the GRADE criteria. Thus, more highly quality research is needed.

A reason for the weak and moderate ratings of the reviewed studies was their limited generalisability. The study samples mostly comprised females, with 62% of the 34 studies including samples of more than 65% females, and young people (62% of studies were of university students aged 19 to 27 years); and most studies conducted experiments in laboratory settings (62% of studies). Their reporting of sample numbers and outcome value differences was also unclear, making it difficult to calculate and compare all effect sizes in a consistent manner. Intervention integrity regarding the testing and reporting of potential contamination was not evident, which may have resulted in overestimation of results. Further, many studies did not provide the complete text of the message frames, preventing the examination of how the presented information may have influenced the magnitude of the effects.

To address these limitations, high-quality RCTs in real-world settings, such as the community, are needed to confirm whether message framing is effective (or not) in influencing actual dietary behaviour. In terms of improving study quality, there is a significant need for future research to minimise selection and sampling bias by conducting experiments on larger samples, to transparently report data collection methods and to clearly report effect sizes, for facilitating meta-analyses and for making it easier to perform power analyses (98). Moreover, there was only one study from Australia in the current review; thus, it is warranted that more Australian studies be added to the literature in order to understand better how Australian populations are influenced by nutrition messages. Evidently, high-quality RCTs are needed to test the effect of nutrition message framing on a sample of Australian adults.

In summary, the narrative review sought to explore studies that have investigated the effectiveness of differently framed nutrition messages in improving dietary outcomes such as intention and/or behaviour. The majority of the nutrition messages were framed to communicate the positive or the negative health outcomes of following a dietary behaviour, or to provide descriptive norms on the dietary behaviour of others. Although nutrition message framing was mostly more effective than control or non-framed messages, no identified study has compared the effectiveness of these nutrition message frames on improving the same dietary behaviour. In addition, the results of most of the reviewed studies were moderated by individual demographic or psychosocial characteristics, such as gender, or baseline intention. These results indicate a certain type of nutrition message frame may be effective for one individual but not another. Thus, there may be a role for tailoring the nutrition message framing, rather than using one nutrition message frame for everyone. Hence, research is needed for comparing nutrition message framing approaches as well as for testing the impact of tailored message framing on dietary behaviour.

1.4.3 Tailoring nutrition messages

Nutrition messages have the potential to persuade individuals to change a range of health behaviours. An approach to improving message effectiveness is to tailor the information communicated based on individual characteristics. Rimer et al. defined tailoring as *'the process for creating individualised communications by gathering and assessing personal data related to a given health outcome in order to determine the most appropriate information or strategies to meet that person's unique needs'* (143 p. S184). Tailoring messages is a popular strategy because it may be more effective than messages that are not tailored or are 'generic' (52, 143-148). Non-tailored messages, although communicating the same information, may be interpreted differently based on people's prior experiences with the topic presented (48, 88, 89, 149, 150). Tailoring messages may thus result in individuals resonating with, and recalling, the information, leading to their increased desire to use, engage in and process the message (143). Greater recall of tailored messages can increase the likelihood of health behaviour initiation and continuation (151) and can increase the commitment to maintain the behaviour change (82). Meta-analytic reviews reported that tailored messages have a substantial increased effect on numerous lifestyle behaviours compared with their effects on no-treatment controls ($r = 0.111$) (146) and compared with non-tailored interventions ($d = 0.158$) (152). Therefore, tailoring nutrition messages is worth considering for improving the effect of dietary feedback.

Dietary feedback messages are currently tailored in many ways (74, 153). *Tailored dietary feedback* often provides a report with messages based on the individual's dietary assessment and diet score. As discussed in section 1.2.5, diet quality assessment tools are designed to deliver messages tailored to each individual's assessment (30). This means that each individual receives messages on the diet components that are most likely to improve *their own* diet quality score. A systematic review showed that tailored dietary feedback messages improved dietary behaviours to a greater extent than did providing general nutrition advice, resulting in a small pooled effect size value ranging from 0.12 to 0.18 (154). The messages usually only communicate *what* to consume to improve the diet score, and the nutrition message is framed the same way for everyone. Therefore, to enhance the effect achieved by feedback interventions to date, a complementary method to tailoring feedback could be providing a tailored nutrition message *frame*.

Researchers suggest that not only should the information delivered in messages be appropriately framed (i.e. positive or negative framing, or using descriptive social norms), but also the framing of the message should be tailored to the message recipient's characteristics (52, 53). However, tailoring the way nutrition messages are *framed* has not been explored. The effects reported from the meta-analytic reviews were in relation to tailored feedback and its impact on several health behaviours, such as smoking, physical activity (146, 152) and, less commonly, dietary behaviour (146, 152). In addition, Teasdale et al.'s systematic review tested the impact of dietary feedback that was tailored to diet quality assessment (154), and not nutrition message frames. Therefore, there is scope to understand whether delivering feedback using tailored nutrition message frames can enhance the effect of the interventions achieved to date.

The ways in which interventions have approached tailoring are important to understand in order to enhance its effect. The reviews (146, 152) identified that messages were tailored to theoretical models, of which the most commonly used was the transtheoretical model (155). Tailoring using this model aims to move individuals through the stages of the change process (pre-contemplation to maintenance) (146). The limitation of using this model is that individuals can move back and forth through various stages, resulting in a risk of the tailored message becoming ineffective (156). In contrast, the theory of planned behaviour posits that intention is the most proximal predictor of performing a health behaviour (157). The intention to change variable may be more rigid, and thus, tailoring a message on intention may have merit (146, 152). Further, intention is easily measurable, and tailoring to an intention score can make it feasible to conduct large-scale interventions (118). In a more recent meta-analysis, only one study tested tailored messages using the theory of planned behaviour, and the outcome was physical activity (152). Evidence indicates that tailoring nutrition message frames to improve diet quality has been less explored. A feasible, effective approach to tailoring messages could be by using an individual's intention score as a proxy to measure behaviour.

It is unclear whether tailoring using intention has been successful on dietary behaviours specifically. The narrative review (section 1.4.2) indicated that baseline intention was associated with message effectiveness and with change in dietary behaviour (111, 113, 117, 118). Hence, there is merit in testing whether tailoring nutrition message frames using intention could lead to larger effects than those achieved by non-tailored nutrition message framing. Using the findings from the narrative review, that is, testing how positive and negative, and the majority and minority descriptive norm message frames could be tailored in interventions, based on the intention to change as a measure, calls for further exploration.

1.4.3.1 Summary of the nutrition message framing and tailoring

Part two of this chapter introduced the topics of nutrition messaging and tailored nutrition messaging. A narrative review was conducted to understand *how* nutrition messages can be framed and tailored, and their potential effect on improving diet quality as part of feedback interventions. The narrative review (section 1.4.2) showed that nutrition messages using positive, negative or descriptive norm theory-based framing were more persuasive for a positive change in dietary outcomes, than were control or health messages. However, the results were mixed and mostly dependent on individuals' baseline psychological characteristics, such as intention, or other characteristics, such as gender, weight or baseline dietary behaviour. Nonetheless, no study tested or compared the effect of all of these nutrition message frames together. Therefore, this review could not arrive at a conclusion about which message frame was the most effective for dietary behaviour change. Further research should consider comparing the effect of a broader set of message frames. Since nutrition message framing effects depended on individuals, the aspect of tailoring these messages for enhanced effect on diet quality was explored.

As reported in section 1.4.3, tailoring has been shown to increase the likelihood of health behaviour change. The common way nutrition messages are tailored is through the provision of feedback associated with individuals' dietary assessment and diet score. This approach to tailored dietary feedback messaging has achieved small effect sizes. Further, current approaches to tailored dietary feedback do not use theoretically grounded and evidence-based nutrition message frames, and thus, may lack persuasive effect. Therefore, in addition to testing the effect of a broader range of nutrition message framing, testing whether tailoring the nutrition message frame enhances the effect of feedback interventions is warranted.

1.4.4 Gap to address: Finding the potential of tailoring nutrition message frames

The evidence available on nutrition message framing is not sufficient to provide a conclusive answer on the most effective nutrition message frame for improving diet quality. As aforementioned, studies have shown that positive and negative, and descriptive majority or minority norm message framing, have a greater positive effect on diet quality than control or health messages. However, which of these messages has the largest effect on diet quality is still unknown, because no study has tested these together and compared the results. Other factors of the nutrition message framing literature contribute to inconclusiveness. The studies were rated as weak or moderate in quality, which was largely due to the studies' samples. The studies were mostly conducted on college-age female students, and only one study was from Australia, limiting generalisability. Further, most nutrition message framing studies have been focussed on dietary behaviour of fruit and vegetable intake, but not all studies have used validated dietary measurement tools. It is necessary to identify how message framing can influence dietary behaviour associated with other, less explored food groups and by using validated dietary measurement tools. The nutrition message framing literature needs to be strengthened with higher-quality study designs while testing a broader set of nutrition message frames together.

In addition to investigating the effect of nutrition message framing, it is essential to test whether tailoring the nutrition message frame can enhance the effect of feedback interventions. This is a key evidence gap, given that tailoring message framing has not been tested within a nutrition context. A psychological measure, intention, has been used by interventions to deliver tailored messages for other health behaviours, such as physical activity. Therefore, testing tailored nutrition message frames using intention as a simple measure, within an intervention that aims to improve diet quality on a large scale, may be a suitable approach.

In summary, two key gaps in nutrition message framing research need to be addressed. The first gap is the comparison of the effect between the positive, negative, majority or minority descriptive norm message frames, for improving diet quality in a representative sample of Australian adults. The second gap is understanding whether nutrition message *frames*, tailored to individuals, would be more effective for improving dietary behaviour than non-tailored message frames (termed ‘generic’ messages in this thesis). An approach to addressing these gaps could be through designing a novel intervention that uses a robust study design to deliver and test framed and tailored nutrition messages, and evaluate their impact on diet quality improvement.

1.5 Part Three: Using a Brief Online Intervention to Deliver Tailored Nutrition Messages

Part one of this chapter highlighted the importance of identifying priority dietary targets that can inform feedback interventions to improve diet quality. *How* to communicate this feedback effectively was explored in part two of this chapter. A narrative review of studies evaluating nutrition message framing revealed that using positive, negative, or descriptive majority or minority norm frames was associated with positive impact on intention and dietary behaviours. The baseline characteristics of individuals also predicted the extent to which the messages influenced dietary behaviour. Thus, tailoring the message frame to an individual may enhance messaging effectiveness. To deliver a tailored large-scale feedback intervention, feasibility needs to be considered, especially when resources are limited. A brief and online approach has been used in dietary feedback interventions to reach a large population. However, their impact on diet quality has not always been evaluated, and when evaluated, the impact has been found to be modest. Therefore, the final part of this chapter will explore the key evidence-based and theoretically derived features that can be used for developing a brief online and tailored dietary feedback intervention. This investigation could inform *whether* these interventions can be effective, and *for whom* (Figure 1-1).

1.5.1 Introduction to a brief online intervention approach

Traditionally, larger-scale nutrition interventions have been delivered via mail-outs or multiple contacts (54-59). However, these traditional interventions have found it difficult to reach people to produce sufficiently large effects on health behaviour at the population level (59). In a rapidly changing environment, people are often short on time (60), and public health resources for disease prevention are scarce (61). Further, tailoring the content of messages, whether for individuals or groups of people, has been the traditional method used for dietary behaviour change by dietitians. Dietary interventions that include an interpersonal component, such as face-to-face education with a dietitian, have consistent, sustained positive effects (158, 159). However, by nature, such methods may be expensive to deliver at scale and are not financially or geographically suitable to all who can benefit from making dietary changes. As an alternative to more intensive methods, interventions can be delivered using a brief online approach (58, 59, 62). Online interventions allow both tailoring messages and their delivery at scale (160). Low-intensity, brief interventions can also leverage reach and improve engagement, leading to sustainable effects (58). For these reasons, a brief online approach to intervention has become more common for delivering dietary feedback (30, 31, 34, 36).

1.5.2 Online interventions for scalability

Given the low proportion of individuals in Australia who comply with dietary guidelines, for interventions to be effective, they need to be scalable. Implementing interventions in cost- and time-efficient ways is important (54) owing to the overwhelming challenges facing public health and the limited resources available to meet them (61). A review of 23 interventions for promoting fruit and vegetable intake through conventional dietary counselling, telephone contact, worksite promotion or other methods cost approximately AU$50,000 per disability-adjusted life year cost-effectiveness threshold; with the most effective intervention only resulting in a 5% reduction in disease burden (54). To counterbalance the costs of conventional interventions, contemporary methods, such as online delivery of dietary interventions, can be used (59).

In this regard, one advantage of online delivery is that internet use is now ubiquitous. Among Australian households, 86% had internet access by 2017, a sharp increase from 3.4% in 1996 (161). Use is not limited by socio-economic status or geographical boundary, given that 88% and 77% of households in major cities and remote areas, respectively, have internet access at home (161). Thus, online dietary interventions have the potential to reach a larger number of people and improve diets, while being less time and cost intensive (162). Reviews of online dietary interventions have shown their promise in achieving modest, short-term improvements in health-related attitudes and behaviours, compared with control or conventional approaches (163, 164). Online interventions were associated with a significant increase of fruit and vegetables by 0.24 serves per day (163) and significant mean weight-loss difference ranging from 1.5 kg to 2 kg, in 4–30 weeks, as a result of healthier dietary behaviour (164). Therefore, online nutrition interventions can be used successfully for large-scale intervention delivery. However, they do have some limitations.

One limitation is that the heterogeneity of online dietary interventions has resulted in limited conclusiveness about their effects (165). Interventions are often inconsistent in terms of content provided, feedback frequency, the presence of control groups and the use of other support tools (164, 165). Another limitation is that samples have often comprised younger age groups and significantly more females than males. Further, the high risk of bias may also be an issue due to the lack of reporting on intervention randomisation techniques, adherence and participant familiarity with the internet (164). Next, unlike face-to-face approaches, online interventions have high attrition rates, which affects the ability to detect their true effects (164, 165). Last, many online nutrition programs are not constructed using evidence-based processes or theoretical frameworks (160, 166). After systematically reviewing the impact of online interventions on dietary behaviour, Harris et al. (163) recommended that using a strong, updated evidence base is a crucial first step to developing interventions (163), with other researchers reporting this can enhance intervention efficiency and effectiveness over time (160). Harris et al. (163) also recommended:

> Further clinical trials of individual [online] interventions should not be undertaken until theoretically informed work that addresses the question of which characteristics of the target population, target behaviour, content and delivery of the intervention are likely to lead to positive results, is completed. (163) p. iv.)

Evidently, the development of online nutrition interventions that use a theoretical framework and a robust study design still needs consideration.

This section has clarified that higher-quality, evidence-based, resource-efficient online dietary interventions still need to be developed. However, the majority of online nutrition interventions involve multiple intensive contacts delivered over periods of weeks to months (58, 59). People live in rapidly changing environments, and time constraint is a major barrier to healthy eating and participation in health behaviour (60). To mitigate these issues, evidence-based, low-intensity, brief interventions, which leverage reach and improve sustainability, should be considered (58). Thus, brief interventions could be an added solution to deliver large-scale interventions feasibly and efficiently.

1.5.3 Brief interventions for efficiency

To address resource intensity and reach, a brief approach to intervention can be appealing (58, 59, 62). A standard definition for the number or length of contacts, the frequency and the optimal dose of online interventions required to ensure effective behaviour change is still being established (167). Nonetheless, the word brief has been described as being *'purposely limited in the number and length of contacts'* (58). Brief interventions have been effective in improving dietary behaviour. In a secondary analysis of a large European multi-centre 'Food4Me' study, involving more than 1,500 people, the authors investigated whether higher-frequency feedback (provided at baseline and at Months 1, 2, 3 and 6), led to more changes in diet and adiposity than lower-frequency or *brief* feedback (provided at baseline, Month 3 and Month 6 only). The analysis results showed that those receiving the higher-frequency feedback scored 1.84 more points (out of 100) on the Healthy Eating Index that those receiving brief feedback (Mdiff = 1.84 points, 95% CI [0.79, 2.89], p = 0.0001), but found no significant difference at 6 months (168). Another analysis found that those in the higher-frequency group were nearly twice more likely to drop out of the study than those in the lower-frequency group (OR 1.81, 95 % CI [1.36, 2.41], p < 0.001) (169). These results suggest that the small added effect of interventions delivered at a higher frequency and dose may not be worthwhile if participants are likely to drop out. Therefore, a brief approach to intervention should be considered.

Nevertheless, the optimal number or length of contacts, the frequency and the optimal dose of brief interventions still need to be identified. In this regard, five systematic reviews have examined the effect of brief interventions on dietary behaviour (41, 165, 170-172). The systematic reviews' definitions of 'brief interventions' differed slightly. Ryan et. al (169) and Whatnall et. al (170) defined 'brief' as limited in number and length of contact, while Young et. al (164) and Lau et. al (171) included studies with once-off interventions without follow up, or interventions lasting 12 – 14 weeks. Jinnette et. al (41) included 'brief' studies based on length of dietary questionnaires, which had a limited number of survey items (4 – 7 dietary questions). Intervention time length ranged from immediate to 2 years, with the most common length being 4 weeks. Researchers found that this average period was effective for weight loss and improved diet quality for up to a year (41, 170, 171). In one review, half of the studies comparing brief with higher-intensity interventions (n = 11 of 20) found that one-point-in-time interventions were more effective than the longer alternatives, with effects lasting up to 24 months (171). Other features of brief interventions were also associated with success. Independent of intervention length, a prompt or reminder system was an important feature for keeping participants engaged and ensuring follow-up measurement completion (165). The frequency of feedback was also found to be beneficial as per three reviews (41, 170, 172), which recommended that the behavioural 'dose' of an intervention needs to be high enough to keep participants engaged (170), but, simultaneously, not too intensive, in order to reduce dropout rates (41). Thus, an average of two follow-up sessions/prompts were recommended for interventions (41, 170, 171). Hence, there is promise in using brief interventions that last an average of 4 weeks and include two prompts. Moreover, developing and testing brief interventions may contribute further knowledge to the evidence base and allow a clearer definition of effective 'brief' interventions to be established.

In summary, the evidence suggests there is promise in using brief interventions that last for an average of 4 weeks and include two prompts, since these features have been associated with long-term effectiveness in improving diet quality. To ensure that future dietary feedback interventions are designed using the evidence base, the following section aims to extract key recommendations provided by researchers who have systematically reviewed the evidence on brief online, tailored dietary interventions.

1.5.4 Features associated with tailored, brief and online intervention success

The previous section provided evidence for using a brief online intervention approach to deliver tailored dietary feedback interventions. Brief and online dietary feedback interventions have been designed; however, they have either not been evaluated (30, 31), or on evaluation, have been found to have a modest effect on diet quality (36). To design a dietary feedback intervention with the aim of enhancing the effectiveness that has been achieved to date, recommendations for designing a brief online, tailored intervention should be considered.

Six systematic reviews were identified, which investigated the effectiveness of (1) brief, (2) online or (3) tailored interventions in relation to diet quality outcomes (n = 4) or weight loss (n = 2) (41, 154, 165, 170-172). Not all reviews included studies that combined the three features; one of the systematic reviews found that only 18 of 45 (40%) of brief studies were online and that 29 (69%) included a tailoring component (171). This section will synthesise the evidence on the effectiveness associated with some or all of these features when embedded in interventions. Systematic reviews focussed on weight loss were included because lifestyle behaviours associated with this outcome also included a dietary measurement. In these reviews, 125 intervention trials were included, and the only trial included in all the reviews was the Food4Me study (39, 40). The main tailoring approach used was providing feedback based on individuals' dietary assessment (41, 154, 165, 171) or on other demographic or physiological characteristics (170). No study tested the effect of tailoring nutrition message framing. Nevertheless, with this number of systematic reviews already available on a mixture of studies, another review was not needed. Therefore, the purpose of this section was to combine the recommendations that have been established to develop interventions that successfully improve diet quality.

1.5.4.1 Intervention effectiveness

First, it is important to understand how effective brief online and/or tailored interventions are in improving dietary outcomes, before ascertaining the features that are associated with their effect. The systematic reviews reported overall positive effects. One review found that 11 of the 20 studies it included had tested brief interventions and had compared the results with those for a control or an active control (171). The findings showed that brief interventions with instructional feedback components were more effective than education alone or generic advice. The increase in fruit and vegetable intake after these brief interventions was higher (from 0.30 to 0.64 serves per day) than that for the control. Further, the reduction in the percentage of energy intake from fat was greater by 1.2 to 8.0% than that for the control (171). In trying to identify studies examining the effectiveness of online dietary interventions against active controls (delivered using alternative modes), Young et al. found that 12 of 19 studies had reported significant improvement in at least one dietary behaviour, with five of these studies reporting a reduction in energy intake (d = 0.50), or high energy snack intake (d = −0.30) or fat intake (unstandardised b = −1.07) post-intervention (165). Of note, this review reported that 33% of the studies measured long-term intervention effect, but observed no significant maintenance of dietary behaviour change (165). Similarly, another review found that 80% of studies resulted in at least one dietary behaviour improvement when a tailored feedback component was administered compared with a control (41). The dietary behaviours that were improved included alcohol intake, fat quality, sodium and overall diet quality (no pooled effect data shown) (41). Interventions that tailored feedback on a diet component based on a dietary assessment, compared with waitlist controls, also showed improvement in dietary behaviours with a pooled effect size value ranging from 0.12 to 0.18 (154). In general, brief online and/or tailored interventions have a small to medium positive effect on diet quality, but some recommendations for future studies need to be considered.

The trials included in the reviews were mostly high quality, but the authors recommended that future trials be well-designed, well-reported RCTs that specifically report changes in the dietary outcome from baseline (41, 172). Protocols that have been registered and published prior to initiation are also warranted (172). In addition, allocation concealment within trials must be ensured (41, 154, 165, 170, 171). The effectiveness of brief online and/or tailored interventions on dietary outcomes is evident, but there is room for improvement.

1.5.4.2 Target dietary behaviour

The reviewed studies focussed on a limited number of dietary outcomes. Out of the 125 trials examined in the six systematic reviews, more than 50 individual studies were focussed on fruit, vegetables or a combination of the two. For example, 28 of 45 studies reviewed by Whatnall et al. had fruit or vegetables, or both food groups, as dietary outcomes of interest (171). The remaining studies focussed on a nutrient (fat or fibre), or a meal occasion or multiple dietary components (171). The 11 studies that Jinnette et al. reviewed measured a variety of dietary outcomes using either food frequency questionnaires or brief diet questions, focussing on specific nutrients, food groups and dietary patterns but, most commonly, fruit and vegetable intake (41). Researchers have recommended that since most trials primarily focussed on a limited selection of foods or food groups, brief trials are still needed to determine the effectiveness of interventions in improving overall diet quality (171), by measuring and assessing the entire diet at baseline and each follow-up time point of interest (165, 171). Jinnette et al. concurred and have recommended that future interventions use dietary assessment tools that capture the entire diet (41). Thus, a broader range of dietary outcomes should be considered for future intervention development.

Moreover, these reviews have suggested that focussing on a broader range of dietary outcomes would enable a more rigorous appraisal of changes in dietary intakes (41, 165, 171), given the increasing focus on overall diet quality of global dietary guidelines and policies (42). While considering overall diet quality improvement as the major public health goal, interventions should prioritise single components that affect overall diet quality, since behaviour change evidence and theory suggest that this approach may be more successful than implementing multiple changes at once (173-175). Hence, the use of behaviour change theory in interventions is important.

1.5.4.3 Enhanced behavioural support using theory

The use of theory to underpin intervention development was recommended by five research groups (41, 165, 170-172). Theory allows an appreciation of whether, why and how interventions work. The most commonly used theories in the studies were the theory of planned behaviour (157), whereby participants' intention was used as a proxy for behaviour, and the Behaviour Change Wheel (173), a three-layer model suggesting a systematic approach for behaviour diagnosis and planning interventions. In addition, behaviour change theory was associated with successful dietary behaviour outcomes. Nearly 70% of studies that reported a significant result in Young et al.'s review were based on a behaviour change theory (165). Similarly, nearly half of the studies in Jinnette et al.'s review incorporated behaviour change theories, such as motivational interviewing, action, coping plans and implementation intentions, into their study design, allowing the authors to conclude that including theory is a key feature that contributes to the significant improvement in dietary intakes as a result of the interventions (41). Lau et al.'s review indicated that 73% of their reviewed studies had a theoretical basis (172), whereas the last review did not provide this information and instead coded the Behaviour Change Techniques (BCTs) provided by the interventions (171). Research portrays that the use of behaviour change theory is essential for developing effective interventions.

Within theory, four reviews recommended the use of a particular set of BCTs (41, 165, 171, 172). Some BCTs overlapped across the reviews. 'Information about health consequences', 'instruction on how to perform a behaviour', 'action planning', 'feedback on behaviour' and 'social comparison' (41, 171) were the most common. Particularly, 'feedback on behaviour', 'self-monitoring of behaviour' and 'goal setting', featured in more interventions reporting significant outcomes than those that did not report a significant outcome; however, the authors warned that these were not used in isolation (165). Less-observed BCTs used were 'social support', 'motivational interviewing', 'prompts' (172), 'commitment', 'information about others' approval', 'pros and cons', 'adding objects to the environment' and 'valued self-identity' (171). Further, one review calculated the proportion of effective versus non-effective interventions by the number of BCTs used; it revealed that using seven BCTs was associated with 100% of effective interventions, whereas the two interventions that used more than nine BCTs were not effective (171). In summary, using behaviour change theories and embedding seven to nine BCTs may improve the effect of future dietary interventions.

1.5.4.4 Engagement and attrition rates

To identify long-term intervention effectiveness, two important features—engagement and attrition rates—need to be considered (176). Evaluating attrition rates in online studies can be problematic, since there may be enrolled but non-engaged participants. However, examining non-usage attrition rates can also be challenging (165, 170). Therefore, Young et al. recommended data collection on actual intervention use and engagement metrics, to improve understanding on how engagement affects intervention success and reduces the risk of participants completing follow-up measures (165). Nevertheless, engagement in the studies was found to be under-considered and inconsistently defined (165, 170). A recommendation was made for future online interventions to measure both objective (i.e. through log-in metrics) and subjective engagement (i.e. through self-reported process evaluations) to enable a transparent assessment of the effectiveness of brief online, tailored interventions. All the studies that Young et al. reviewed reported a positive correlation between intervention use and outcomes (165). Therefore, future online interventions should also evaluate engagement, both to ensure the success of interventions, and to advance the understanding of how engagement can improve outcomes and support participants in tailored interventions. Moreover, population subgroups need to be considered when identifying how engaging interventions can be, since engagement may depend on individual characteristics.

1.5.4.5 Individual predictors of intervention effectiveness

Individuals who tend to be interested in health and seek nutrition information online have certain characteristics. In particular, females are more likely than males to have high nutrition knowledge (177) and to be more health conscious (178). In addition, those who source health information have a higher education level (179) and a higher paid job, and are more health conscious and motivated (180, 181). Therefore, it is important to consider the different population subgroups to target, when designing and delivering interventions.

As reported in section 1.3.1, being female, of older age and in a healthy weight range have been documented as strong predictors of healthier diet quality (4, 27, 68). Longitudinal studies on change in dietary behaviours conducted in free-living Australian populations have also consistently reported associations between healthier diets and older age, being female and having high levels of education (182, 183). Predictors of dietary outcomes following interventions delivered conventionally (184), online (185) or through tailored approaches (36, 181) again found that participants characterised as female, of older age and with reported healthier behaviours are more likely to acquire and adhere to such interventions. The cross-sectional and longitudinal studies that have shown associations between some individual characteristics and dietary behaviour provide some insight into who engages in positive dietary behaviour. However, there is limited literature on the individual characteristics associated with greater improvement in dietary behaviours after participating in online interventions, particularly those that have been delivered with a tailored feature and have been brief in nature. Therefore, identifying the predictors of diet quality improvement following a brief online, tailored dietary feedback intervention is warranted.

1.5.4.6 Summary of recommendations for future interventions

In this section, six systematic reviews were synthesised to showcase the evidence base behind developing successful brief online tailored interventions. Overall, studies that were conducted online, were brief, had a tailored dietary feedback message component and were underpinned by behaviour change theory and BCTs, showed small to moderate effects for improving diet quality. However, not all studies used these features in designing the intervention. For example, one of the systematic reviews found that only 40% of brief studies were online, and 69% included a tailoring component (171). Further, the outcome focus of intervention has mostly been on selected aspects of dietary intake, such as food groups or nutrients (i.e. fruit and/or vegetables, with or without fat intake), whereas limited research has considered overall diet quality. Therefore, identifying priority dietary targets may be an important starting point to maximise overall diet quality improvement. Then, combining online, brief, tailored features with behaviour change theory in future intervention development could lead to enhanced diet quality effectiveness. The targeting of specific population subgroups was also recommended. A focus on participants from under-represented subgroups, such as males and younger adults, and people from a range of socio-economic status levels, was recommended in order to achieve larger intervention effect on diet quality (41). In summary, dietary interventions that incorporate brief, online and/or tailored features have shown small to moderate improvements in diet quality; however, combining the features to develop novel interventions could enhance the success that has been achieved to date.

1.5.5 Gap to address: Combining evidence-based features, recommended for the design of successful tailored interventions

Results and recommendations from six systematic reviews were synthesised in order to understand the work needed to advance the research on brief online tailored dietary feedback interventions. First, there was a clear argument for the use of technology to deliver interventions efficiently and at scale. However, online dietary interventions are not always developed using evidence-based processes or theoretical frameworks, and thus, this aspect needs to be considered to improve future intervention design (160, 166). Second, there were indications about the length of time and number of contacts of interventions. The brief interventions that were reviewed varied in time but the most common period, which was also associated with success, was 4 weeks. On average, two prompts were used in the brief interventions to keep participants engaged and to ensure the completion of intervention measures. Given the continuing inconsistency in the understanding about what an effective 'brief' intervention entails, developing and testing brief interventions may contribute knowledge to the evidence base and allow establishing a clearer definition of effective 'brief interventions'. Third, a broader range of dietary outcomes should be considered for future intervention focus because most interventions have measured or targeted fruit and vegetable intake. Therefore, future interventions should assess overall diet quality to understand the impact of particular components on the whole diet.

The fourth recommendation to ensure positive effects on dietary outcomes was that the intervention should have a theoretical basis and use the appropriate type and number of BCTs. It was reported that using up to nine BCTs was associated with intervention effectiveness; and providing 'information about health consequences', 'instruction on how to perform a behaviour' and 'self-monitoring' were some examples of BCTs associated with diet quality improvement. Therefore, testing these recommendations in future interventions could advance knowledge on the optimal number of BCTs needed in interventions. Reports on the engagement with, and the usage of, online interventions are limited in the literature; thus, the fifth recommendation was to collect engagement metrics to evaluate intervention success based on usage rates. Last, it is important to identify the individual participant characteristics that can predict intervention success, to help future interventions target under-represented population subgroups, who may need added behavioural support.

In summary, the literature suggests that online, brief and/or tailored interventions that are delivered with behavioural support are associated with more improvements in dietary behaviours than conventional, higher-intensity interventions (41, 154, 165, 170-172). Combining these features together into one novel intervention may result in enhanced diet quality improvement, compared with the results achieved to date.

1.6 Behaviour Change Theory for Intervention Design

High-quality interventions require the use of the evidence base to inform intervention design and development. In contrast, the use of theory helps to maximise intervention effect. That is, theory plays an integral role in the design, development and evaluation of interventions.

1.6.1 The theory of planned behaviour

The theory of planned behaviour (157) posits the idea that a positive attitude, subjective norms and perceived behavioural control towards health behaviours are essential for increasing intention, which is proximal to actual behaviour change (157, 186). The narrative review in section 1.3

indicated that intention to change is a key characteristic that predicts dietary behaviour change after exposure to different nutrition messages. Thus, there is merit in using this theory to tailor nutrition messages in a novel intervention. In addition to knowing how to tailor a message in an intervention, it is crucial to use theory to guide intervention development, to maximise its success.

1.6.2 The Behaviour Change Wheel

The Behaviour Change Wheel (BCW) incorporates elements of 19 behaviour change frameworks into a single comprehensive tool, linked to an overarching model of behaviour. It was developed to (1) support researchers to understand the behaviour of interest, (2) identify the sources of the behaviour and theory to explain the behaviour change and (3) select appropriate ways to design and deliver intervention functions (187). The BCW framework (173) is underpinned by three 'psychosocial' domains—Capability (C), Opportunity (O) and Motivation (M)—that are designed to interact to provoke behaviour change (COM-B). They are defined as (1) Capability (psychological and/or physical; e.g. knowledge and skills); (2) Motivation (reflective and/or automatic; e.g. self-efficacy and emotion); and (3) Opportunity (physical and/or social; e.g. environmental resources and social influences). A recent recommendation is to address the psychological and social factors that influence dietary patterns and that differ considerably between individuals (41). Therefore, the COM-B model can be used to assess whether participants' psychological 'triggers' facilitate or hinder behaviour change, thus further improving future intervention effects.

The COM-B model has a taxonomy of 93 BCTs (173). The number and type of BCTs recommended from previous systematic reviews can be embedded into the intervention design (41, 165, 171, 172) to test whether this added behavioural support enhances the impact of dietary behaviour change. Last, the most important aspect of an intervention is the outcome it attempts to achieve. An intervention should consider focussing on one target behaviour and build on small successes, rather than attempting to change too many behaviours simultaneously (188). Doing so will allow continuous, incremental targeting of different dietary behaviours, leading to effective, efficient and sustainable overall diet quality improvement (173). Therefore, intervention design should consider the COM-B model to understand the psychological facilitators of intervention success. Using BCTs in the intervention design, while aiming to improve one dietary behaviour, can maximise intervention success.

1.7 Summary, the Evidence Gaps and Research Questions

1.7.1 Summary of the evidence explored in the chapter

The diet quality of Australian adults is poor, with most of the population not complying with the ADG recommendations for all food groups. However, if large-scale dietary feedback interventions are to be more feasible, it is important to identify one food group, or dietary target, that can maximise diet quality improvement. Part one, section 1.3 of the chapter reported that there are some differences in population subgroups' compliance with diet quality components or food groups. However, by defining population subgroups more clearly, population-level feedback on diet quality components may become more targeted. Finding priority dietary targets based on more defined population subgroups could then allow testing other intervention strategies, such as message framing, for changing the behaviours associated with those dietary targets.

Moreover, it is important to consider how feedback is delivered to improve dietary behaviours associated with priority dietary targets. The current approach to communicating feedback is to either deliver the messages used in ADGs and/or to use messages that communicate health outcomes associated with dietary behaviour. The impact of these nutrition messages on diet quality improvement has either not been evaluated or has been evaluated to be modest. A communication technique documented as effective for behaviour change is termed message framing. The narrative review reported in part two, section 1.4.2, demonstrated that positive, negative, and majority or minority descriptive norm message frames are more influential than control or health messages in bringing about dietary behaviour change. Yet, it remains unclear whether any single nutrition message frame can have the largest impact on dietary behaviour. Further, the impact associated with nutrition message frames is possibly predicted by individual characteristics, such as baseline intention. The approach of tailoring the nutrition message frame to an individual's intention to change dietary behaviour is yet to be tested, but may induce an enhanced effect on improving diet quality compared with non-tailored or 'generic' nutrition messages. This novel approach to nutrition messaging should be tested via an evidence-based, theoretically grounded intervention.

Part three of the chapter, section 1.5, synthesised evidence that demonstrated that online interventions that are brief in nature, use the appropriate length and dose to keep participants engaged, use key BCTs and incorporate a tailored component, can reach more of the population and be more effective than more intense, conventional methods. Therefore, incorporating these key features into an intervention that also tests tailored nutrition message framing could be a strategy to enhance diet quality. Research has indicated that there are some population subgroups that may be under-represented in brief online dietary interventions. Hence, it is important to identify which individual characteristics predict, or do not predict, success in brief online dietary interventions, to allow future interventions to focus more closely on the population subgroups that need more behavioural support.

1.7.2 Summary of the evidence gaps that need to be addressed

In summary, the key evidence gaps identified from this literature review chapter are as follows. First, it is unknown whether priority dietary targets differ by more defined population subgroups; therefore, the approach of using more defined population subgroups could identify *what* dietary targets need priority in dietary feedback interventions, to maximise diet quality improvement on a population level. To enhance the impact of feedback on dietary behaviour, nutrition message framing can be used. Positive, negative and descriptive norm message framing has been commonly used to influence dietary behaviour change; however, these messages have not been compared with each other. Identifying the message that can have the largest impact on dietary behaviour could inform *how* dietary feedback interventions can deliver more effective messages on a population level. Nutrition message framing effect was predicted by individual-level characteristics, such as intention; therefore, tailoring nutrition message frames could be a strategy to influence change in dietary behaviour on an individual level. No study has tested *whether* tailoring message frames, using intention as a characteristic, improves dietary behaviour, which justifies the need for more research in this area. Last, embedding tailored nutrition message frames within a brief online dietary feedback intervention and using behavioural support through BCTs is a novel strategy that may enhance diet quality improvement, in comparison to what interventions have achieved to date. This novel strategy warrants exploration, specifically, to understand whether its effect differs between population subgroups in order to understand *for whom* future interventions should be a focus. Therefore, this thesis intends to contribute original knowledge by filling in the identified research gaps and answering the research questions presented in the next section.

1.7.3 Research questions

To maximise improvement in overall diet quality, *what* should the priority dietary targets be? To progress research on tailored nutrition message framing, *how* should nutrition messages be framed for increasing the intention for dietary behaviour change? This leads to the question *whether* a novel brief online dietary feedback intervention, which uses tailored nutrition message frames and enhanced behavioural support, is more effective than using a generic nutrition message. Last, *for whom* is such an intervention most effective? These questions lead to the following overarching thesis aim and objectives.

1.8 Thesis Aim and Objectives

The thesis aim is to design and test a brief online dietary feedback intervention with tailored nutrition message framing and enhanced behavioural support, for improving the diet quality of Australian adults. To achieve the thesis aim, the following individual objectives will be addressed in five chapters:

1. To identify priority dietary targets for an intervention and to understand whether these targets vary by more defined population subgroups, using gender, age, weight status and of diet quality level as characteristics. This will aid in identifying *what* priority diet component to target in a brief online tailored messaging intervention (Chapter 2).
2. To test for differences in reported intention to improve dietary behaviour after exposure to four different nutrition messages framed as (1) positive, (2) negative, and (3) majority and (4) minority descriptive norms, within a sample of Australian adults. This test will identify the most effective nutrition message frame for increasing the intention to improve dietary behaviour and will aid in selecting *how* the individually tailored nutrition message frames will be presented to participants in the brief online intervention (Chapter 3 and 4).
3. To design, test and compare the effects of a brief online dietary feedback intervention, between delivering a tailored nutrition message frame, and a generic nutrition message, on improving diet quality, in a sample of Australian adults. This investigation will show *whether* tailoring message frames to individuals is more effective than the generic messages used in standard practice (Chapter 3 and 5).
4. To determine participants' demographic, anthropometric, behavioural and psychosocial characteristics that predict (i) an improvement in diet quality, and (ii) compliance with the dietary guidelines, after a brief online intervention. This will aid in deciding, among an Australian population, *for whom* the intervention would be most effective in order to develop more targeted interventions in the future (Chapter 3 and 6).

CHAPTER 2 IDENTIFYING PRIORITY DIETARY TARGETS FOR INTERVENTION: A SECONDARY ANALYSIS

2.1 Overview and Rationale

To design a brief online intervention that aims to improve the diet quality of Australian adults, it is important to determine the key components of overall diet quality that need targeting. Chapter 1 reported that the diet quality of the Australian population is poor as defined by low compliance with the ADG recommendations. Currently, many brief online interventions assess overall diet quality and then deliver brief feedback on all, or several, diet quality components that constitute overall diet quality (30, 34, 36). Section 1.3 of Chapter 1 summarised the differences in diet quality component scores that are associated with population subgroups defined using simple characteristics, such as gender, age, weight status and baseline diet quality level. However, a gap in the evidence was identified regarding the dietary targets that need to be prioritised in an intervention for a more complex set of population subgroups—for example, a subgroup that is defined not by one characteristic alone, such as gender, but by two or more characteristics. Therefore, this chapter aims to address thesis objective 1: as stated in section 2.1.1.

To this end, this chapter presents a secondary analysis of dietary intake data on Australian adults. This chapter reports the methods (section 2.2) and results (section 2.3) of the study. The exploration of diet quality and its components will provide an understanding of the dietary targets that need to be prioritised for subgroups of the population, and thus contribute to developing more effective interventions that increase the potential for maximising overall diet quality improvement. This concept is discussed in more detail in section 2.4, leading to the conclusion of the chapter in section 2.5.

2.1.1 Chapter aim and objectives

To identify priority dietary targets for an intervention and understand whether these targets vary by more defined subgroups using gender, age, weight status and levels of diet quality as characteristics.

1. To describe overall diet quality score, and diet component scores by their compliance with the ADGs, for the overall sample and each subgroup.

2. To identify the diet components that are priority dietary targets and compare them between the overall sample and each subgroup.

2.2 Methods

2.2.1 Overall study design

This study was a secondary analysis of cross-sectional data from a large online dietary assessment survey. Food intake data were collected from a large sample of Australian adults via a free online survey, the CSIRO Healthy Diet Score (30). The survey was developed to assess diet quality based on compliance with the ADGs (24). The CSIRO Healthy Diet Score survey was launched on 21 May 2015, and data collection is continuous and ongoing. This chapter was prepared using the STROBE statement for reporting observational studies (189) (Appendix 3).

2.2.2 Ethics

Ethics approval was received from the CSIRO Health and Medical Human Research Ethics Committee Low Risk Review Panel (LR 29/2016). All participants who wish to complete the Healthy Diet Score must confirm, through a check box, that they are at least 18 years old and consent to the Privacy Policy which states participants are consenting to their data is being used by CSIRO for research.

2.2.3 Study procedures

2.2.3.1 Recruitment

Data collection methods have been described in detail and published elsewhere (30). Briefly, the online survey launch in May 2015, was followed by four media releases (between May 2015 and September 2016 (30) as a recruitment method, which used a variety of media including local and national television and radio. The survey remains freely available to all Australians. This chapter describes data collected from participants who completed the survey up to January 2019.

2.2.4 Data collection

2.2.4.1 Short Food Survey

The CSIRO Healthy Diet Score is an extension of the SFS (29) mentioned in Chapter 1. The survey is a 38-item self-reported measure of individual dietary intake, developed for the Australian population, and provides valid estimates of diet quality for adults (29). The survey asks individuals to report their usual dietary consumption patterns, such as the frequency and quantity of core food group serves (grains, fruit, vegetables, meat and alternatives, and dairy and alternatives) and discretionary choices (e.g. cakes and biscuits, chocolate and confectionary, takeaway foods, savoury pies and pastries, sugar-sweetened beverages, and alcohol) consumed. Individuals are also asked to report the quality of core foods (frequency of wholegrain and reduced fat dairy) and the variety of intake within core food groups, defined as the proportion of foods consumed at least once per week.

2.2.4.2 Overall diet score and diet components

Within the CSIRO Healthy Diet Score survey, individuals report their usual intakes of food, in serves, per day, week or month, which is the information used to calculate serves of food consumed per day for the quantity component. A score is then calculated for nine diet components: grains (including breads and cereals), vegetables (including starchy vegetables and vegetable juice), fruit (including dried fruit and 100% fruit juice), meat (including meat, poultry, fish, eggs and alternatives: legumes, tofu and nuts), dairy (including cow's milk and plant-based milks, cheese and yoghurt), discretionary choices (cakes, confectionary, processed meats, takeaway foods, alcohol and sugar-sweetened beverages), fluid (water), healthy fats (spreads and trimmed meat), and dietary variety (number of different types of foods eaten) (30). The scoring system compares the reported serves to the ADG's recommendations for the five core food groups and discretionary choices. For the quality component, an assessment is conducted of the frequency of consumption of wholegrains, reduced fat dairy, trimming of meat, type of fat spreads used and water intake. All nine components are summed and scaled to provide an overall diet score, ranging from 0–100, where a higher score reflects greater compliance with the ADGs, and thus higher diet quality.

2.2.4.3 Demographic and anthropometric characteristics

Participants were asked to report their gender (female/male), year of birth, weight (in kg), height (in cm) and the Australian state or territory in which they reside.

2.2.5 Data cleaning and preparation

Given the nature of self-reported data, a previously published standard data cleaning protocol was used to remove erroneous values (30). Further, a unique identification variable was used to remove duplicates (n = 274,137) to ensure that only the first attempt of the completed surveys was included in this analysis. Of the 264,867 unique surveys, 47,150 surveys were incomplete, leaving 217,717 surveys. Outliers were removed based on extreme age (less than 18 and above 100 years), BMI (less than 13 and more than 97 kg/m^2), height (less than 1 m and more than 3 m) and weight (less than 13 kg and more than 250 kg). Based on the data cleaning protocol, 1,672 outlier surveys were removed, leaving 216,045 surveys for analysis.

2.2.6 Adjustment and weighting

Adjustment factors account for the known difference between the portion size consumed per occasion of eating and the standard serving size (190). A ratio was calculated by dividing the portion size consumed by the recommended serving size provided in the ADGs. The usual portion size of Australian adults was calculated as the median amount reported per eating occasion in the 2011–2012 Australian National Nutrition and Physical Activity Survey (14). Adjustment factors for each question were created for the adult population using the median portion size values for the population as a whole and were stratified for age group and gender using the median portion sizes reported for each of these groups separately. In addition, to account for sampling and recruitment bias, the current survey data were weighted to better reflect the gender and age distribution of the general Australian population as per the 2016 Census data (191).

2.2.6.1 Segmentation of the overall sample

Segmentation is defined as '*the degree to which the audience is divided into increasingly more defined, homogenous groups'* (74 p. 456) for identifying subgroups that cluster individuals with shared characteristics, to deliver interventions suited for each subgroup (75). Varying degrees of segmentation were proposed to define the subgroups. In simple segmentation, one individual characteristic is used to create subgroups, and in complex segmentation, different combinations of individual characteristics are used. The characteristics used for segmentation, based on the hypothesised predictors of diet quality, were gender, age (24, 64), weight status (4, 28, 75, 192) and variations in the calculated diet quality score (39, 193).

2.2.6.2 Simple segmentation using one characteristic

2.2.6.2.1 Gender, age and weight status

Gender was categorised into male and female. Age was calculated and categorised into four groups consistent with the nutrient reference values (194): 18–30 years, 31–50 years, 51–70 years and 71+ years. Reported height was converted to metres from centimetres, and BMI was calculated by dividing reported weight (kg) by height (m^2). As per the World Health Organization International Classifications of BMI for adults, weight status was categorised into four groups: underweight (<18.5 kg/m^2), healthy weight (18.5–24.9 kg/m^2), overweight (≥ 25.0 kg/m^2) and obesity (≥30.0 kg/m^2).

2.2.6.2.2 Quintiles of diet quality

A diet quality score can be divided into different levels of diet quality categories, to inspect how variations in diet quality are associated with participant characteristics or health outcomes. The literature examining relationships between diet quality and health outcomes has commonly ranked overall diet quality scores into quintiles, to create a categorical variable (4, 73, 195), whereas others have used tertiles (8) to maximise power from the sample size.

For this large dataset, multiple approaches for categorising diet score were examined to identify an optimal but feasible way to categorise overall diet quality. Overall diet score data were grouped into 3 (tertiles), 4 (quartiles), 5 (quintiles) and 10 (deciles) diet quality score categories (Appendix 4). In this thesis, hereafter, 'diet quality category' indicates tertiles, quartiles, quintiles or deciles of diet quality. 'Diet quality level' indicates low, medium or high levels *within* diet quality categories. Criteria were developed to compare differences between the diet quality categories. The deciles of diet score category were used as the 'optimal' category that was comparable with the overall data. To distinguish which, out of the other diet quality categories, was best in comparison to the decile categories, the range of diet scores within different diet quality levels were examined. Then, within each diet quality level, individual diet component scores were compared. For each level of diet quality (Appendix 4), diet component scores were ranked in ascending order. Key differences in the rank order of components within each diet quality level were compared between diet quality categories. For example, the rank order of the three lowest scoring components within the lowest level of deciles, were compared with the rank order of the three lowest scoring components found in the lowest level of quintiles, quartiles and tertiles. This comparison was conducted to identify which diet quality category best simulated the decile levels of diet quality, to be taken forward as the appropriate segmentation approach to characterise participants on their baseline diet score.

Overall diet and component scores using quintile levels of diet quality simulated deciles of diet quality the most. The quartile and tertile levels of diet quality under-represented some diet components that were the lowest scoring within decile levels. Therefore, quintile level of diet quality (quintiles of diet quality) was the characteristic used to categorise overall diet quality in an optimal but feasible way. This characteristic was also used for complex segmentation.

2.2.6.3 Complex segmentation using a combination of characteristics

In complex segmentation, different combinations of individual characteristics were used to further define the subgroups. In addition to the single participant characteristics—gender (2 categories), age (4 categories), weight status (4 categories) and quintiles of diet quality (5 categories)—five subgroups were computed and used for analysis. These were quintiles of diet quality by gender (10 categories); quintiles of diet quality by age (20 categories); quintiles of diet quality by weight status (20 categories); gender by age by weight status (32 categories); and quintiles of diet quality by gender, age and weight status (132 categories). Therefore, a total of nine simple and complex segmentation approaches were used for the subgroup analysis.

2.2.7 Statistical analysis

All analyses were conducted in SPSS statistical software package, Version 23 (IBM SPSS Statistics [computer program]. Version 23. Armonk, NY: IBM Corp; March 23, 2015). Data normality was visually checked using frequency histograms and normal Q-Q plots. Means and standard deviations (SD) for discrete and continuous data (diet component scores and the overall diet score out of 100) are presented for the overall sample, and by subgroup. Data for categorical variables and frequencies are presented as percentages. Independent samples *t*-test and one-way analysis of variance (ANOVA) with post hoc analyses using Bonferroni's and Tukey's tests, were used to compare the mean differences in the component and overall scores for the entire sample and for the subgroups. Significance levels were set at $p < 0.001$. Due to the large sample size and based on a previously published protocol, a statistically significant difference of less than five points between sample categories was considered small; of five to 10 points was considered a medium-sized difference; and of 10 or more was considered a large difference (4).

2.2.7.1 Overall diet quality and component scores between the overall sample and subgroups

The overall diet quality and component scores were derived for each subgroup and compared for the overall sample and the nine subgroups mentioned in section 2.2.6.1. Component scores were ranked in ascending order of scores, and a new variable was derived to identify the lowest scoring (=1) to highest scoring (=9) component.

2.2.7.2 Priority dietary targets

The three lowest scoring components were identified as priority dietary targets—an approach that is in line with current standard practice (30, 34, 38). The frequency of the diet components being a dietary target was examined for the overall sample and the subgroups. A new variable was computed to categorise the components into two categories: 1 = the component was a target and was in the lowest three out of nine component scores, and 0 = the component was not a target.

2.3 Results

2.3.1 Demographic and anthropometric characteristics

The majority of the sample was female (72.8%). The 18–30, 31–50 and 51–70 age groups (Table 2-1) had a relatively even distribution, whereas 3.4% were in the 71+ age group. Nearly half were categorised into healthy weight status (49.3%), and 28.9% and 19.1% were classified with overweight and obesity, respectively. Compared with the 2016 Census (191), that included 49.3% males, 19% in the 18–30 age category and 10.7% in the 71+ age category, this study's overall sample had nearly half the number of males, more adults aged 18–30 years and slightly less adults aged 71+ years (Table 2-1). The overall sample represented the distribution in the Australian population's state of residence. More than half (55.9%) reported their state of residence being Victoria or New South Wales, which is a similar figure to where more than half of the Australian population (57.3%) currently resides (191) (Table 2-1).

Table 2-1: Characteristics of the overall sample (*N* = 216,045) and the demographic profile of the general Australian population taken from the 2016 Census data (191) and population weight statistics from the 2017-18 National Health Survey (5)

Characteristics	Total sample (%)		% of national population*
Gender			
Male	58,711	(27.2)	49.3
Female	157,334	(72.8)	50.7
Age groups (years)			
18–30	67,365	(31.2)	24.4
31–50	75,417	(34.9)	33.8
51–70	65,832	(30.5)	28.7
71+	7,431	(3.4)	13.1
Weight status category			
Underweight	5,846	(2.7)	1.6
Healthy weight	106,426	(49.3)	35.0
Overweight	62,406	(28.9)	35.5
Obesity	41,367	(19.1)	27.9
State of residence			
New South Wales	58,280	(27)	32.0
Queensland	32,703	(15.1)	20.1
Australian Capital Territory	9,534	(4.4)	1.7
Northern Territory	1,977	(0.9)	1.0
Tasmania	6,547	(3.0)	2.2
Victoria	62,427	(28.9)	25.3
Western Australia	21,906	(10.1)	10.6
South Australia	21,263	(9.8)	7.2

Note:
*Age group percentages were manually calculated from the Census population (data on total persons) to represent 100% of Australians in the age groups of 19 to 85 and above, for comparability with the study sample (191).
Age was calculated and categorised into four age groups consistent with the nutrient reference values (194).
Weight status categories are according to Body Mass Index (BMI) (kg/m^2); Underweight: <18.5 kg/m^2; Healthy weight: 18.5–24.9 kg/m^2; Overweight: 25–29.9 kg/m^2; Obesity: >30 kg/m^2.

2.3.2 Overall diet quality and diet component scores

The overall sample's mean diet score was 56.0 ± 12.0 out of a possible 100, ranging from 0.0–99.2 (Table 2-2). Significant mean differences (Mdiff) of the overall diet scores were observed between gender, age and weight status groups (Table 2-2). Females reported a higher average diet score (57.5 ± 11.7) than males did (Mdiff = 3.2, $p < 0.001$).

Participants in the 71+ age group reported the highest diet score (60.7 ± 11.1) compared with the other age groups. Small and statistically significant mean differences were found between the 71+ age group, and the 18–30 (Mdiff = 6.7, $p < 0.001$) and 31–50 (Mdiff = 6.9, $p < 0.001$) age groups. The difference was not meaningful compared with that for the 51–70 age group (Mdiff = 2.8, $p < 0.001$). The 31–50 age group reported a score (53.8 ± 11.6) similar to that of the 18–30 age group (Mdiff = 0.2, $p = 0.02$) and a smaller score than that of the 51–70 (Mdiff = 4.2, $p < 0.001$) age group.

Participants in the healthy weight group reported the highest diet score (57.3 ± 12.0) among all the weight status groups. The largest diet score difference was between the healthy weight group and the obesity group, but was not meaningful (Mdiff = 3.9, $p < 0.001$) (Table 2-2).

Table 2-2: Characteristics of the sample and summary diet scores by demographic characteristics (*N* = 216, 045)

Characteristics*	Overall diet score (Mean ± SD)
Gender	
Male	54.3 ± 12.1
Female	57.5 ± 11.7
Age groups (years)	
18–30	54.0 ± 12.4
31–50	53.8 ± 11.6
51–70	58.0 ± 11.6
71+	60.7 ± 11.1
Weight status category	
Underweight	56.4 ± 13.8
Healthy weight	57.3 ± 12.0
Overweight	55.6 ± 11.6
Obesity	53.5 ± 12.0
Total sample	56.0 ± 12.0

Note:
*Sample weighted by age group and gender to reflect the demographic profile of the general Australian population taken from the 2016 Census data.

2.3.3 Diet component scores and their rank order

2.3.3.1 Diet component rank order by the overall sample

The overall sample's mean component scores (out of 100) were ranked from lowest scoring to highest scoring (Table 2-3). Low scores indicate least compliance with the ADGs. Overall, discretionary choices was the lowest scoring component (21.4 ± 30.1). Dairy and healthy fats were the second and third lowest, with average scores of 38.9 ± 24.7 and 51.9 ± 27.7, respectively. The mean component score for vegetables was 58.3 ± 29.3, whereas the scores for fruit (61.0 ± 34.6) and variety (65.2 ± 13.2) were slightly higher. The highest component score was for fluid (92.8 ± 15.1).

Table 2-3: Diet component scores for the overall sample *(*N* = 216,045)

Diet component scores (out of 100)	Mean	±	SD
Discretionary choices	21.4	±	30.1
Dairy	38.9	±	24.7
Healthy fats	51.9	±	27.7
Vegetables	58.3	±	29.3
Fruit	61.0	±	34.6
Variety	65.2	±	13.2
Grains	71.0	±	25.7
Meat	77.7	±	24.1
Fluid	92.8	±	15.1

Note:
*Data are weighted by age group and gender to reflect the demographic profile of the general Australian population taken from the 2016 Census data.

2.3.3.2 Diet component rank order by simple segmentation

The previous section reported on the diet quality component scores of the overall sample and found that the discretionary choices, dairy and healthy fats components had the three lowest scores. The following section will describe the differences in component scores by gender, age group, weight status and quintile of diet quality subgroups. The rank order of the lowest scoring components relative to the other components within diet quality will be reported.

2.3.3.2.1 Gender

The rank order of the lowest to highest scoring components by gender is shown in Table 2-4. The rank order of components was the same for males and females. Discretionary choices was the lowest scoring component, with an average score of 18.7 ± 29.0 for males and a meaningfully and statistically higher score for females (23.9 ± 30.9, $p < 0.001$). The subsequent lowest scoring components for both genders were dairy and healthy fats. The vegetables component score was the fourth lowest for males, but fifth lowest for females. Both genders scored the highest for grains, meat and fluid. There were significant between-group differences for all component scores, except for the dairy and grains components.

Table 2-4: Mean ± SD of diet component scores (out of 100) by gender (*N* = 216, 045)* †

Diet component scores (out of 100)	Males (n = 58,177)		Females (n = 157,334)	
Discretionary choices	18.7	±29.0	23.9	±30.9
Dairy‡	38.8	±24.5	39.0	±24.9
Healthy fats	50.5	±28.7	53.2	±26.6
Vegetables	53.8	±29.4	62.4	±28.5
Fruit	59.9	±35.5	62.1	±33.7
Variety	64.7	±13.4	65.7	±12.9
Grains‡	71.1	±25.5	70.9	±25.9
Meat	76.3	±24.4	79.1	±23.7
Fluid	90.5	±17.1	94.9	±12.6

Note:
*Data are weighted by age group and gender to reflect the demographic profile of the general Australian population taken from the 2016 Census data.
† *T*-test indicated that the differences between genders were significant ($p < 0.001$), unless otherwise indicated.
‡ *T*-test indicated no significant difference between genders ($p > 0.001$).

2.3.3.2.2 Age group

The rank order of the lowest to highest scoring components by age groups is shown in Table 2-5. Regardless of age group, discretionary choices ranked as the lowest scoring component (range of scores across age groups: 20.2–22.8). The second and third lowest scoring components for all age groups were the dairy and healthy fats components, respectively. All age groups had vegetables as their fourth lowest scoring component, except for the 18–30 age group, for which fruit was the fourth lowest scoring component (55.6 ± 35.2). There were differences in component scores for fruit and vegetables between groups. The 71+ group scored 20.7 points higher for fruit, and 10.7 points higher for vegetables ($p < 0.001$), than the 18–30 age group.

Similar results were found for the 51–70 and 18–30 age groups, where the older age group scored higher on all diet components, except healthy fats. However, the 31–50 age group scored lower on the discretionary choices, dairy, healthy fats, vegetable, fruit and grains components, than the 18–30 age group. Dietary variety scores increased as age groups increased; the largest meaningful difference was between the youngest and the oldest age groups (Mdiff = 7.9, $p < 0.001$). All the age groups scored the highest for grains, meat and fluid.

Table 2-5: Mean ± SD diet components scores (out of 100) by age groups in years (*N* = 216, 045)*

Diet component scores (out of 100) †	18–30 years (*n* = 67,365)		31–50 years (*n* = 75,417)		51–70 years (*n* = 65,832)		71 years+ (*n* = 7,431)	
Discretionary choices ‡a	21.4	± 29.6	20.2	± 29.3	22.2	± 30.8	22.8	± 31.6
Dairy ‡b	36.6	± 24.6	39.5	± 25.0	40.0	± 24.5	39.0	± 24.2
Healthy fats ‡c	53.1	± 29.0	49.9	± 28.3	52.6	± 26.8	54.0	± 24.9
Vegetables	56.0	± 29.7	54.8	± 28.6	60.7	± 29.0	66.7	± 28.6
Fruit ‡d	55.6	± 35.2	55.0	± 34.4	66.0	± 33.5	76.3	± 29.7
Variety	62.0	± 14.0	64.1	± 13.3	67.1	± 12.2	69.9	± 11.1
Grains	67.9	± 25.1	66.7	± 26.1	73.4	± 25.3	80.6	± 22.7
Meat	74.3	± 26.0	75.0	± 24.2	82.5	± 21.9	83.0	± 22.5
Fluid ‡e	92.2	± 14.6	93.1	± 14.7	93.2	± 15.2	92.2	± 16.8

Note:
*Sample is weighted by age group and gender to reflect the demographic profile of the general Australian population taken from the 2016 Census data.
†All differences are significant, unless otherwise indicated.
‡ No significant difference ($p > 0.001$) between:
[a] the 51–70 and 71+ age groups
[b] the 31–50 and 51–70; the 51–70 and 71+ age groups
[c] the 18–30 and 31–50 age groups
[d] the 18–30 and 31–50 age groups
[e] the 18–30 and 71+; and the 31–50 and 51–70 age groups.

2.3.3.2.3 Weight status

The rank order of the lowest to highest scoring components by weight status is shown in Table 2-6. The discretionary choices component ranked as the lowest scoring, regardless of weight status (range of mean scores between weight status groups: 17.2–28.3). The second and third lowest scoring components were dairy and healthy fats, respectively. Excluding the obesity group, all groups had vegetables as their fourth lowest scoring component, which was followed by fruit as the fifth lowest.

The discretionary choices and dairy component scores were significantly different between all weight status groups. The obesity group had the lowest score for discretionary choices (17.2 ± 28.0) but the highest for dairy (41.0 ± 25.3). However, regardless of weight status, dietary variety, grains, meat and fluid had the highest scores.

Table 2-6 Mean ± SD diet components scores (out of 100) by weight status (*N* = 216, 045)*

Diet component scores (out of 100)	Underweight (*n* = 5,846)		Healthy weight (*n* = 106,426)		Overweight (*n* = 62,406)		Obesity (*n* = 41,367)	
Discretionary choices	28.3	±34.0	24.3	±31.3	19.4	±29.0	17.2	±28.0
Dairy	34.1	±24.1	37.6	±24.3	39.7	±24.7	41.0	±25.3
Healthy fats ‡a	55.9	±30.0	54.4	±28.0	51.2	±27.1	47.0	±26.6
Vegetables ‡b	60.4	±30.9	59.2	±28.8	57.4	±29.2	57.3	±30.0
Fruit ‡c	63.3	±35.4	64.6	±33.5	60.9	±34.4	52.9	±35.8
Variety	63.7	±14.9	66.5	±12.8	65.3	±12.8	62.2	±13.9
Grains ‡d	69.1	±26.8	72.3	±25.4	70.8	±25.6	68.6	±26.4
Meat	69.5	±28.1	76.3	±24.6	78.7	±23.4	80.3	±22.9
Fluid ‡e	90.8	±17.7	93.8	±13.4	92.6	±15.3	91.1	±17.8

Note:
*Data are weighted by age group and gender to reflect the demographic profile of the general Australian population taken from the 2016 Census data.
†All differences are significant, unless otherwise indicated.
‡ No significant difference ($p > 0.001$) between:
[a] the underweight and healthy weight groups
[b] the underweight and healthy weight groups; and the overweight and obesity groups
[c] the underweight and healthy weight groups
[d] the underweight and obesity groups
[e] the underweight and obesity groups.

2.3.3.2.4 Quintiles of diet quality

The rank order of the lowest to highest scoring components by quintile of diet quality score (quintiles) is shown in Table 2-7. The rank order of the component scores between quintiles differed to some extent. The lowest scoring component across the first four quintile levels was discretionary choices (range of mean scores: 4.0–55.7), except for the highest quintile level (quintile 5), where dairy was the lowest scoring component (48.2 ± 26.0). Discretionary choices, dairy and healthy fats were the three lowest scoring components from quintiles 2 to 5. However, fruit was the second lowest scoring only in quintile 1, indicating that participants with overall diet score between 0.0–46.0 (out of 100), had a lower score for fruit, than those who had a higher overall diet score. Across all quintile levels, the fourth lowest scoring component was either vegetables or fruit, except for quintile 5, where the fourth lowest score was dietary variety. Within quintiles 3 to 5, the fruit component score increased as dietary variety score decreased. Across all quintiles of diet quality, meat and fluid components consistently scored the highest, apart from quintile 5, where the component score for fruit was higher than that for meat.

Table 2-7: Mean ± SD diet components scores (out of 100) by quintiles of diet quality (N = 216, 045)*

Diet component scores (out of 100)	**Quintile 1 (0.0–46.0) (*n* = 42,902)**		**Quintile 2 (46.0–52.8) (*n* = 42,904)**		**Quintile 3 (52.8–58.8) (*n* = 42,904)**		**Quintile 4 (58.8–65.9) (*n* = 42,903)**		**Quintile 5 (65.9–99.2) (*n* = 42,903)**	
Discretionary choices	4.0	±12.4	8.7	±18.6	14.1	±23.5	24.4	±28.9	55.7	±30.8
Dairy	28.1	±21.2	35.3	±22.7	39.6	±23.7	43.3	±24.6	48.2	±26.0
Healthy fats	36.4	±26.0	45.1	±25.5	50.9	±25.2	57.9	±24.9	69.3	±24.8
Vegetables	36.3	±23.7	50.9	±26.3	59.5	±26.8	67.8	±26.8	76.9	±24.8
Fruit	26.2	±25.3	48.4	±30.9	65.4	±30.4	77.8	±26.3	87.4	±19.9
Variety	53.2	±13.4	62.6	±11.2	67.0	±10.7	70.3	±10.5	72.9	±9.9
Grains	55.4	±25.3	68.0	±24.3	73.5	±23.9	77.4	±24.1	80.6	±23.4
Meat	65.9	±25.9	75.2	±23.8	79.3	±22.9	82.4	±22.0	85.7	±20.4
Fluid	84.3	±23.7	92.4	±14.0	94.3	±11.4	95.7	±9.9	97.4	±7.3

Note:
*Data are weighted by age group and gender to reflect the demographic profile of the general Australian population taken from the 2016 Census data.

2.3.4 Priority dietary targets

The previous sections reported on the rank order of the lowest to highest diet component scores using the overall sample, and the gender, age, weight status and quintiles of diet quality subgroups. The focus of this section is to describe the frequency percentage in which the priority dietary targets (lowest three scoring components) appear, using the results for the overall sample and the subgroups.

2.3.4.1 Priority dietary targets using the overall sample

The first, second and third frequently appearing priority dietary targets (or 'targets'), for the overall sample, are shown in Figure 2-1. The most frequently appearing target was discretionary choices, since 63.8% of the sample had the lowest score for discretionary choices. About 15% of the sample had the lowest score for the dairy component, followed by 5.3% for healthy fats and 5.8% for fruit (Figure 2-1). Less than 5% of the sample had the lowest score for the vegetables, grains, meat, variety or fluid components.

About three-quarters of the sample (74.2%) had discretionary choices as the second lowest scoring component. Just over 40% of the sample had dairy as the second lowest scoring component; and less than a quarter of the sample had healthy fats, fruit and vegetables (24.4%, 21.6% and 19.2%, respectively) as the second lowest scores. Further, less than 8% of the sample had the second lowest score for grains, meat, variety and fluid.

The discretionary choices component was a target for the majority of the sample (80.9%). Dairy and healthy fats were targets for 65.3% and 44.2% of the sample, respectively. A larger percentage of the sample had vegetables, rather than fruit, as a target (37.0% and 34.2%, respectively). Less than 15% of the sample had grains, meat, dietary variety and fluids (14.4%, 12.1%, 9.9% and 2.1%, respectively) as targets.

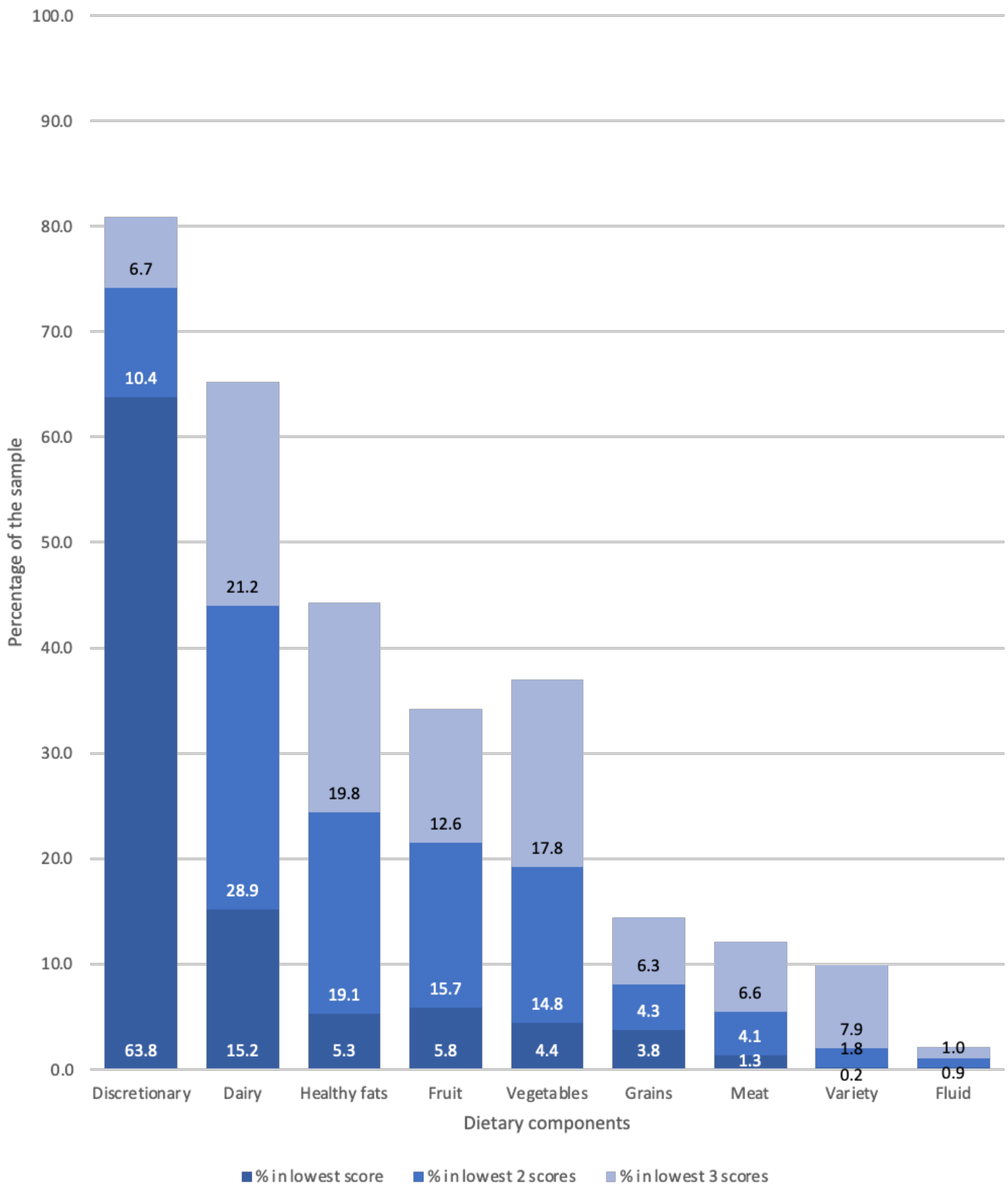


Figure 2-1: Frequency percentage of priority dietary targets based on the first, second and third lowest scores, for the overall sample (*N* = 216,045).

2.3.4.2 Priority dietary targets using simple segmentation

The following sections aim to show the frequency of priority dietary targets by gender, age group, weight status and quintiles of diet quality subgroups.

2.3.4.2.1 Gender

The discretionary choices component appeared as a target slightly more frequently for males (82.6%) than for females (79.2%) (Figure 2-2). Dairy was a target for 62.5% of males and 67.8% of females, and healthy fats for 42.7% of males and 45.6% of females. Male and female samples had similar frequencies for fruit as a target (33.8% and 34.6%, respectively). More males (41.2%) than females (33.2%) had vegetables as a target; but fewer males (8.7%) than females (11.1%) had dietary variety as a target. More females (15.8%) than males (12.9%) had grains as a target, and about 12.0% of both genders had meat as a target. Last, less than 3% of both genders had fluid as a target.

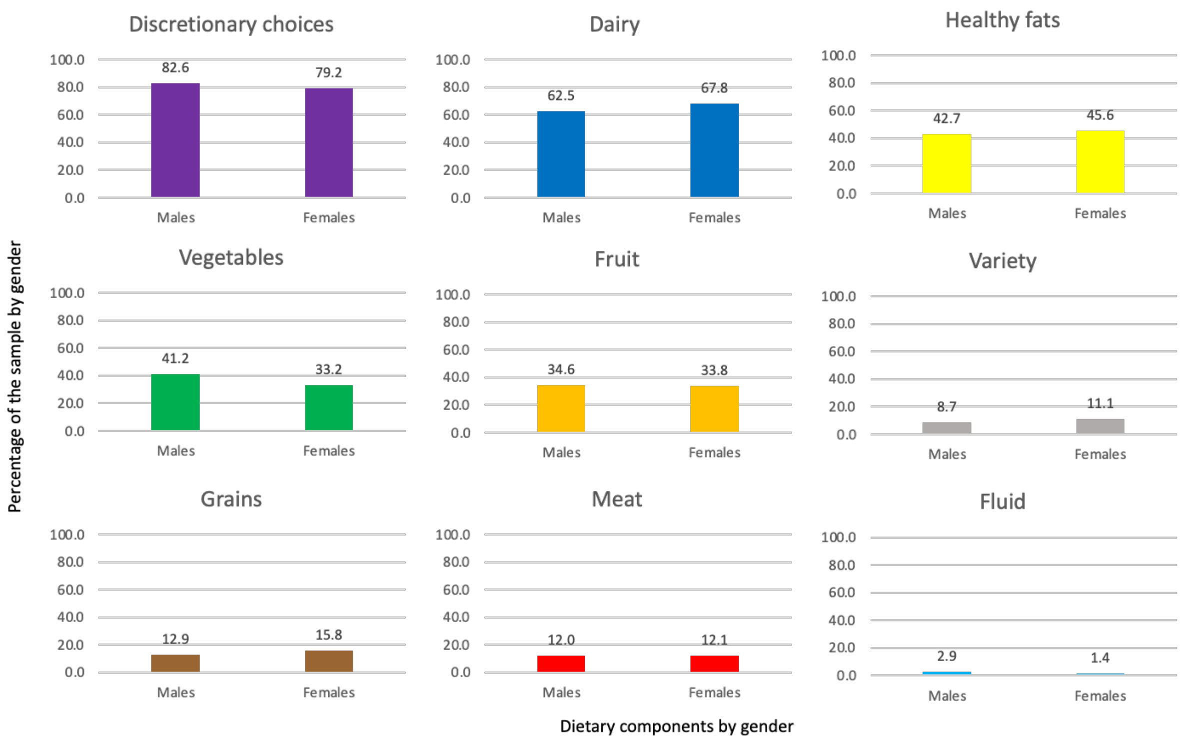


Figure 2-2: Frequency percentage of priority dietary targets (three dietary components with the lowest scores) by gender.

2.3.4.2.2 Age groups

The frequency percentage of participants with discretionary choices as a target was consistent across age groups (range: 79.9% for the 18–30 age group, to 81.7% for the 71+ age group) as shown in Figure 2-3. More of those in the 71+ year old age group (76.4%) had dairy as a target than those in the other age groups (range: 60.0%-67.7%). The frequency for the healthy fats component as a target incrementally increased with age (range from the 18–30 to 71+ age group: 38.7% to 51.2%).

Fruit was a target for approximately 40.0% of both the 18–30 and 31–50 age groups, but less often for the older age groups (29.4% and 19% of the 51–70 and 71+ age groups, respectively). Vegetables as a target was consistent across the 18–30, 31–50 and 51–70 age groups (36.8% to 38.4%), but less frequently for the 71+ age group (32.5%). The 71+ age group (12.1%) had dietary variety as a target more often than all other age groups, whereas the 31–50 age group had grains as a target more often (16.2%) than the other age groups. Meat and fluid were targets for less than 15% and less than 4.0% of all age groups, respectively.

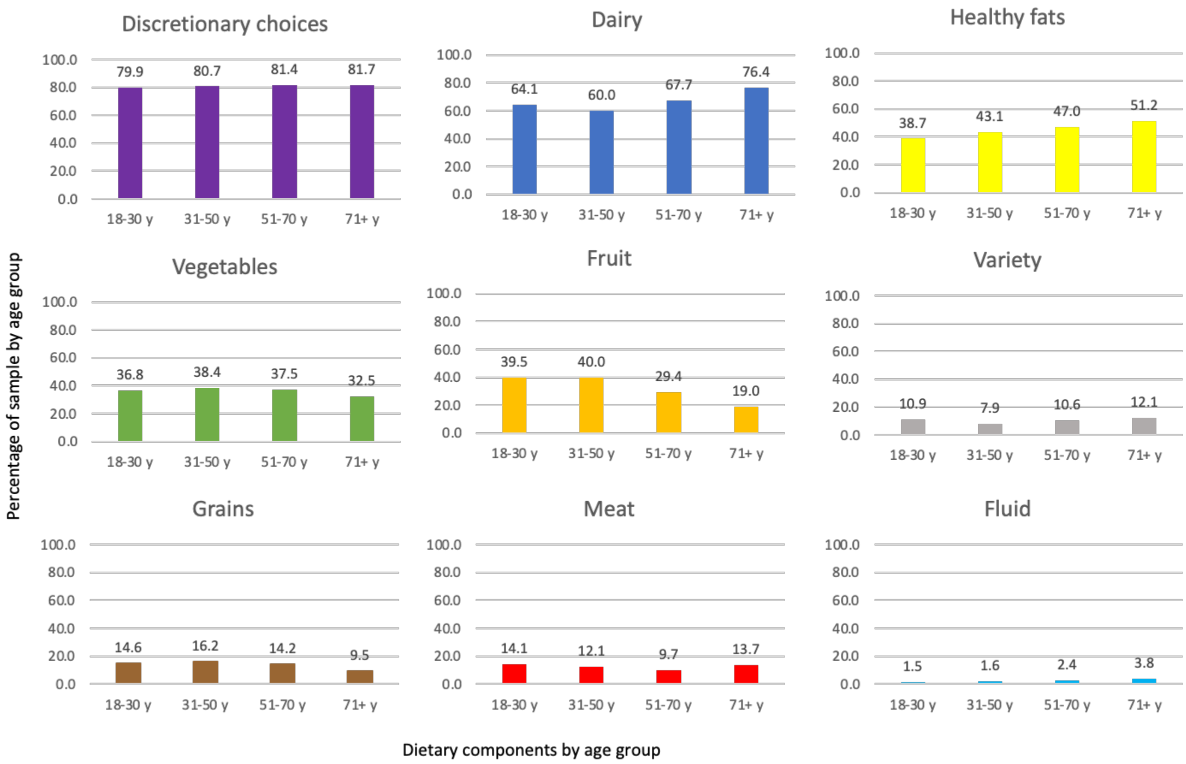


Figure 2-3: Frequency percentage of priority dietary targets (lowest three scoring dietary components) by age groups; y = years.

2.3.4.2.3 Weight status

The discretionary choices component appeared as a target for all participants, regardless of weight status group. The frequency of it appearing as a target increased by order of weight status, from 71.8% for the underweight and 78.7% for the healthy weight sample, to 82.5% and 84.1% for the overweight and obesity samples, respectively (Figure 2-4). Dairy as a target appeared more frequently for the underweight and healthy weight subgroups (71.3% and 69.6%, respectively) than for the overweight and obesity subgroups (64.0% and 56.7%, respectively). The healthy fats component was a target more frequently for the obesity group (47.0%) than for the other groups.

Participants in the obesity group had fruit (43.4%) more frequently than vegetables (34.5%) as a target. The fruit and vegetable components were otherwise similar in how frequently they appeared as targets in other weight status groups. The frequency of grains appearing as a target was consistent across weight status groups (range: 14.3%–16.0%). To a lesser extent, dietary variety was a target for less than 13% of the sample. Meat was a target for 21.3% of the underweight group, but for less than 10% of the obesity group. Less than 3% of all weight status groups had fluid as a target.

Figure 2-4: Frequency percentage of the priority dietary targets (three dietary components with the lowest scores) by weight status; Uw = underweight, Hw = Healthy weight, Ow = Overweight, Ob = Obesity.

2.3.4.2.4 Quintiles of diet quality

The frequency of dietary targets by quintiles of diet quality are shown in Figure 2-5. The discretionary choices component most commonly appeared as a target. Three-quarters or more of participants in quintiles 1 (85.8%) to 3 (93.3%) had discretionary choices as a target, compared with only just over half of participants in quintile 5 (56.8%). Relative to the other components, the higher the quintile level, the less frequently was discretionary choices a target.

In the opposite direction, the higher the quintile of diet quality, the higher the frequency for the dairy component being a target. Just over half of the participants in quintile 1 (51.1%) had dairy as a target, but this frequency increased to 78.4% for participants in quintile 5.

The healthy fats component appeared as a target more frequently across quintiles 3 to 5 (range: 47%–51.7%), than across quintiles 1 and 2 (34.2% and 40.7%, respectively). Quintile 1 (60.9%) had fruit as a target at nearly double the frequency of those in quintile 3 (32.0%) and at nearly six times the frequency of those in quintile 5 (12.0%). Vegetables appeared as a target at a similar frequency between quintile groups (range: 33.7%–39.3%). The dietary variety (20.7%), grains (21.2%) and meat (18.1%) components were targets for those in the higher quintile level (quintile 5) more frequently than for those in the lower quintiles. Fluid was consistently the target that appeared the least frequently for all quintile groups.

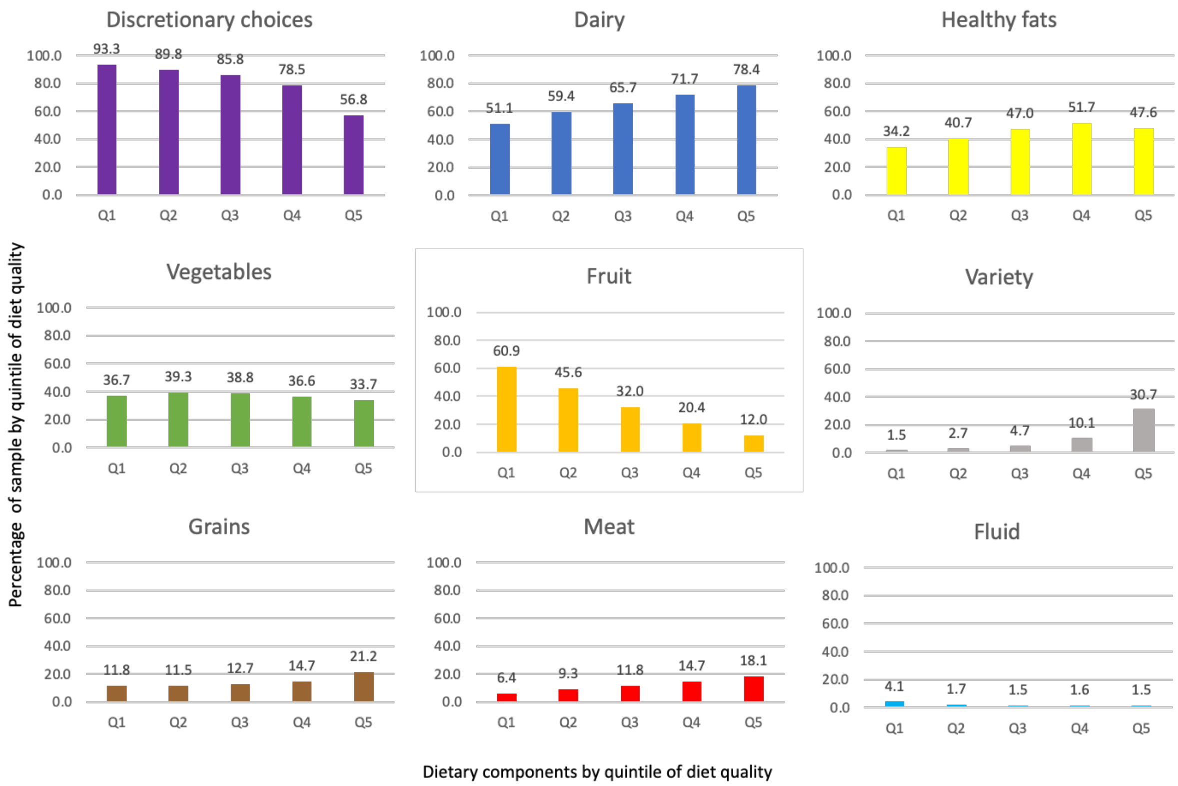


Figure 2-5: Frequency percentage of priority dietary targets (three dietary components with the lowest scores) by quintiles (Q) of diet quality.

2.3.4.3 Priority dietary targets using complex segmentation

The previous section reported the frequency of the priority dietary targets as they appear for the overall sample and by subgroups. The results (Table 2-4, Table 2-5, Table 2-6 and Table 2-7) showed that regardless of simple segmentation of subgroups, the discretionary choices, dairy and healthy fats components consistently appeared as priority dietary targets.

To ensure feasible, large-scale personalisation of dietary feedback, prioritising a dietary target for more defined population subgroups can be an alternative approach. Therefore, the following section aims to identify the best segmentation approach for identifying a priority dietary target. This will be done by comparing the frequency percentages of targets for the overall sample, with the frequency percentages on using more complex segmentation approaches. This approach could help determine whether more defined subgroups, using different combinations of characteristics, could represent the dietary patterns of the overall sample.

The frequency percentage of targets using complex segmentation approaches are shown in Figure 2-6**.** The overall sample data are shown for comparison in the figure, which displays the same results as in Figure 2-1. Across all complex segmentation approaches, the discretionary choices and dairy components appeared as targets 100% of the time. The healthy fats component was a frequent target for the quintile by gender group (80%) but was less frequent when the sample was grouped by quintiles by age, and quintiles by weight status (66.2% each group). Fruit appeared as a target 20% of the time for quintiles by gender group; 29.1% of the time for the quintile by age group; and most frequently (33% of the time) for the quintile by weight group. When the quintiles of diet quality characteristic were used in any subgroup (with or without other characteristics), the fruit component appeared as a target at a frequency that was more comparable with that for the overall sample, relative to subgroups that do not use quintiles as a characteristic. For example, 34.2% of the overall sample had fruit as a target, and all subgroups that use quintiles of diet quality as a characteristic, had fruit as a target 20.0% to 33.0% of the time. However, for the subgroups that exclude quintiles of diet quality as a characteristic, the frequency of fruit as a target was 11.6%.

The overall sample shows that each of the nine components appeared as a target at some frequency. This was not the case for the subgroups. For example, for the quintile by gender subgroup, only the discretionary choices, dairy, healthy fats and fruit components appeared as targets. In contrast, for the most complex segmentation (i.e. the more the characteristics used for segmentation), there was more variation in types of dietary targets (Figure 2-6). In the age by gender and weight status subgroup, vegetables and fruit appeared as targets in addition to discretionary choices, dairy and healthy fats. In quintiles of diet quality by age, gender and weight status subgroups, the following seven components all appeared as targets: discretionary choices, dairy, healthy fats, vegetables, fruit, dietary variety and grains (0.04% frequency may not be visible in the figure).

In summary, discretionary choices, dairy and healthy fats components most frequently appeared as priority dietary targets. The more complex the segmentation approach, the more comparable was the variety of dietary targets with the overall sample. When subgroups were defined using the quintiles of diet quality characteristic (with or without other characteristics), the variety of dietary targets increased. For these subgroups, the discretionary choices, dairy, healthy fats and fruit, appeared as a target at a frequency that was somewhat comparable with the frequency for the overall sample.

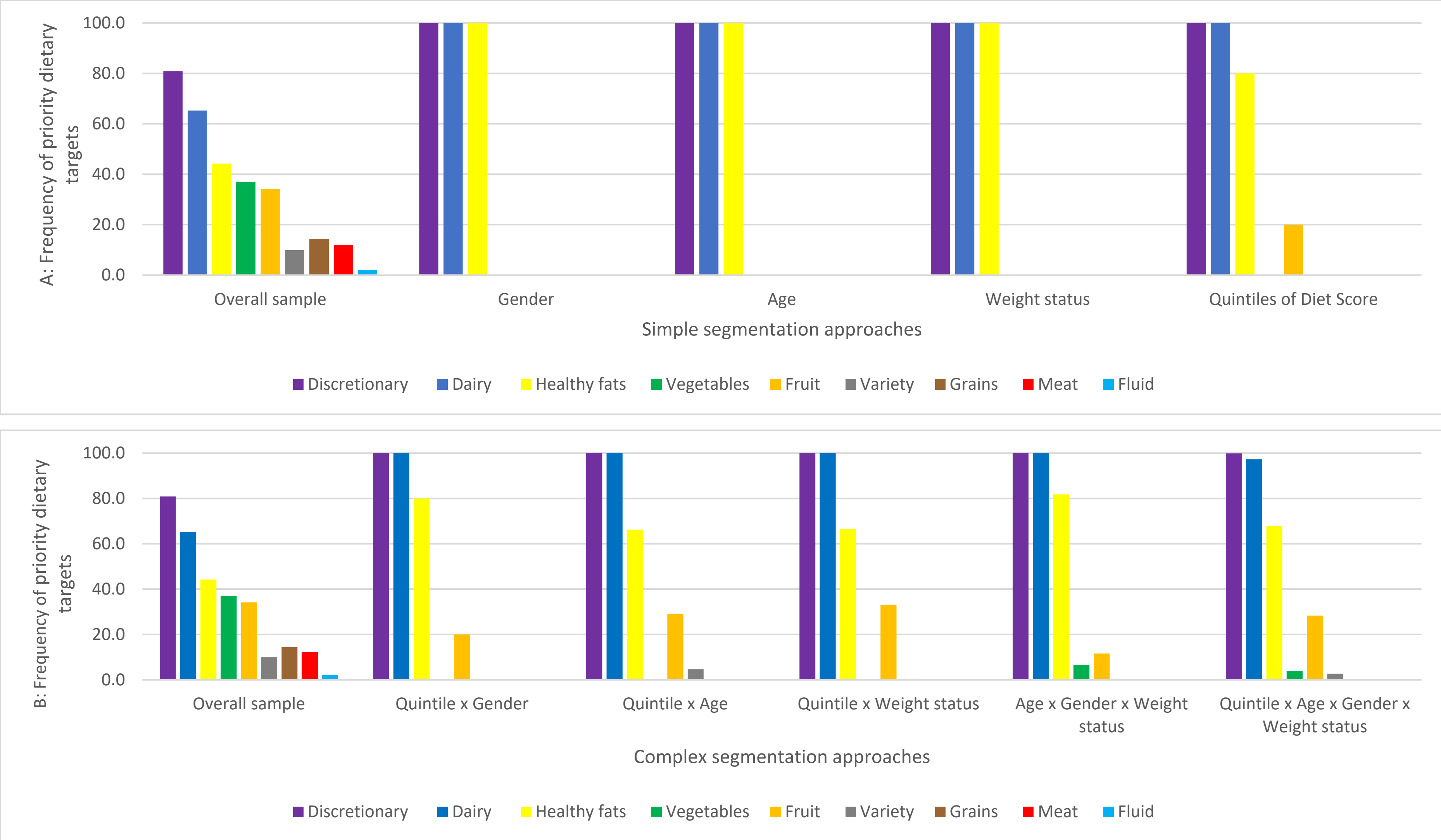


Figure 2-6: Overall frequency percentage of priority dietary targets appearing for overall sample and by segmentation approaches using simple (one characteristic) or complex (more than one characteristic combination) segmentation.

2.4 Discussion

2.4.1 Purpose of this study

The purpose of this study was to identify priority dietary targets for intervention and to understand whether these targets vary by more defined subgroups using gender, age, weight status and levels of diet quality as characteristics. This study analysed overall diet quality scores and diet component scores using nine simple and complex segments of population subgroups and compared the scores extensively with those for a large sample of the Australian population. The novel approach of this analysis revealed whether priority dietary targets need to differ with the increasing complexity of population subgroup segmentation. Three key findings were observed. First, regardless of segmentation approach for the subgroups, the discretionary choices component (food group) consistently had the lowest score based on the lowest compliance with the ADGs. Second, the dairy and healthy fats food groups were consistently the second and third lowest score, regardless of segmentation approach for the subgroups. Last, any subgroup that included quintiles of diet quality as a characteristic had the most similarity in the rank order of component scores with that for the overall sample. The study findings inform that the discretionary choices group is the priority dietary target for interventions that aim to maximise overall diet quality improvement at the population level. Dairy and healthy fats are the second and third dietary targets for maximising diet quality improvement. If interventions were to tailor the rank order of dietary targets by any subgroup, tailoring could be based on the quintiles of diet quality characteristics.

2.4.2 Discretionary choices as the priority dietary target for intervention

The analysis revealed that regardless of subgroup, 81% of the sample complied the least with the discretionary choice dietary guideline (10), meaning that the discretionary choices food group is the priority dietary target for intervention. This finding is supported by the National Nutrition and Physical Activity Survey 2011–2012 data, which demonstrated that adults obtained more than one-thirds (35%) of their total daily energy from discretionary choices (14). A recent secondary analysis of this database found that 97.5% of Australian adults consumed discretionary choices daily, and over 60% consumed more than the maximum recommended intake of three serves per day (63). An older study on the dietary intake of samples in two American states found that the reported intake of discretionary choices (including high sugar foods, beverages and alcohol) exceeded guidelines by over 60% in Los Angeles and by 120% in Louisiana (196). This was compared with the consumption of fruits and vegetables. which fell short of the guidelines by 10%– 20% (196). These findings convey that the overconsumption of discretionary choices may be a larger issue than the underconsumption of fruits and vegetables.

In diet quality index studies, similar findings for component scores were found. Using a food frequency questionnaire and applying DGI scoring, a study conducted on older adults found that discretionary choices scored the least among all diet components. For example, out of 10 points, males had the lowest score for discretionary choices (2.6 ± 0.11), whereas females had the third lowest score for discretionary choices (3.8 ± 0.11) (64). In contrast to these findings and the current study's results, an analysis using the Healthy Eating Index for Australian Adults found that discretionary choices scored an average of 5 points out of 10 (45). The score achieved for discretionary choices was higher than that achieved for grains, vegetables and fruit (45), meaning the latter food groups would be a 'higher priority' for intervention, than discretionary choices. Conversely to Grech and colleagues, the current study results showed that fruit and vegetables were, on average, the fourth and fifth lowest scoring diet components. Nonetheless, since the discretionary choice intake of the majority of the Australian population is excessive, this behaviour could be displacing the intake of core food groups, such as fruit and vegetables.

Discretionary choices are high in kilojoules, added sugars, salt and fat, and are associated with a lower intake of healthy core food groups (66). The overconsumption of discretionary choices and the underconsumption of fruit and vegetables, as a dietary pattern, is associated with the risk of chronic diseases, such as type 2 diabetes, cardiovascular disease and stroke (197, 198), which accounted for more than half of total global deaths in 2017 (2). Although conducting the online nutrition interventions that have focussed on increasing fruit and vegetable consumption as proxy measures to overall diet quality is warranted (41, 134, 153, 163, 165, 171), these approaches have resulted in small increases in fruit and vegetable intake, by 0.24 (163) to 0.34 serves per day (171). Solely focussing interventions on increasing fruit and vegetable consumption may be politically more expedient, to maintain the number of food sales, rather than decreasing discretionary choices (196). However, such interventions may have a limited impact on maximising improvement in overall diet quality and health outcomes. Thus, in addition to fruit and vegetables, discretionary choice intake needs priority intervention focus.

Only a few studies have focussed on discretionary choices as the priority dietary target. For example, a 2018 systematic review of feedback interventions and the related effects on dietary behaviours found that only 11 of 25 studies focussed on nutrients associated with discretionary choices, such as the total fat or saturated fat intake (154). Of two similar reviews, one found that 10 of 45 studies focussed on total fat intake (171) and the other found that four of 21 studies focussed on saturated fat intake (165). Given their common focus on reducing the intake of particular nutrients (i.e. fat or saturated fat), none of the identified studies considered discretionary choices as a whole food group. However, one recent study published in 2021 examined changes in intake of discretionary choices following a feedback intervention (199). Its results demonstrated that the intervention reduced the percentage of energy, total fat and sugar contributed from discretionary choices, confirming the merit of focussing on discretionary choices as dietary outcomes in interventions (199).

2.4.3 Number of priority dietary targets needed for a feasible intervention

This study demonstrated that the discretionary choices food group needs prioritising in interventions, followed by dairy and by healthy fats. Although other diet quality assessment studies have shown that dairy is a low scoring component (45, 64), there is a lack of evidence on healthy fat intake within overall diet quality. Nonetheless, the current focus in online feedback interventions, such as the CSIRO Healthy Diet Score in Australia (30) and international interventions (34, 38), is to target three dietary components. Conversely, the Healthy Eating Quiz survey provides feedback on all components associated with diet quality simultaneously in one detailed report (31). Targeting multiple diet components in interventions is warranted if time and cost resources are available. However, theory has suggested that intervening on one dietary behaviour at a time is associated with optimal behaviour change success (173). Therefore, starting with one dietary target may be a feasible, effective approach for intervention.

Focussing on one dietary target, in this case discretionary choices, and then introducing other dietary targets incrementally, may allow interventions that aim to improve overall diet quality to be more effective and sustainable, as opposed to targeting all diet quality components simultaneously (173). Based on the present study's findings, dietary interventions could focus on discretionary choices as the first and most important dietary target. Dairy and healthy fats were consistently the second and third lowest scoring components in the current analysis and thus could be the subsequent priority dietary targets to achieve overall diet quality improvement. However, the rank order in which dietary targets are prioritised in interventions could differ by population subgroup.

2.4.4 Prioritising dietary targets by population subgroups

This study tried to identify whether priority dietary targets differ by gender, age and weight status subgroups. Results showed that regardless of subgroup, the rank order of diet component scores remained the same. However, when the sample was segmented into quintiles of diet quality (quintiles) subgroups, the rank order of component scores varied to a greater extent. For example, the highest quintile (quintile 5) had dairy as the lowest scoring component, instead of discretionary choices. The lowest quintile level (quintile 1) had a lower component score for fruit, which replaced healthy fats in the components with the lowest three scores. These results portray that if an intervention were to target different diet components based on quintiles of diet quality subgroups, the order may differ and thus result in more potential for maximising overall diet quality improvement.

In regard to other subgroups, characterised by gender, age and weight status, this study found that females (v. males), those in the older age groups (v. younger) and those in the healthy weight range (v. overweight and obesity) had a slightly higher overall diet quality score. This finding is in line with well-established research that indicates that men have poorer diet quality than women, and that older adults have better compliance with ADGs than younger adults (24, 64). Further, adults in the healthy weight range, or that have a healthy waist circumference, are more likely to have healthier diets than those in the overweight or obesity weight ranges (4, 28, 75, 192). Regardless, there were no differences in diet component score ranks between these subgroups, indicating that discretionary choice intake should be a dietary target for the majority of people.

In summary, all segmentation approaches for population subgroups resulted in discretionary choices, dairy and healthy fats as priority dietary targets. However, if a large-scale dietary intervention were to choose one dietary target to prioritise, it would be discretionary choices, because this could maximise diet quality improvement on a population level. Further, were an intervention to tailor the dietary targets to prioritise for population subgroups, segmentation by quintiles of diet score as a characteristic could result in more variety in the rank order of the dietary targets. Nevertheless, other characteristics could be used to segment population subgroups, as discussed in the next section..

2.4.5 Using other demographic characteristics to identify dietary targets

The characteristics chosen to identify priority dietary targets in the current study may have been limited. The segmentation of the current sample into easily measurable, broad demographic and baseline diet quality characteristics did not appear to make a substantial difference in component score rank order, even if there were varying overall diet quality scores. In addition to gender, age and weight status, the database used for this study had data on participant postcode (area of living), state of residence and occupation (30). Using these as additional characteristics in the subgroups may have resulted in variation in diet component scores. Cross-sectional studies conducted in Australia (66, 200) and internationally (201) suggested that particular socio-economic factors, such as income and area-level disadvantage, are related to overall diet quality. Earlier research conducted on the DGI assessment tool found significant associations between higher Socio-Economic Index for Areas (SEIFA) quintiles and higher diet quality scores, especially among those aged less than 55 years (202) and females (24). However, considering the consistency observed in diet component scores based on other demographic subgroups, and the high association between SEIFA quintiles and diet quality, using SEIFA as a characteristic may not have resulted in different priority dietary targets—and nor would have using state of residence or occupation as a characteristic. Published results examining diet quality between states of residence have found minimal differences in scores. For example, in Australia, a diet quality score point difference of 2.2 separated the highest (the Australian Capital Territory) and lowest (Tasmania) scoring states (30). Minimal differences in diet quality score have also been shown between occupations. Retired adults and those working in the health industry reported a higher diet quality score (by about 8 points) than did construction workers and those unemployed at the time (30). It can be concluded based on these small differences in diet score that the priority dietary targets are unlikely to vary between these subgroups. Nonetheless, geographic variables may be important to use as covariates in future analyses of diet quality.

2.4.6 Strengths and limitations

This is the first study to conduct a comprehensive analysis on overall diet quality and diet components, by population subgroup. The large dataset used for the analysis was a major strength for powered analyses on multiple subgroup categories. This dataset facilitated the use of several participant characteristics for varying degrees of segmentation. This approach allowed using an innovative method to assess diet component scores and to compare the scores between subgroups, and to the overall sample. The findings from this study are also in line with previously published findings using this dataset, thus validating the study results (4, 30). Last, a further strength of this study is its analysis of overall diet quality using food groups, which may allow its results to be more applicable in practice than, for example, results found on analysing micronutrients or single foods. Despite the strengths associated with this secondary analysis, its limitations should also be acknowledged.

One such limitation is that the cross-sectional nature of the data did not support inferring causal relationships between diet quality and subgroups. One important consideration of the current analysis is that the sample, although large, may not be representative of the whole Australian population (5). Analysis is likely to be influenced by self-selection bias (203), given that those who completed the survey did so of their own accord. Therefore, they are likely to have a stronger interest in nutrition than those who have not completed the survey. In addition, reverse causality may have occurred in some subgroups, especially for the overweight or obesity subgroups (24). Those with overweight or obesity, especially women, are more likely to be more conscious of healthier behaviour to lose or manage their weight and thus consume more core food groups (24). Yet another limitation is that this study also used self-reported data from a validated online survey. Given the social and psychological factors associated with diet, such data could produce social desirability bias. For example, misreporting bias may have affected the diet quality scores, particularly in participants with overweight and obesity, who may underreport their consumption of foods that have an unhealthy stigma (204, 205). Misreporting bias is a frequently reported limitation in these types of dietary data collection studies (24, 26, 30, 31). However, this bias may have been accounted for, given the confidential and anonymous environment of online dietary data collection (206). Further, to account for self-selection and misreporting bias in this study, the reported dietary intake was adjusted to the national dietary data (190).

In addition, the survey used to collect dietary data may have limitations. For instance, a study that attempted to validate the SFS (29) showed that intra-class correlations for compliance with the discretionary choices and healthy fat recommendations were below an acceptable level, meaning these survey questions need further refinement. Individuals were asked to estimate their fruit intake in one question, whereas they had to report on meat intake in five separate questions and on discretionary choice data across 10 questions. The rationale offered for asking the additional questions was that it is important to estimate individuals' consumption across such diverse food categories (29). However, the survey needs refinement to balance the number of questions with the accuracy of responses.

Further, as commonly observed in nutrition studies of this type, certain subgroups of the population, including males, older adults (191) and people with obesity, were under-represented relative to the Australian population (5). These differences were partially accounted for by weighting the data to reflect the national distribution of gender and age (191). To improve generalisability, future efforts for online recruitment could focus on advertising recruitment for dietary data collection surveys in male-dominant environments, such as construction-type workplaces, and identifying approaches to attract individuals who may be less motivated to improve their health and dietary behaviours.

2.4.7 Implications for practice and future research

This study has added evidence to the diet quality assessment literature on discretionary choices being an important diet component, or food group, to prioritise in feedback interventions aimed at a population. Current practice involves the delivery of feedback to individuals on the lowest scoring diet components based on their compliance with dietary guidelines, following an assessment of their overall diet quality. However, this study showed that, if an intervention were to focus on one, or a few, dietary targets to maximise the improvement of overall diet quality on a population level, discretionary choices, followed by dairy and healthy fats would be the three priority dietary targets for intervention. Although the study aimed to understand whether these priority dietary targets differed by more defined population subgroups, it found no differences in the rank order of diet component scores. However, using quintiles of baseline diet quality score showed more variation in the rank order; hence, if the aim is to deliver more targeted feedback in an intervention, the sample could be categorised into subgroups by their baseline diet quality.

2.5 Summary and Chapter Conclusion

To address the evidence gap on whether priority dietary targets need to differ for population subgroups to maximise diet quality improvement, a data-driven subgroup analysis was conducted on diet quality and its components. The findings showed that regardless of the segmentation approach for subgroups, the discretionary choices group was consistently the priority dietary target for intervention, owing to the sample's low compliance with the ADGs for discretionary choices. The results demonstrate the need to intervene in the discretionary choices food group. Excessive discretionary choice intake is a ubiquitous dietary behaviour, but population-level efforts to reduce the intake of this food group have been limited. Further investigations are needed on effective approaches to decrease the population's discretionary choice intake and to potentially maximise overall diet quality improvement.

2.5.1 Bridging summary

The discretionary choices food group was identified as the priority dietary target, regardless of population subgroup. The next chapter will embed this knowledge and report the methodology used for designing and testing a nutrition message framing intervention that aims to reduce discretionary choice intake, as a first step to improving overall diet quality. Since the priority dietary target did not differ between subgroups based on gender, age or weight status characteristics, other unexplored characteristics for tailoring nutrition messages, delivered via feedback interventions could be explored, such as a psychosocial variable like intention. By focussing on one dietary target in an intervention, discretionary choices, efforts can be devoted to tailoring *how* a nutrition message is framed to address this dietary target, to effectively reduce discretionary choice intake.

CHAPTER 3 STUDY METHODS

3.1 Overview

This chapter reports the methods of a randomised controlled trial (RCT) with a nested randomised crossover trial. First, the study design is presented in the next section, followed by a description (section 3.3) on the crossover trial that addressed thesis objective 2: to test for differences in reported intention to improve dietary behaviour after exposure to four different nutrition messages framed as (1) positive, (2) negative, and (3) majority and (4) minority descriptive norms, within a sample of Australian adults. The outcomes of this study also informed which tailored nutrition message frame participants would receive in the intervention. Using the RCT design (section 3.4), thesis objective 3 was addressed: to design, test and compare the effects of a brief online dietary feedback intervention, between delivering a tailored nutrition message frame, and a generic nutrition message, on improving diet quality, in a sample of Australian adults. From here onwards, a reduction in *discretionary choice intake* is the priority dietary target for intervention, since the secondary analysis reported in Chapter 2 found it to be the key component for maximising diet quality improvement. After the RCT, process-evaluation data were collected (section 3.4.5). Last, individual characteristics as predictors of intervention effectiveness were investigated (section 3.4.6) to address thesis objective 4: to determine participants' demographic, anthropometric, behavioural and psychosocial characteristics that predict (i) an improvement in diet quality, and (ii) compliance with the dietary guidelines, after a brief online intervention.

The development of the intervention was informed by current evidence. The review of the evidence presented in Chapter 1 was used to (1) identify the nutrition messages that needed further testing in a tailored intervention, (2) synthesise key intervention features that have been associated with diet quality improvement and (3) address the literature gaps about the current effectiveness of brief online interventions on diet quality. The review of evidence informed the development and testing protocol of an innovative model for intervention, which used different nutrition message frames tailored on a theoretical concept, with the aim to reduce discretionary choice intake.

3.2 Study Design

This section will discuss a two-trial study. The two-trial study was designed as a two-armed parallel RCT, with a nested crossover trial (Figure 3-1). The study was designed to allow the RCT to build on the outcomes of the crossover trial, to deliver a tailored nutrition message in a brief online intervention and to test its effectiveness against that of a generic nutrition message given to the control group.

Individuals who provided consent and were eligible to participate were randomised into the RCT. Separate allocation schedules were designed for the RCT and the crossover trial. A survey-generated randomisation sequence using an A/B block design for the RCT was used to randomise participants into the tailored intervention or the control group. Upon completion of baseline questionnaires, the survey-generated allocation sequence for the crossover trial was processed. This placed each participant in one of 24 sequences to be exposed to the four messages in a random order and minimise allocation bias. This process is explained in more detail in section 3.3.

At baseline, all participants reported their intention to change discretionary choice intake for the next 28 days. All participants self-reported baseline dietary intake through the SFS and completed the COM-B Self-Evaluation Questionnaire version 1 (COM-B-Qv1). The tailored intervention participants then went on to conduct the crossover trial. The control group did not conduct the crossover trial, but all participants were asked to report demographic and anthropometric measures, and their best contact email address so the intervention content could be emailed to them.

The crossover trial was used to test the effectiveness of different nutrition message frames on intention to change discretionary choice intake. This process was used to inform the tailored nutrition message that participants would receive in the tailored intervention in the RCT. The four nutrition message frames chosen for testing in the crossover trial were based on theoretical frameworks and previous research (49, 51, 89, 207). Participants were exposed to the four nutrition messages in a random sequence. Then, they were asked to report their intention to eat less discretionary choices for the next 28 days. The message that resulted in the highest intention score was the tailored message that participants received in the RCT.

In the two-armed parallel RCT, participants randomised to the tailored intervention group were emailed the nutrition message that was associated with the highest intention score. The control group received a generic nutrition message. The generic message was based on the standard practice of current dietary feedback interventions. In addition, only the tailored intervention participants received enhanced behavioural support on reducing discretionary choices, guided by BCTs previously been associated with intervention effectiveness (173).

All participants received an email on day 1 and day 14. On day 28, all participants received an email with a unique link to complete the follow-up survey. This consisted of follow-up measures of intention to change discretionary choice intake and dietary intake using SFS, and a process-evaluation questionnaire to quantitively and qualitatively measure satisfaction with the intervention.

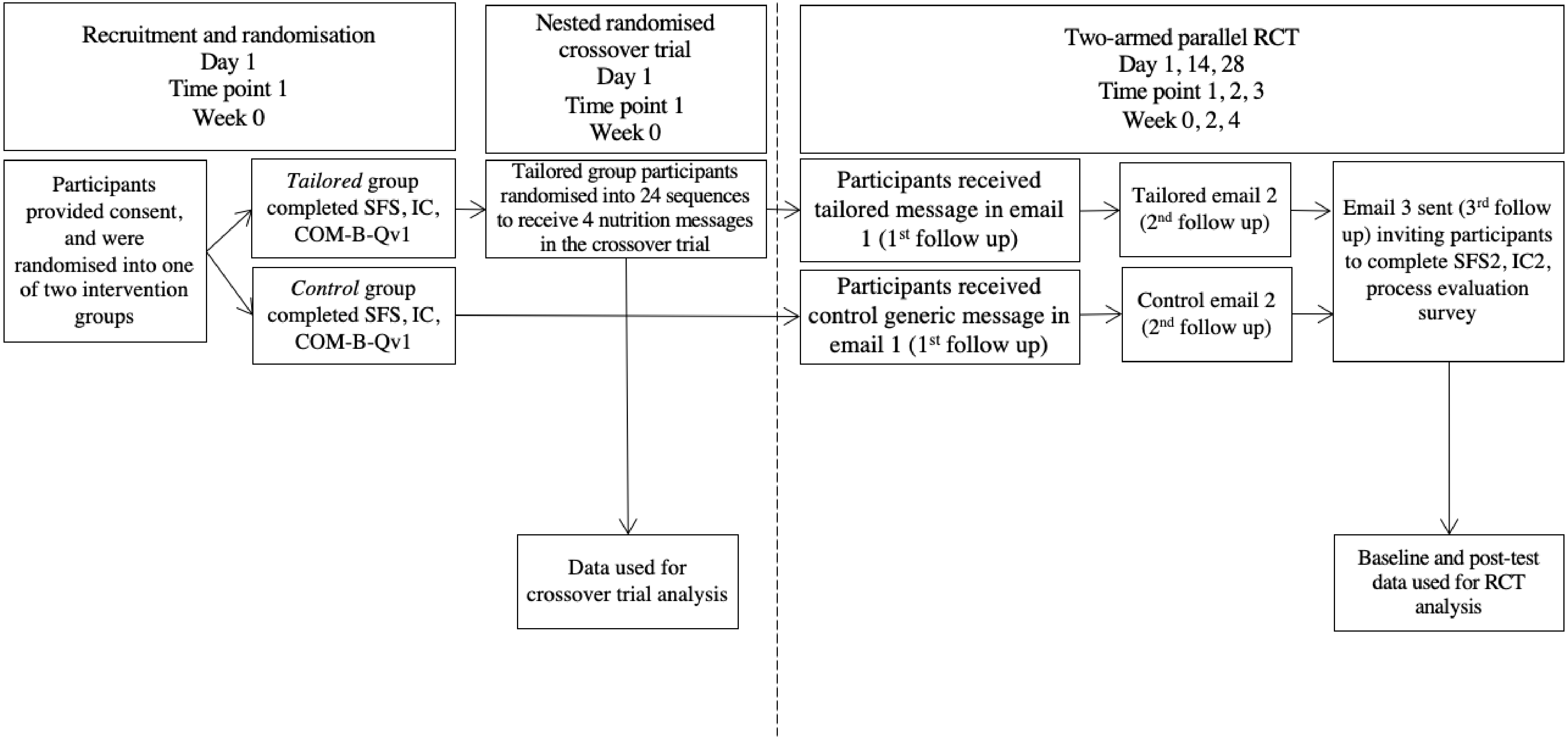


Figure 3-1: Process of the two-armed parallel randomised control trial (RCT) with a nested crossover trial. SFS: Short Food Survey; IC: Intention to Change; COM-B-Qv1: Capability, Opportunity, Motivation-Behaviour System Self-Evaluation Questionnaire version 1.

3.2.1 Ethics

Ethics approval was received from the CSIRO Low Risk Health & Medical Research Ethics Committee (2019_051_LR) and reciprocal ethics was approved by the Flinders University Social and Behavioural Research Ethics Committee (OH-00224) in August 2019 (Appendix 5). The trial was registered on the Australian New Zealand Clinical Trials Registry (ACTRN12619001202156) and approved on the 28 August 2019. An incentive was offered to participants, with a chance to go into a draw of winning one of 30 gift vouchers to the value of AU$100.

3.2.2 Target population

3.2.2.1 Inclusion criteria

Participants were included in the study if they reported they were at least 18 years old; residing in Australia; not purposely avoiding major food groups (wholegrains, fruit, vegetables, dairy and/or alternatives, and meat and/or alternatives); having internet access; and having good spoken/written English language skills. These criteria were reported on in responses to the initial questions in the baseline questionnaire (Appendix 6). Participants were excluded from the study if they did not consent to taking part as per section 3.2.3.3.

3.2.2.2 Settings and location

SurveyGizmo, and online software program, was used for data collection at baseline and follow-up; and for delivering the intervention and control content using email templates. Individuals interested in the study were able to access the study information. After this study was conducted, the software program was rebranded to Alchemer (https://www.alchemer.com/). For the purpose of this chapter, the software name will be stated as SurveyGizmo.

3.2.3 Study procedures

3.2.3.1 Recruitment

Data for the study were collected online from Australian adults, from 8 September to 23 December 2019. Recruitment for the open study survey was conducted through multiple modes. The first mode was paid Facebook and Instagram advertisements—to the value of AU$1,104.99—using the CSIRO social media pages. The total spent on Facebook advertisements was $997.29, and on Instagram, $107.70. Because research conducted via social media usually attracts mostly females (208), 70% of this budget was chosen to target males ($896.36), with the aim of achieving an even ratio of males to females. Overall, the advertisement (ad) statistics showed that these ads were displayed on the newsfeed of 161,965 people; they were seen by 91,935 people; and 2,491 clicked into the ad. The second recruitment mode was via an email sent directly to all participants in the CSIRO volunteer database. This database comprises adults who had previously given consent to be contacted about additional research that CSIRO was conducting. Of the survey invitation emails sent to the 13,958 recipients in the database, 7% bounced back as undeliverable. Therefore, 12,981 participants were reached via this recruitment mode. The third recruitment mode was through publishing the study details on public webpages: ‘CSIRO current studies’ and ‘Flinders University current studies’. Last, CSIRO’s Twitter and LinkedIn accounts published recruitment invitations for the study; and posters were displayed on levels 5 and 8 of the South Australian Health and Medical Research Institute building in Adelaide.

3.2.3.2 Pilot testing

To gather important insights that aid intervention success, intervention development should involve some qualitative research with a range of people to better inform intervention development, from planning to feasibility testing and implementation (209). Three levels of pilot testing were conducted prior to the official recruitment. Upon finalising the initial crossover trial survey design, a convenience sample of 10 people from the Nutrition and Dietetics department of Flinders University were asked to provide qualitative feedback on the readability of the survey questions and intervention messages and on the functionality of the survey (whether randomisation was working as protocol and without error).

The second level of pilot testing was conducted for the RCT. Another set of 10 people were recruited through word of mouth, including this PhD candidate’s family members, friends and members of the community who were interested in being involved in the piloting stage. They were asked to provide feedback on the readability of survey questions and the persuasiveness/intrigue of the crossover trial messages. They were also asked to provide qualitative feedback on the timeframe of the trial and the practicality of accessing the intervention via email.

The third and final phase of pilot testing was focussed on ensuring the randomisation functions were performing as per protocol. Another 10 people—the candidate’s colleagues from CSIRO and Flinders University—were asked to conduct a pilot of the crossover trial that also led them into the RCT; this pilot intervention was conducted over a week (as opposed to 28 days), for timeliness.

The main changes applied after the pilot phases were a reduction in the survey preamble and the use of more informal language. Pilot participants reported they preferred instructions to be bold, clear and straightforward. They also asked for the option to ‘save’ their responses, so they could come back to finish the survey later. Last, their feedback to remove the emotive language used in defining ‘discretionary choices’ was applied to reduce the risk of influencing participants’ reported intention at baseline.

3.2.3.3 Consent

Once eligibility was confirmed, the study details were presented via a standardised study information sheet with electronic consent (Appendix 6). Only participants who voluntarily consented were given permission to proceed to the study. Those who did not were guided to a study conclusion page thanking them for their time.

3.2.4 Data collection

3.2.4.1 Intention to reduce discretionary choice intake questionnaire

The theory of planned behaviour (157) was used to inform the development of intention questions. A published manual developed to assist health researchers in producing an effective questionnaire to measure the theory of planned behaviour constructs (210), and a previous study measuring intention after message exposures (118, 157), were used to guide the intention to change questionnaire.

To measure intention, participants were asked to complete a questionnaire with three items. Using a visual analogue scale, participants rated, from 'strongly disagree' (=1) to 'strongly agree' (=100), the following statements: 'I expect to—', 'I want to—' and 'I intend to—' followed by 'eat less discretionary choices at meal and snack times, each day for the next month' (Appendix 6). A visual analogue scale with measurements to the nearest millimetre was chosen since it allows a finer measurement of potential change, and since this approach has been used in previous studies (127, 211). This measurement method can also minimise carryover bias by making it challenging for participants to remember their previously reported intention score. The baseline measure of intention was calculated as the mean score of the three items. The reliability of the three items of intention at baseline and after each message exposure was analysed using Cronbach's alpha (for more details, see section 3.3.4).

3.2.4.2 Dietary intake data using Short Food Survey

The SFS was used to collect dietary consumption data in this study, including on discretionary choice intake. A recent systematic review, in synthesising the validity and reliability of short survey tools from 30 validation studies (212), found that the SFS (29) was reliable and valid since it provides the most comprehensive set of questions that can be compared against dietary guidelines. This measurement tool is described in detail in Chapter 2, section 2.2.4. In brief, data from the SFS were used to calculate a score (out of 10) for nine diet quality components. These components were individually scored, and these scores were summed to provide an overall diet score, ranging from 0–100, where a higher score reflects higher diet quality owing to greater compliance with the

ADGs. Discretionary choice intake in serves was measured at baseline and follow-up, and the variable is detailed in section 3.4.4.

3.2.4.3 Demographic and anthropometric characteristics

Demographic and anthropometric measures were self-reported at baseline. Information on gender (male or female), birth year, height (cm), weight (kg) and postcode were collected. Consistent with the methods described in Chapter 2 (section 2.2.4), participants' age was calculated, based on which they were categorised into four groups. Further, their BMI was calculated, and they were categorised into four groups based on their weight status. In this study, socio-economic status was assessed using the SEIFA indices for postcode, which are validated measures of geographical SES derived using principle component analysis from the 2016 Census of population and housing (213). The SEIFA indices consist of four related domains: advantage (high scores indicating high income, skilled labour) to disadvantage (low scores indicating low income, low educational attainment, high unemployment and employment in relatively unskilled occupations). Area-level disadvantage was divided into quintiles, ranging from the least disadvantaged (i.e. most affluent—quintile 5) to the most disadvantaged (quintile 1). Where there were category sample numbers that comprised less than 2% of the overall sample, the results were not shown.

3.2.4.4 Psycho-social characteristics using the Behaviour Change Wheel

The development of the RCT intervention drew on the BCW framework as a theoretical grounding, which is underpinned by three psychological domains: capability, opportunity and motivation to provoke behaviour change (COM-B). The first step of the BCW process was to specify the priority dietary target (discretionary choices, as informed by Chapter 2). The next step was to identify the barriers or facilitators that could hinder or support the dietary target behaviour. To quantify this aspect and to understand better whether and how COM-B can enhance intervention effectiveness, the COM-B-Qv1, extracted and adapted from Michie et al., was administered to participants at baseline (173).

In this regard, eight items related to each of three COM-B domains, comprising 24 items shown in a random order to each participant (Table 3-1). Within each domain, each item was associated with its behavioural component: physical or psychological *capability*; physical or social *opportunity*; and automatic or reflective *motivation*. Participants were asked to select as many of the 24 statements that applied for supporting a reduction in discretionary choice intake, at meal and snack times, every day. They could select as many or as few statements that applied to them (Appendix 6). The items were summed to identify a score for capability, opportunity and motivation, on a continuous scale (0–8) for each domain. This procedure provided the score of each domain for participants, allowing a behavioural diagnosis of the relevant COM-B components.

Table 3-1: COM-B self-evaluation items with corresponding response options for the question: 'When it comes to you personally, what do you think it would take for you to eat less than two serves of discretionary choices every day? Take the time to consider this and select all the statements that apply (select as many or as little as you find apply to you.)'.

Psychological domain	Response options
Capability	1. Know more about why it is important 2. Know what to do 3. Have better food planning skills 4. Have better cooking skills 5. Have greater willpower 6. Know how to enjoy the taste of other, healthier food 7. Overcome physical limitations like injuries or disabilities 8. Overcome mental limitations like stress associated with time constraints or pressure
Opportunity	1. Have more money 2. Have more time to plan meals 3. Have more time to cook or prepare 4. Have less access to discretionary choices 5. Have better access to kitchen and/or cooking facilities 6. Have more people around me eating healthier 7. Have more triggers to prompt me 8. Have more reminders to plan, shop, cook and stick at it
Motivation	1. Feel that I want to do it enough 2. Feel that I need to do it enough 3. Feel that it would be a good thing to do 4. Care more about the health consequences associated with it 5. Develop a habit of planning to eat less discretionary choices 6. Develop a habit of not buying discretionary choices 7. Develop a habit of preparing healthier food 8. Develop a habit of eating healthier food

3.2.5 Data analysis

3.2.5.1 Sample size calculation

Since the crossover trial was nested within the RCT, a final sample size calculation was conducted for the RCT. Based on a hypothesised 0.25 to 0.30 (163, 171) serve size difference of discretionary choice intake between the two intervention groups, a priori power calculations indicated that a sample range of 732 to 1,430 participants would give 80% power to detect a small effect size at a significance level of 0.05. An additional 25% accounted for potential participant attrition. This resulted in a sample size estimate of 915 to 1,788 participants.

3.2.5.2 Data handling and preparation management

Data from the SurveyGizmo software were exported to Microsoft Excel (2013, Microsoft Corporation, Redmond, WA) and anonymised. The data were imported into the SPSS statistical software package, Version 25 (IBM SPSS Statistics [computer program]. Version 25. Armonk, NY: IBM Corp; 25 August 2017).

3.2.5.3 Data preparation

SurveyGizmo was used to ensure that participants were eligible for the study and that there were no duplicate surveys or missing data based on the Internet Protocol (IP) address. Extreme values for demographic data were managed by setting limits on the data collected within the survey. Participants were not able to press the back button once they had answered all questions. Based on the criteria for biologically realistic data for height and weight, a three-numeral limit was set on the system, which allowed only height values between 100 cm to 200 cm to be accepted. For weight, limits were set so that responses accepted indicated a weight between 13 kg and 250 kg. Birth year also had a limit set to ensure no participant was aged less than 18 years or more than 100 years; the system only accepted responses using four figures and a number between 1919–2002 for the year. Nonetheless, all data were checked for erroneous results. To detect extreme values identified as outliers, 5% trimmed mean analysis was used to assess whether these extreme values were influencing the skew of the outcome variables. If they were not influencing the skew the data, they were not deemed as outliers and were therefore retained in the final dataset.

3.2.6 Summary of the overall design of the two-trial study

Section 3.2 jointly discussed the methods and data collection measures used for the RCT with a nested crossover trial. Sections 3.3 and 3.4 will focus on reporting the methods of the two trials independently.

3.3 Crossover Trial

3.3.1 Rationale

The current body of evidence in studies on nutrition messaging shows its promise in changing dietary intentions and behaviours. However, among other limitations, one is that these studies have largely yielded mixed outcomes, and no study has compared the effect between positive, negative, majority or minority descriptive norm framing. Thus, the aim of the crossover trial was to address thesis objective 2: to test for differences in reported intention to improve dietary behaviour, after exposures to four different nutrition messages framed as (1) positive, (2) negative, (3) majority and (4) minority descriptive norms, within a sample of Australian adults. This trial will aid in selecting *how* the individually tailored nutrition message will be presented to participants in the RCT. The crossover trial was designed as a randomised four-factorial, by one time point, by 24 sequence, study.

Many advantages are associated with conducting a crossover trial. The first is that the influence of confounding covariates is reduced because each participant serves as their own control (214). In behavioural science, participants tend to think, translate information and behave differently. Therefore, it was important to expose each participant to the same intervention treatments (i.e. message frames). Since four messages were to be tested in this study, a larger sample size would have been needed for conducting a parallel-group trial. As opposed to other repeated measure designs, such as RCTs, crossover trials are statistically efficient since they require a smaller sample size (215). Therefore, for timeliness and the advantage of reduced confounding bias, a crossover trial was conducted.

3.3.2 Overall trial design

This section was prepared using the CONsolidated Standards of Reporting Trials (CONSORT) statement: extension, for reporting randomised crossover trials (216) to facilitate transparent reporting of the design, conduct, analysis and interpretation of the crossover trial (Appendix 3).

3.3.2.1 Number and duration of periods

Participants were randomised to one of 24 groups in which the order of messages was random (Figure 3-2). Baseline data were then reported, as discussed in section 3.2.4. Then, participants received four treatments (messages) over four periods (survey pages). A brain teaser activity was used as a run-in period to allow participants to break away from their previously reported intention measure. A description of one of the brain teasers is a picture of a triangle with multiple triangles inside, and the participant is asked to count the number of triangles they see; another example is a picture of many white and black dogs and the participant is asked to find the black and white rabbit amongst the dogs (Appendix 6). Each of the message exposures was also separated by the brain teaser activity, used as a washout period to reduce the risk of carryover effect (217). Each brain teaser activity was automated to appear on the screen for at least 30 seconds, because previous research has documented that this time frame reduces the chance of the correct recall of previously shown wordlists (218). The length of time (period) for each treatment (message) was not captured, given that the whole trial was conducted in one sitting. After each message, participants were asked to immediately report their intention to reduce discretionary choice intake. The sufficient washout periods and the 24 sequences into which participants were randomised, ensured that any carryover and order effects were minimised.

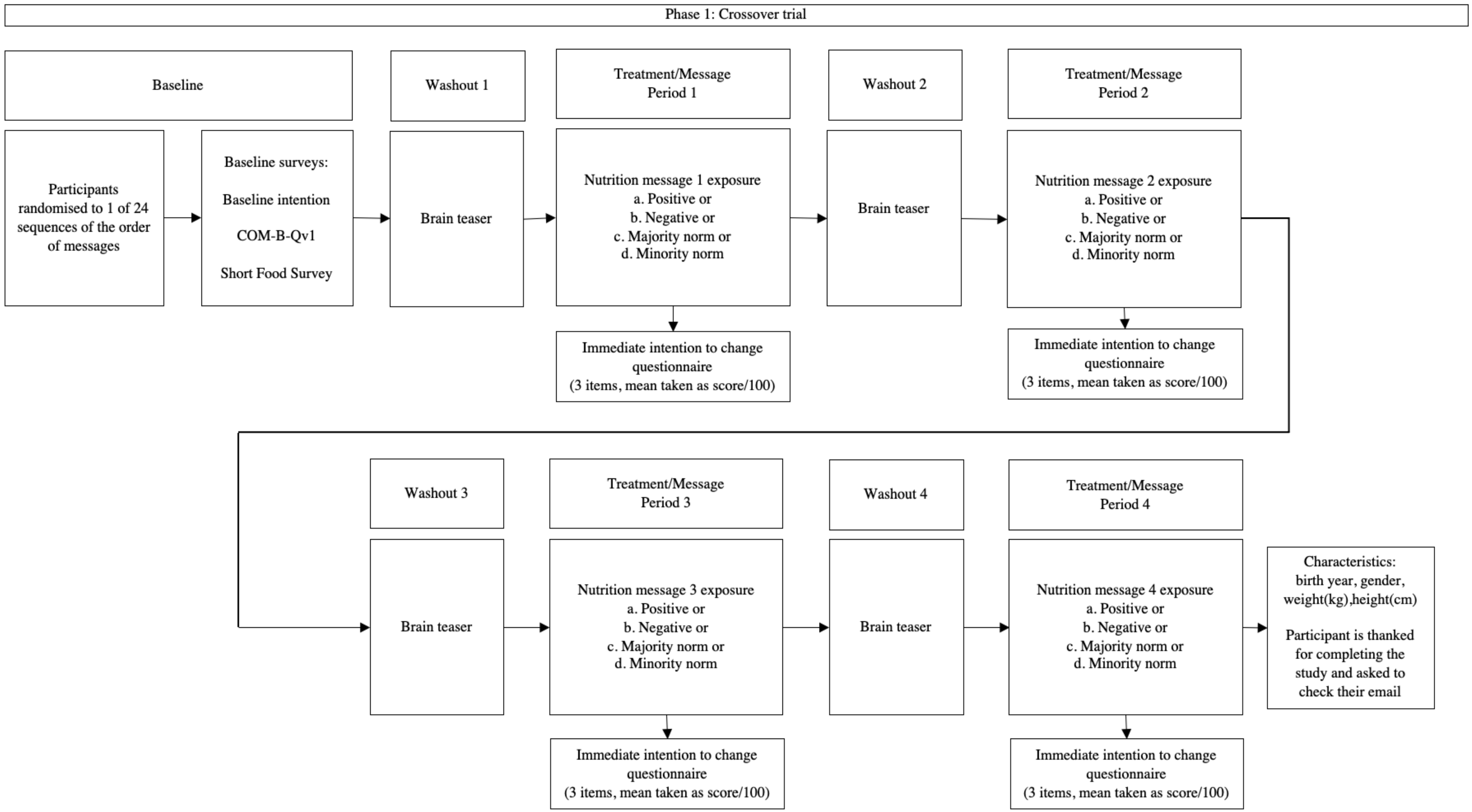


Figure 3-2: Process of the within-subject randomised crossover trial, in which participants were exposed to four nutrition message frames in a random order, with washout activities. The crossover trial was conducted in one sitting.

3.3.3 Study procedures

3.3.3.1 Recruitment

Recruitment details are reported in section 3.2.3.1. For the crossover trial, participant recruitment commenced on 8 September and continued up to, and including, 22 November 2019.

3.3.3.2 Randomisation

Simple randomisation was automatically conducted by SurveyGizmo to allocate participants to one of 24 sequence groups, representing all possible permutations of message sequence. This type of simple, automatic randomisation reduced the risk of potential allocation or investigator bias. It was decided to include 24 sequences because there were six possible message permutations (the number of different ways the four messages can be reordered: 4×3×2×1 = 24 sequences).

Four periods were established in four separate pages. On each of the four pages, the messages were labelled as Positive: *Message1*, Negative*: Message2*, Majority: *Message3*, Minority: *Message4*, and the order in which the messages appeared were randomised. The survey logic was designed so that each message, on each page, would only be displayed once to each participant based on the participant's randomised sequence number (range: 1–24). For example, if the positive message was displayed on page 2 (of 4), only those randomised in the sequence 7, 8, 13, 14, 19 or 20 would see this message displayed first. All the logic that was applied to instruct the system on the order of message exposure can be found in Appendix 7.

3.3.3.3 Interventions

The four nutrition message frames chosen for testing were based on theoretical frameworks and previous research (49, 51, 89, 207), outlined in Table 3-2. The positive message communicated the positive health outcomes associated with a reduction in discretionary choices, whereas the negative message communicated the negative health consequences of consuming discretionary choices excessively. The majority norm message highlighted information about how many (majority) Australian adults eat too many discretionary choices, whereas the minority norm message highlighted information about how many (minority) Australian adults *do not* eat too many discretionary choices. Each message was displayed on a separate page within SurveyGizmo, using black-coloured font and emojis for modern appeal.

Table 3-2: Type, definition and outline of nutrition messages used in crossover trial and tailored intervention in the RCT

Type	Definition	Message
Positive/ Negative framing	Positive message: Presentation of the desirable (gain) outcome by following the message:	Please read the following message carefully. **If you start eating less discretionary choices, you'll improve your chances of:** ✅ **Better heart health** ✅ **Better mental health** ✅ **Lower blood sugar levels** ✅ **Lower cholesterol levels** ✅ **Lower blood pressure** **In turn, you'll be much more likely to live a longer, healthier life!** 😲 **Is your health worth a shot?**
	Negative message: Presentation of undesirable (loss) outcome by following the message:	Please read the following message carefully. **If you keep eating too many discretionary choices, you'll increase your risk of:** ❌ **Poor heart health** ❌ **Poor mental health** ❌ **Higher blood sugar** ❌ **Higher cholesterol levels** ❌ **Higher blood pressure** **In turn, you'll be much more likely to develop heart disease, stroke and even some types of cancer!** 😲 **Is your health worth the risk?**
Descriptive social norm messages	Majority norm message: Presentation of the dietary habits of the majority of people:	Please read the following message carefully. **We know eating too many discretionary choices every day is not recommended.**👎❌ **Yet, recent data shows that 97% of Australian adults eat discretionary choices every day!!** 😲 **Do you want to be a part of this statistic?**
	Minority norm message: Presentation of the dietary habits of the minority of people:	Please read the following message carefully. **We know eating too many discretionary choices every day is not recommended.**👎❌ **Yet, recent data shows that only 3% of Australian adults limit their intake of discretionary choices every day!!**😲 **Do you want to be a part of this statistic?**

3.3.4 Data collection

All data collection methods have been discussed in section 3.2.4. Next, section 3.3.4.1 details the outcome variables of the crossover trial.

3.3.4.1 Data measure: Intention to change score

Intention was measured at baseline and after each of the four message exposures (treatments). Details of the three-item measurements have been discussed in section 3.2.4.1. The internal consistency and reliability of the three-item intention measurements at baseline and after each treatment were analysed using Cronbach's alpha (α), yielding the values of α=0.87 at baseline, and α=0.92, α=0.94, α=0.95 and α=0.96 after the first, second, third and fourth message exposures, respectively. All results represented a high degree of internal consistency as per Cronbach's criteria (219). The final intention score was calculated as the mean score of the three items.

3.3.5 Data preparation

SurveyGizmo was used to calculate a mean intention score from the three items. Therefore, each participant had a mean score calculated for intention at baseline and after each of the four messages. These scores were used to identify the message that resulted in the highest intention to reduce discretionary choice intake from baseline to each message exposure.

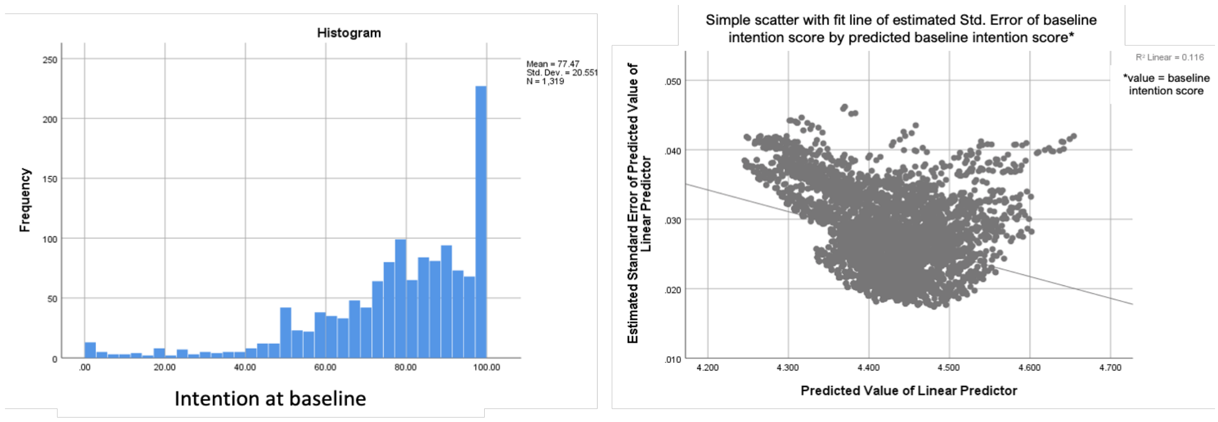
3.3.5.1 Data normality

Data were visually checked for normality using frequency histograms and normal Q-Q plots, and statistically by calculating and examining skewness and kurtosis Z-values (−1.95 to + 1.95). On visually checking the distribution of the intention measures, where the measurement scale was from 1–100, the data for each of these measures were found to be negatively skewed. In the case where the outcome variable is bounded to a measurement scale, it may be a result of participants answering highly on every item and thus triggering the ceiling effect (220). Reaching the ceiling on the items restricts identifying whether the true response has been accurately measured. This phenomenon is commonly observed in psychological data (221).

Next, to check whether the transformed variable would have distribution towards normality, a log transformation (LG10) approach was applied. To satisfy the homogeneity of variances assumption for the errors, a scatterplot using standardised residuals by the predicted values of the mean values of intention (at baseline and after message exposure) scores, was visually assessed for the intention variables. A visual examination of the residuals for both the original and transformed variables showed a heteroscedastic residual plot, with a high level of homogeneity of variance in the data ((a)

(b)

Figure 3-3). Upon log transformation, the residual plots did not improve. When ceiling effects are present, common parametric statistical methods (e.g. ANOVA, linear regression) produce biased estimates.



(a) (b)

Figure 3-3: (a) Frequency histogram and (b) scatterplot. The frequency histogram shows a negatively skewed distribution of intention score at baseline, and the scatterplot, using standardised residuals by the predicted values of the mean values of intention scores, shows data with a high level of homogeneity of variance. A visual assessment of the post-message intention scores showed similar distributions.

3.3.6 Data analysis

3.3.6.1 Justification for dealing with carryover bias

To deal with the possibility of carryover effect, and to adjust for baseline data, multiple studies have reported using change scores from baseline to follow-up as the primary outcome (113, 222-224). Studies measuring participants at the beginning and at the end of the study, where the outcome variable is the change score of those two time periods, may be logical and intuitive because it is claimed this approach could reduce the carryover effect. However, the CONSORT 2010 statement on randomised crossover trials objects to this approach since it does not reduce the carryover effect and can introduce bias (216). Therefore, absolute intention scores were used in the current analysis.

All data were analysed using IBM SPSS Statistics (Version 25). Means and standard deviations (SD) are presented for normally distributed data, whereas median (*Mdn*) and interquartile ranges (IQR) are presented for data not normally distributed. Categorical data are presented as percentages. A visual analysis of demographic and anthropometric characteristics between the 24 sequence groups showed no differences (Appendix 8). Therefore, statistical analysis was conducted on the overall sample.

Given the ceiling effect observed for the intention variable, using non-parametric (225) and post hoc analyses with Bonferroni correction was deemed a sensible approach. The literature has preferred the advantages of more power and simplicity of parametric methods relative to non-parametric methods. More recent research has suggested that the power loss of non-parametric methods is often negligible (226).

To determine whether exposure to four differently framed nutrition message resulted in differences in participants' reported intention to eat less discretionary choice, Friedman tests were used. If significant differences were observed, a Wilcoxon signed rank test was used to identify the differences (between which of the six pairwise associations) in intention scores that were significant. The Wilcoxon signed rank test was also used as a pre-test to ascertain the absence of any carryover effects (227).

The sequential tests for the six pairwise associations—positive v. negative, positive v. majority norm, positive v. minority norm, negative v. majority norm, negative v. minority norm, and majority v. minority norm messages—required statistical adjustment to control for Type I errors. When conducting multiple analyses on the same dependent variable, the chance of committing a Type I error increases, thus increasing the likelihood of a significant result by pure chance. Therefore, a Bonferroni correction was conducted. To obtain the Bonferroni corrected p value, the observed p-value was multiplied by the number of analyses on the dependent variable (i.e. six analyses, testing effects between each message). Statistical significance was declared if any of the corrected values were below 0.05.

3.3.6.2 Effect size and significance

Statistical significance reveals whether the findings are likely to be due to chance (228), whereas effect size describes the magnitude of differences found (96, 98, 221). Effect sizes were calculated for comparison between the effects of messages on intention. For this study, values (z) of intention between messages from the Wilcoxon signed rank tests were used to calculate an approximate effect value (r). The effect size was calculated by dividing the z value by the square root (number of tests) of the sample number (N). This formula is usually proposed when the general assumptions of Cohen's formula (normal distribution) are violated (229). In the following formula, the square root of N was multiplied by six, the number of tests.

$$r = z \,/\, \textit{square root (number of tests) of } N$$

Effect sizes (r) were considered based on the Cohen's criteria of d: 0.1 = small effect, 0.3 = medium effect and 0.5 = large effect (96).

3.3.7 Summary

Section 3.3 outlined the methods used to conduct the crossover trial to identify the most effective nutrition message frame on increasing intention to reduce discretionary choice intake. The crossover trial results also informed the intervention that was tested in the RCT. That is, a tailored nutrition message, delivered by email to each participant, in order to identify whether a tailored message improves diet duality more than a generic message. Section 3.4 will outline the methods specifically used for the RCT.

3.4 Randomised Controlled Trial

3.4.1 Rationale

In developing a dietary feedback intervention to improve diet quality, effective features of previous interventions need to be considered. These features include interventions being brief and/or being online. However, such features have not been used in conjunction with delivering theoretically derived nutrition message frames tailored for individuals. Therefore, developing an intervention that is brief, online and tailored may enhance the effectiveness of dietary behaviour change. In addition, the process of online interventions needs to be evaluated to understand the associated success factors and the ways in which engagement can lead to sustainable outcomes and support participants in future efforts (230). Given the likely under-representation of population subgroups in these types of interventions, it was also important to identify individuals who need more behavioural support in future interventions. Thus, the aim of this two-armed 28-day RCT was to address thesis objective 3: to design, test and compare the effects of a brief online dietary feedback intervention, between delivering a tailored nutrition message frame, and a generic nutrition message, on improving diet quality, in a sample of Australian adults. The brief online dietary feedback intervention will be termed '*Shifting My Nutrition Score in 28 Days*'. The secondary aim was to evaluate the acceptability of the intervention between the intervention groups. The third and final aim was to address thesis objective 4: to determine participants' demographic, anthropometric, behavioural and psychosocial characteristics that predict (i) an improvement in diet quality, and (ii) compliance with the dietary guidelines, after a brief online intervention.

3.4.2 Overall trial design

The study was designed as a two-armed parallel RCT design. Individuals who provided their consent to participate in the study were randomised into either the tailored intervention group, who received a tailored nutrition message, or the control group, who received a generic message based on standard practice. This section was prepared using the CONSORT statement (231), which facilitates the transparent reporting of RCT design, conduct, analysis and interpretation. Since this study used online data collection methods with a self-selected sample, guidance from the Checklist for Reporting Results of Internet E-Surveys (CHERRIES) was also used in reporting the methods and results (232). For transparent reporting of the exploratory analysis, the STROBE reporting statement was used (189). The reporting statements can be found in Appendix 3.

As mentioned in section 3.2.4, all participants reported their baseline dietary intake data using the SFS, together with their psychosocial drivers for behaviour change through the COM-B-Qv1. The individually tailored message was identified from the crossover trial. The message frame that resulted in the highest intention to change score was delivered as the tailored message frame within a brief email. The control group received a generic message, also within a brief email. Both groups received two intervention emails, one on day 1 and one on day 14 of the study. The tailored emails included each participant's individually tailored nutrition message, and extra behavioural support information (173). The control group participants received emails providing them with only a generic message, which was designed to encourage eating less discretionary choices. The generic message is currently provided by the ADGs (10) and the feedback used by current standard intervention practice (30, 33). On day 28, participants from both intervention groups received a unique email with a link to complete the follow-up intervention survey. The survey asked participants to report their intention to change their discretionary choice intake, to report their diet intake data and to complete a process evaluation by ranking overall program satisfaction on Likert scales and through open-ended questions. Up to four email reminders (one per week) were sent to encourage participants to complete the follow-up survey (233).

3.4.3 Procedures of the study and intervention delivery

Recruitment, randomisation and consent details for the RCT are all discussed in section 3.2.

3.4.3.1 Identifying tailored messages

SurveyGizmo was used for scheduling and delivering the intervention emails. A calculation was established to identify the tailored nutrition message that the participants in the tailored intervention group would receive. The calculation was based on the change score between one reported intention and the next. For example, if a participant were to report an intention score of 70.0 at baseline, 81.0 after the first message, 84.0 after the second message, 80.0 after the third message and 75.0 after the fourth message, the differences would be calculated as 11.0, 3.0, −4.0, and −5.0. This would mean the participant had the highest change in intention score between baseline and the first message. Therefore, their first message would be matched to a message frame (positive, negative, majority or minority) and delivered as their individually tailored nutrition message. For the control group participants, one generic message was set up for delivery. The tailored and generic message templates were mapped into the SurveyGizmo custom fields so that when each participant finished their baseline survey, the right information would be sent to them.

3.4.3.2 Delivering intervention emails

Within the SurveyGizmo system, the email protocol was set up so that participants received their first email (on day 1) immediately after finishing the baseline survey. The follow-up emails were then set up separately to be sent on day 14 and day 28 to participants, using the SurveyGizmo campaign tool. The process was performed by extracting baseline participant data (unique identification variable, first name, email, the group that they were randomised to and the message they were receiving for the intervention) and exporting these from SurveyGizmo to Excel. This step was performed at the end of each week during the intervention period. The information in Excel was then cross-checked with the data within SurveyGizmo. Each Excel spreadsheet included headings about participants' baseline data, and were then uploaded into the campaign tool in SurveyGizmo. Each custom field was mapped to the corresponding heading within Excel (i.e. participants' baseline data) to allow the follow-up emails to be tailored and scheduled. Email delivery statistics were available on SurveyGizmo and were checked weekly to ensure all emails were delivered and that none bounced back. The content delivered in the intervention emails are shown in Appendix 9.

3.4.3.3 Intervention features

The features of the two intervention groups and the tailored and generic nutrition messaging approaches are summarised in Table 3-3. The intervention features that were identical between the two interventions were the intervention name *Shifting My Nutrition Score in 28 Days*; using email as method of delivery; the 28-day time frame; personalisation by addressing each participant by their first name; the intensity and dose (two emails, 14 days apart); and discretionary choices as the priority dietary target.

The content of the emails differed between the intervention groups. The tailored intervention group received the tailored nutrition messages with enhanced behavioural support using extra BCTs (Table 3-3). BCTs were used according to the techniques and definitions listed in the 93-item Behaviour Change Taxonomy v1 (173). The number and type of BCTs delivered were informed from recommendation of previous systematic reviews in the field of online nutrition interventions (41, 165, 171, 172). Specifically, Whatnall et al. found through a systematic review that 17 types of BCTs were associated with effectiveness in more than 50% of the reviewed studies, and having seven to nine BCTs in an intervention was associated with effectiveness (171).

The control group received a generic message without enhanced behavioural support. The control group's emails included three BCTs inherently present in the intervention design. These were 'goal setting', because participants reported an intention to reduce discretionary choice intake over a set period; ‘self-monitoring of behaviour’ with self-reported diet intake data via the SFS; and the use of ‘prompts/cues’ in the half-way email reminder (Table 3-3).

Table 3-3: Comparative description of the different elements provided in the brief online 28-day intervention, by type of intervention group

Type of intervention group	Tailored intervention group	Control group
Intervention name	*Shifting My Nutrition Score in 28 Days*	
Method	Online, via email	
Timeframe	28 days	
Email description	Brief but longer email (words approximately = 650) encouraging the new behaviour to eat less discretionary choices, using a tailored message, and supported by BCTs to reduce discretionary choices, guided by the Behaviour Change Wheel framework (173).	Brief but shorter email (words approximately = 150) encouraging the new behaviour to eat less discretionary choices, using only a generic message.
Personalisation	Sent addressing participant by first name	
Intensity and dose	Two emails on two separate occasions (14 days apart)	
Message type	Message tailored on participant-reported baseline intention score after message exposure as per Table 3-2.	Non-tailored generic message as per CSIRO Healthy Diet Score: 'Eat fewer discretionary foods. Your diet could be improved if you ate fewer discretionary foods also known as "extra foods". Extra foods include cakes, biscuits, pastry, chips, lollies, ice-cream, processed meats, regular sausages, sugar-sweetened beverages, alcohol and similar foods. It is recommended that you eat these foods only sometimes and in small amounts.'
Behaviour change techniques (BCTs) applied	Nine BCTs (173) based on best available evidence (171): 1. Goal-setting (behaviour) 'implementation intention' (BCT 1.1) 2. Self-monitoring of behaviour (BCT 2.3) 3. Social support (practical) (BCT 3.2) 4. Instruction on how to perform a behaviour (BCT 4.1) 5. Information about emotional consequences (BCT5.1) 6. Monitoring of emotional consequences (BCT 5.4) 7. Prompts/cues (BCT 7.1) 8. Behavioural substitution (BCT 8.2) 9. Avoidance/reducing exposure to cues for the behaviour (BCT 12.3)	Three BCTs (173) inherently found in the construction of the intervention: 1. Goal-setting (behaviour) 'implementation intention' with intention score assessment (BCT 1.1) 2. Self-monitoring of behaviour (BCT 2.3) with Short Food Survey 3. Prompts/cues (BCT 7.1)
Priority dietary target	Discretionary choices	

3.4.4 Outcome variables and measures

Data collection for the primary analysis was discussed in section 3.2.4, which included information about collecting demographic, anthropometric, psychosocial and dietary intake data at baseline. The following section will elaborate on the outcome variables of the RCT.

3.4.4.1 Primary outcome variable: Discretionary choice intake post intervention

The outcome variable of the RCT was discretionary choice intake in serves at follow-up (day 28). Within the SFS, participants reported the frequency and amount of discretionary choice intake (11 items) in serves, by each day, each week or each month. The total serves of discretionary choices were summed into serves per day and used to identify total discretionary choice intake reported at baseline and at follow-up.

3.4.5 Secondary outcomes

The process-evaluation questions were used with guidance from 'Process-Evaluation Plan for Assessing Health Promotion Program Implementation Guide' (234). This guide was used together with recommendations from a recent systematic review on the appropriate collection and reporting of intervention engagement data (165), and a pilot RCT (235) evaluating the feasibility of a brief web-based nutrition intervention. Process-evaluation components are summarised in Appendix 11. The follow-up survey and evaluation questionnaire can be found in Appendix 10.

3.4.5.1 Intervention satisfaction (11 items)

All participants completed the evaluation survey on completion of the intervention study. Overall program satisfaction (11-items) was ranked on a 5-point Likert scale, from 'strongly agree' (=5) to 'strongly disagree' (=1). Participants were also asked to rank, using the same Likert scale, how much they agreed that the intervention was worthwhile, motivating and met their expectations. Participants were asked about the amount of time they believed the intervention demanded, from three options ('too much time', 'the right amount of time' and 'too little time').

The 11-item satisfaction questions with their shortened term are as follows:

1. Applicable: The content provided in the email(s) was applicable and/or relevant to me.
2. Motivating: The content provided in the email(s) motivated me to change my eating.
3. Worthwhile: The content provided in the email(s) was worthwhile to me.
4. Content: I liked receiving the content by email.
5. Online: I liked that the study was completely online.
6. Amount: I am satisfied with the number of emails I received.
7. Frequency: I am satisfied with the frequency of emails I received.
8. Expectations: *Shifting My Nutrition Score in 28 Days* met my expectations.
9. Change: There is nothing I would change about *Shifting My Nutrition Score in 28 Days*.
10. Overall Satisfaction: Overall, I am satisfied with *Shifting My Nutrition Score in 28 Days* (i.e. emails as a mode of communication, how frequently I was contacted and the information I received).
11. Time demand: The time this study took from me over the last 28 days.

3.4.5.2 Engagement with the intervention: Dose received and intervention usage (three items)

Participants were asked to report their frequency of opening and reading the emails (two items). They were asked whether they opened and read the emails (Yes/No), and they were asked to select one of five options to report the frequency of opening and reading them: 'At least once…' followed by: 'a day', 'a week', 'a fortnight' and 'not at all'. Dose exposure (one time) was also identified, with participants being asked to report the length of time taken to read the emails, using one of three options: 'less than 5 minutes', 'between 5 to 15 minutes' and '15 minutes or more'.

3.4.5.3 Qualitative evaluation feedback

All participants had a voluntary option to give feedback and elaborate on reasons for (not) interacting with the intervention, through one open-ended response box, after the 11 satisfaction items and the three engagement items.

3.4.5.4 Mode of recruitment (one item)

Participants reported the method of recruitment into the study, through selecting from a list of options or providing an open-ended response.

3.4.5.5 Preference of intervention mode of delivery and content (two items)

To understand whether participants would have preferred the same or an alternative method for intervention delivery, they were asked to rank the following methods from 'least preferred' (=1) to 'most preferred' (=5) using one item. Options were email, text message, a combination of email and text messages and social media platform (with the option to specify a preferred platform). Through the same ranking method, using one item, participants in the tailored intervention group were asked to rank their preference about the types of messages they would have liked to receive. All four message frames from the crossover trial were displayed.

3.4.5.6 Contamination (one item)

Participants were asked whether they sought help for dietary behaviours outside the intervention. A list of options of where help may be sought from was given for participants to choose (Appendix 10), such as 'already seeing a nutrition professional', 'attended a workshop on nutrition' and 'participating in another program', as well as the option to provide an open-ended response.

3.4.6 Exploratory data measures

To explore whether there were predictors associated with intervention effectiveness at the end of the study, demographic, anthropometric, psychosocial and behavioural characteristics were analysed according to two definitions of intervention effectiveness, defined in the next two sections.

3.4.6.1 Primary exploratory outcome variable: Reduction in discretionary choice intake

The first outcome of the exploratory analysis was a reduction in discretionary choice intake after intervention. The average reduction in the serves of discretionary choices that resulted from the intervention was defined as intervention success. A dichotomous outcome was then computed and defined as participants with a reduction in discretionary choice intake by one serve or more (change from baseline to post-intervention).

3.4.6.2 Secondary exploratory outcome variable: Compliance with dietary guidelines for discretionary choices at follow up

The second outcome of the exploratory analysis was compliance with dietary guidelines for discretionary choices at follow-up. This was defined as participants' compliance with the dietary guidelines for discretionary choices after the intervention. Compliance was computed according to the approximate number of additional serves from discretionary choices recommended for gender and age groups, found in the Eat for Health Educator's Guide (10). Participants were classified as complying with the recommendation if their consumption of discretionary choices per day was equal to, or less than, the recommended number of serves. Compliance ranges per gender and age are shown in Table 3-4.

Table 3-4: Approximate range of number of additional serves from discretionary choices recommended by gender and age group in the *Eat for Health Educator's Guide*, p. 41 (10)

Gender	Age group	Discretionary choice dietary guideline compliance range
Men	19–50	0–3.0
	51–70	0–2.5
	70+	0–2.5
Women	19–50	0–2.0
	51–70	0–2.5
	70+	0–2.0

3.4.6.3 Predictor variables

In all, 11 predictors were used for analysis. The first predictor was allocation to either the tailored intervention group or the control group. Second, discretionary choice intake at baseline, as a continuous variable, was used as a predictor. Discretionary choice intake data collection is described in section 3.4.4. Third, overall diet quality at baseline was used as a predictor, by categorising the score into quintiles of diet quality. Quintile categorisation was selected as the optimum methodology for examining prediction by diet quality score as per the results of Chapter 2. Demographic and anthropometric characteristics that were used as predictors were defined by gender (female or male); age (categorised as '18–30', '31–50', '51–70', or '71+'); weight status (categorised as 'underweight': BMI < 18.5 kg/m^2; 'healthy weight': BMI 18.5–25 kg/m^2; 'overweight': BMI >25–30 kg/m^2; or 'obesity': BMI >30 kg/m^2); and SEIFA quintile indices for postcode. Where the sample size within a category was less than 2% of the overall sample, the resulting values are not shown. The data collection methods of these variables are described in section 3.2.4.

The remaining four predictor variables were psychosocial characteristics. Baseline intention measure was categorised into data-driven tertiles of scores to identify low, medium and high levels of intention as predictor variables. The highest tertile indicated that participants had very high intention to reduce discretionary choice intake at baseline. Tertiles were selected to maximise power from the sample size. Last, each of the COM-B measures was categorised into data-driven tertiles of scores to identify low, medium and high levels of each of the capability, opportunity and motivation domains. High scores for each of these domains indicated that participants were in need of more capability, opportunity and motivation, as per section 3.2.4.4. The tertiles were re-coded in a way that the highest tertile of capability, opportunity and motivation meant that participants were in less need of that domain, meaning they had high capability, opportunity and motivation at baseline, whereas the lowest tertile indicated that participants were in more need of these behavioural domains.

3.4.7 Data preparation

Each participant's data from the baseline survey and the follow-up survey were matched based on a session identification variable provided by SurveyGizmo.

3.4.7.1 Data normality

Data normality was visually checked using frequency histograms and normal Q-Q plots, and by examining the distribution of the residuals and standard errors of the variable of interest. If data were normally distributed visually on scatterplots, this meant that the effects of the outcome between groups could be assessed using a parametric model because the statistical assumptions were met. For normally distributed continuous data, means and SD are presented, whereas for skewed data, median and IQR are presented. Categorical data are presented as frequency percentages.

3.4.8 Data analysis

3.4.8.1 Impact evaluation

Data were analysed using IBM SPSS Statistics (Version 25). To check for differences in the study sample characteristics between the two intervention groups, the inspection of descriptive analysis, chi-square tests for categorical variables and *t*-tests for continuous variables were used. Significance was set at $p < 0.05$.

Preliminary analyses were conducted to ensure there was no violation of the assumptions of normality, linearity, multicollinearity, homoscedasticity and homogeneity (236). For this purpose, Levene's test was performed and the normal probability plot (P-P) of the regression standardised residual and the scatterplot were inspected. The presence of outliers was checked by inspecting Cook's distance residuals, to ascertain whether there were values larger than 1 (236).

To evaluate the main effects of the intervention and between-group effects, analysis of covariance (ANCOVA) was used. Analysing a change score from baseline to post-intervention does not control for baseline imbalance owing to a regression to the mean, where baseline values are negatively correlated with change because, generally, there is more room to improve low scores at baseline than to improve high scores (237). Therefore, ANCOVA is considered the better approach, where in effect, two parallel straight lines (linear regression) are obtained relating to the post-intervention outcome score to baseline score in each intervention group (237). To adjust for baseline differences between the intervention groups, any significantly different outcomes between groups were used as covariates in the statistical model.

To detect extreme values identified as outliers, a 5% trimmed mean analysis was used to assess whether these extreme values were influencing the skew of the outcome variables. Data points with a reported discretionary choice intake more than three standard deviations above or below the sample mean, were used to identify whether outliers were affecting the results substantially. A sensitivity analysis was conducted by repeating the ANCOVA with and without these outliers.

Effect sizes were calculated, to aid the interpretation of the magnitude of differences (96, 98). Effect sizes were reported as partial eta-squared (ηp^2) and Cohen's *d* values. As part of the *r* family and an extension of r^2, the η^2 assessment examines the proportion of variance that a covariate or variable explains, that is not explained by other variables between groups (97, 98, 238). Effect size was considered based on the Cohen's *d* criteria of 0.1 = small effect, 0.3 = medium effect and 0.5 = large effect (96).

3.4.8.2 Process evaluation

Process-evaluation measures are reported as frequency percentages for quantitative response items. Pearson's chi-square tests (χ^2) were used to examine differences in the responses of the tailored intervention and control groups, relating to intervention acceptability, engagement, preference of intervention delivery mode, contamination and mode of recruitment. Significance was set at $p < 0.05$.

For the open-ended questionnaire items, participants were able to give feedback, and reasons for interacting, or not, with the intervention. All open-ended responses were entered into Excel. Key words were identified and entered into a new column in order to condense the responses into similar thematic groups. This process was repeated, by identifying key words from the condensed responses into another column. This step was performed to further condense the comments into a limited number of themes. All responses were considered. An example of the theming was as follows.

Quotation: *'I think more frequent emails would have been good motivation and a reminder to make good food choices.'* → Condensed into *'More frequent reminders or emails needed'* → Themed into: *'Needing more reminders.'*

The frequency of times the themes appeared were summed to identify the number of participants who reported similar feedback. The themes were compared between participants in the tailored intervention and control groups. Example quotations from participants are presented for the most common themes.

3.4.9 Exploratory analysis

The total number of participants who completed the RCT were pooled together into one sample for inclusion in this analysis. Logistic regression analyses were employed to examine the participant characteristics that predict the two exploratory outcomes. The chi-square values from the Omnibus Tests of Model Coefficients, together with the 2-log likelihood, Cox and Snell R Square and Nagelkerke R squared values were examined to determine the model goodness of fit (236).

Cases with an extreme discretionary choice serve change, that is, less than −26 ($n = 1$) and more than 17 ($n = 2$) were removed for the purpose of displaying the distribution of change in discretionary choice intake from pre- to post-intervention. All other cases were included in the final analysis. To ensure sufficient power in the sample size (N) for the regression analysis, the following formula was used, where k is the number of predictors.

$$N = 50 + 8\mathrm{k}$$

Of the 11 predictors, there were 35 variables in the regression model, thus, $50 + 8 \times 35 = 330$. A minimum acceptable sample size was 330 participants (236). Significance levels were set at $p < 0.05$.

Analyses were adjusted for baseline discretionary choice intake, intervention group allocation, gender categories, baseline age categories, weight status and socio-economic status using SEIFA quintiles. In regression, 'multicollinearity' refers to predictors (independent variables) that are correlated with other predictors; however, these variables should be independent. Multicollinearity increases or overinflates the standard errors of the coefficients, which in turn, makes some variables statistically insignificant when they should be significant, leading to Type I error (236). Therefore, bivariate and multicollinearity were explored using Pearson's correlation coefficients and tolerance and variance inflation factors (VIF) values. If the Pearson's coefficient value is 0.50 or more, and if the tolerance value is more than 0.2 or 0.1 and, simultaneously, if the value of VIF is less than 10, all together indicate there is no bivariate- or multicollinearity and that the predicted regression model is valid and has satisfactory goodness of fit (236). Collinearity results can be found in Appendix 12.

Sensitivity analyses were conducted to determine the level of impact of extreme outliers on the results. Extreme outliers were identified and removed if the change in the reported discretionary choice intake from baseline to post-intervention was three or more standard deviations from the mean, or if they were deemed biologically implausible (i.e. a value larger than a 10-serve decrease or increase in intake). The regression analyses were also conducted using all predictors as continuous variables. The results from the sensitivity analyses were examined to identify any substantial differences in the pattern of results and to confirm model robustness.

3.5 Summary and Chapter Conclusion

The purpose of this chapter was to present the methods of an RCT with a nested randomised crossover trial. To address how thesis objective 2 will be achieved, the methods of the crossover trial were reported. Then, the RCT and process-evaluation methods were reported, in order to address how thesis objective 3 will be achieved. The results from these studies will be reported in Chapters 4 and 5, respectively. Finally, the methods of the exploratory analysis were described to address thesis objective 4, and this study's results will be reported in Chapter 6. This section concludes the thesis studies' methods, with the proceeding chapters focussing on the studies' results.

CHAPTER 4 EFFECT OF NUTRITION MESSAGE FRAMING ON INTENTION TO REDUCE DISCRETIONARY CHOICE INTAKE: A CROSSOVER TRIAL

4.1 Overview and Rationale

To design a brief online feedback intervention that aims to improve diet quality, understanding how to persuasively communicate feedback is important. Current approaches to communicating feedback use nutrition messages derived from language used in the ADGs (10), such as ‘eat five serves of vegetables’ (30, 31), and/or communicate about the health outcomes associated with different dietary behaviours, such as ‘vegetable intake is associated with better heart health’ (31, 36). The impact of these nutrition messages on diet quality improvement has not been evaluated by all interventions (30, 31). Moreover, the studies that have evaluated the impact of feedback messages on diet quality have found that the effect sizes were modest (34, 36). Other literature has also indicated that the current approach to communicating dietary guideline recommendations often has limited effect on dietary behaviour change (76, 239). Hence, trying other communication techniques could enhance the effect on diet quality.

In this regard, a communication technique termed message framing can be used as an approach to improve the effect of dietary feedback (76, 85). The narrative review conducted in Chapter 1, section 1.4.2, found that positive, negative, and majority or minority descriptive norm framed messages have individually been effective in influencing a change in intention or dietary behaviour in comparison to control or health messages. Nevertheless, it is unclear whether attribute framing (i.e. positive or negative) is more effective (49) than descriptive norm (i.e. majority or minority) (132) messages work better than the other (85, 89). For example, descriptive norm message framing has been associated with improved intentions and dietary behaviours compared with control messages (51, 136). However, descriptive norm messages have not been compared with both positive and negative message frames. A comparison of these four message frames may identify the message frame most effective in improving diet quality, for use in feedback interventions.

For this purpose, the current chapter aims to address thesis objective 2: as stated in section 4.1.1. This chapter reports the results of the crossover trial (section 4.2), designed to identify the nutrition message frame that influences the intention to reduce discretionary choice intake, since Chapter 2 identified this food group as the key component for maximising diet quality improvement. The analysis methods for the results presented in this chapter are reported in Chapter 3. This chapter ends with a discussion of the study results in section 4.3, and the chapter conclusion in section 4.4.

4.1.1 Chapter aim and objectives

To test for differences in reported intention to *improve discretionary choice intake*, after exposures to four different nutrition messages framed as (1) positive, (2) negative, and (3) majority and (4) minority descriptive norms, within a sample of Australian adults.

1. To describe the reported intention scores to reduce discretionary choice intake.
2. To compare the reported intention score differences after exposure to the positive, negative, majority or minority descriptive norm message frames.

4.2 Results

The characteristics of the study participants and their flow through the study are described using the CONSORT statement: extension for reporting randomised crossover trials (216), to facilitate transparent reporting of the design, conduct, analysis and interpretation of the crossover trial (Appendix 3). Then, the self-reported demographic and anthropometric measures are presented. The primary study outcome was intention to reduce discretionary choice intake, which was examined at baseline and after exposure to the four nutrition messages.

4.2.1 Participant flow through the study

The CONSORT flow diagram (Figure 4-1) shows that a total of 2,710 participants clicked on the online survey link to be assessed for eligibility, of which 120 did not meet the inclusion criteria. Participants deemed ineligible for the study reported being less than 18 years of age, or not residing in Australia at the time of survey completion, or unwilling to partake in the study or purposefully avoiding core food groups as per the ADGs. Of the 1,745 participants who gave consent to take part in the study, 338 did not complete the pre-study questionnaire. Upon randomisation, 1,407 were assigned to one of 24 message sequences. The dropout rate of participants after each intervention exposure was highest after the first message, compared with the third message. Participants were able to cease their participation at any point without providing a reason, therefore, simply exiting the survey and not returning to complete it meant those participants would be classified as non-completers. Of the 1,333 participants who finished the crossover trial, 14 did not complete or submit their final questions. Therefore, the final sample analysed had 1,319 participants.

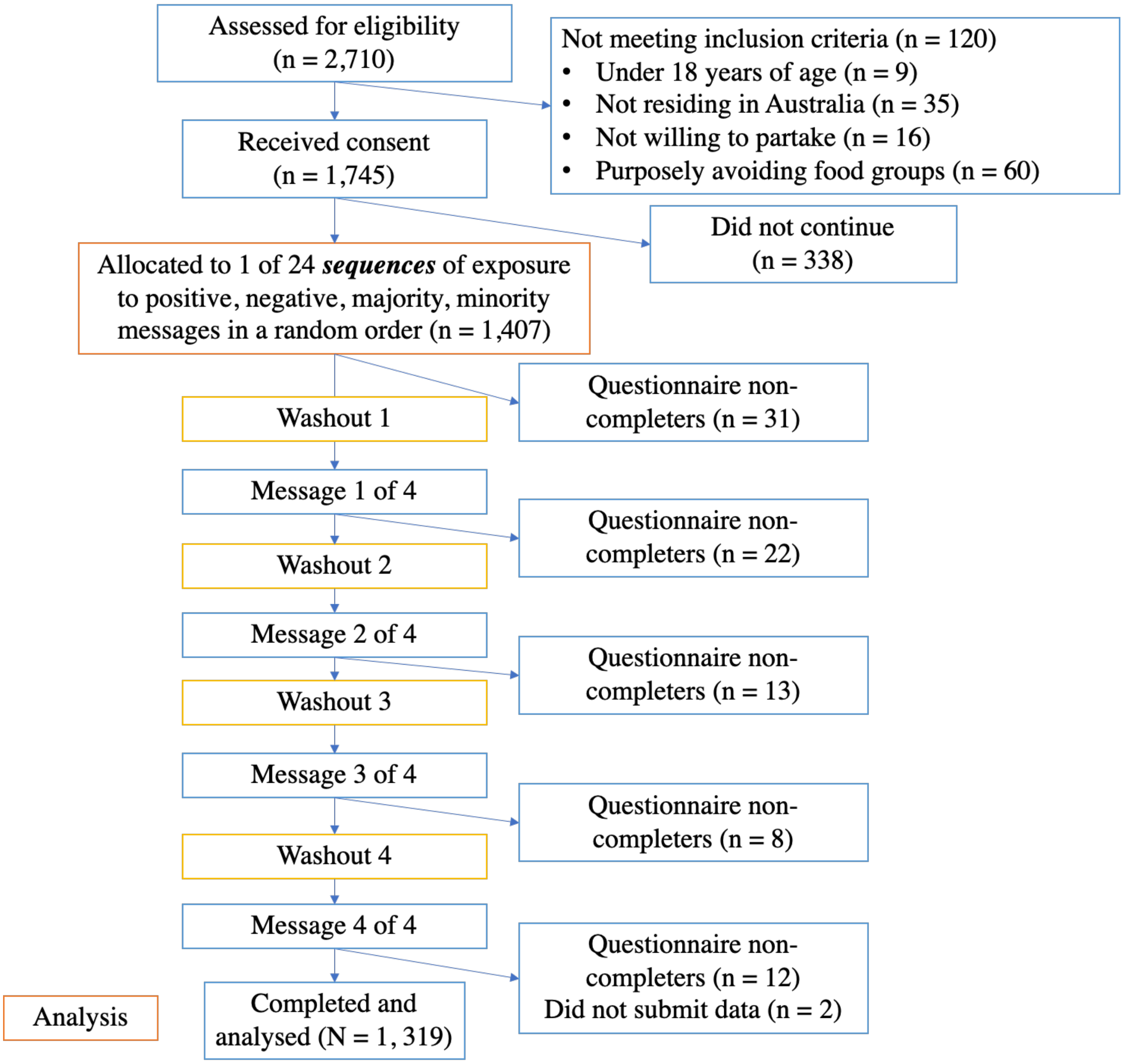


Figure 4-1: CONSORT flowchart of participants' progress through the crossover trial.

4.2.2 Participant characteristics at baseline

The majority of participants were female (79.5%), and the mean age of the sample was 48.8 ± 15.5 years (Table 4-1). In the age group categories, there was an even distribution across the 31–50 and 51–70 age groups (37.5% and 40.6%, respectively). The sample consisted of 14.2% in the 18–30 age group and 7.7% in the 71+ age group. The mean BMI of the sample was 28.7 ± 6.7 kg/m^2, classified as overweight. When BMI was categorised according to weight status categories, the participants were evenly distributed across the healthy weight, overweight and obesity groups (32.2, 31.4 and 35.6%, respectively). Although the sample had representation from all Australia states and territories, most of the study sample (62.2%) resided in South Australia, followed by New South Wales (11.9%). About 16% of the sample reported either Victoria (8.8%) or Queensland (7.5%) as their place of residence. Less than 5% of the sample reported their state or territory of residence being elsewhere (Western Australia, Tasmania, Australian Capital Territory or Northern Territory).

The SEIFA distributions of the sample were more skewed towards suburbs in the higher SEIFA quintiles. About 75% of the sample reported a postcode that placed them in the three highest quintiles, with 29.4% being in the highest quintile, whereas the remaining quarter of the sample lived in suburbs in the two lowest SEIFA quintiles. Compared with the 2016 Census data (191), the study's total sample had a lower percentage of males, a higher proportion of people aged 51–70 years and a good representation of weight status distribution. The study sample had a slightly higher percentage of participants in the obesity group compared with the national representation, but when overweight and obesity were combined, the national and study samples both had an overweight or obesity frequency of 67%. Regarding the SEIFA measure of relative advantage and disadvantage, about 75% of the study sample were from the least disadvantaged SEIFA quintiles (3 to 5), compared with 60% nationally represented from those categories.

Participants were randomised into one of 24 sequences, where each sequence randomised the order in which participants received the intervention messages. Participant gender, age group, weight status category, state of residence and SEIFA quintile differences were visually checked to identify the success of intervention randomisation. There were no meaningful differences between sequence groups (Appendix 8). The range of the number of participants in each of the 24 sequences was 44 to 67 participants, with sequence 9 (message order '2314') having the highest number (n = 67) of participants, and sequence 14 (message sequence '3142') the smallest (n = 44) number.

Table 4-1: Participant demographic and anthropometric characteristics for total sample (*N* = 1,319), presented as *n*(%) unless otherwise indicated; the demographic profile of the general Australian population taken from the 2016 Census data (191) and population weight statistics from the 2017-18 National Health Survey (5)

Characteristic	**Total sample (N = 1,319)**	**% of national population**
	n (%)	(%)
Gender		
Male	271 (20.5)	49.3
Female	1,048 (79.5)	50.7
Age (years)[1]	48.8 ± 15.5	38.0 (median)
Age group (years)		
18–30	187 (14.2)	19.0
31–50	495 (37.5)	27.6
51–70	536 (40.6)	23.4
71+	101 (7.7)	10.7
BMI (kg/m^2) [1]	28.7 ± 6.7	-
Weight status category		
Underweight	-	-
Healthy weight	425 (32.2)	31.7
Overweight	414 (31.4)	35.6
Obesity	469 (35.6)	31.3
State of residence		
New South Wales	157 (11.9)	32.0
Queensland	99 (7.5)	20.1
Australian Capital Territory	22 (1.7)	1.7
Northern Territory	7 (0.5)	1.0
Tasmania	31 (2.4)	2.2
Victoria	116 (8.8)	25.3
Western Australia	66 (5.0)	10.6
South Australia	821 (62.2)	7.2
Socio-economic status		
1 (most disadvantaged)	147 (11.1)	20.0
2	180 (13.6)	20.0
3	274 (20.8)	20.0
4	330 (25.0)	20.0
5 (least disadvantaged)	388 (29.4)	20.0

Note:
[1]Reported as mean and standard deviation.
Age, calculated by subtracting year reported (2019) from participant-reported birth year.
BMI, Body Mass Index (kg/m2) calculated from participant-reported height (cm) and weight (kg).
Weight status category is according to Body Mass Index (BMI) (kg/m^2); Underweight: <18.5 kg/m^2; Healthy weight: 18.5–24.9 kg/m^2; Overweight: 25–29.9 kg/m^2; Obesity >30 kg/m^2.
Socio-economic status as indicated by national Socio-Economic Indexes For Areas (SEIFA) of relative advantage and disadvantage represented by matching participant-reported postcode (213).

4.2.3 Intention scores at baseline and after each message frame

The data for the intention scores are presented in Figure 4-2. These data represent within-person comparisons for the overall sample (N = 1,319). The total sample had a median (IQR) intention score at baseline of 82 (68–93). The median (IQR) of the reported intention score after exposure to the positive message and to the negative message was 89 (73–98) and 88 (72–98), respectively. Further, the majority and the minority norm messages both resulted in the same median (IQR) of the reported intention scores of 87 (70–98).

4.2.4 Differences in intention scores between baseline and each message frame

To compare the differences between the baseline intention score and the intention scores after each message exposure, a Friedman test was conducted, which showed a statistically significant difference between the intention scores between baseline and after the messages ($\chi^2(4,n = 1,319) = 379.35$, $p < 0.001$). The intention score was significantly higher after each message exposure, than at baseline. In the post-hoc analyses (Wilcoxon signed ranks test with Bonferroni adjustments), there were significant differences between baseline intention score, and intention score after all four message exposures (all $p < 0.001$) (Figure 4-2). Based on the standard effect sizes (r) (96), the exposure to the positive message ($r = 0.2$) and each of the negative, majority norm and minority norm messages ($r = 0.1$) had small effects on intention from baseline.

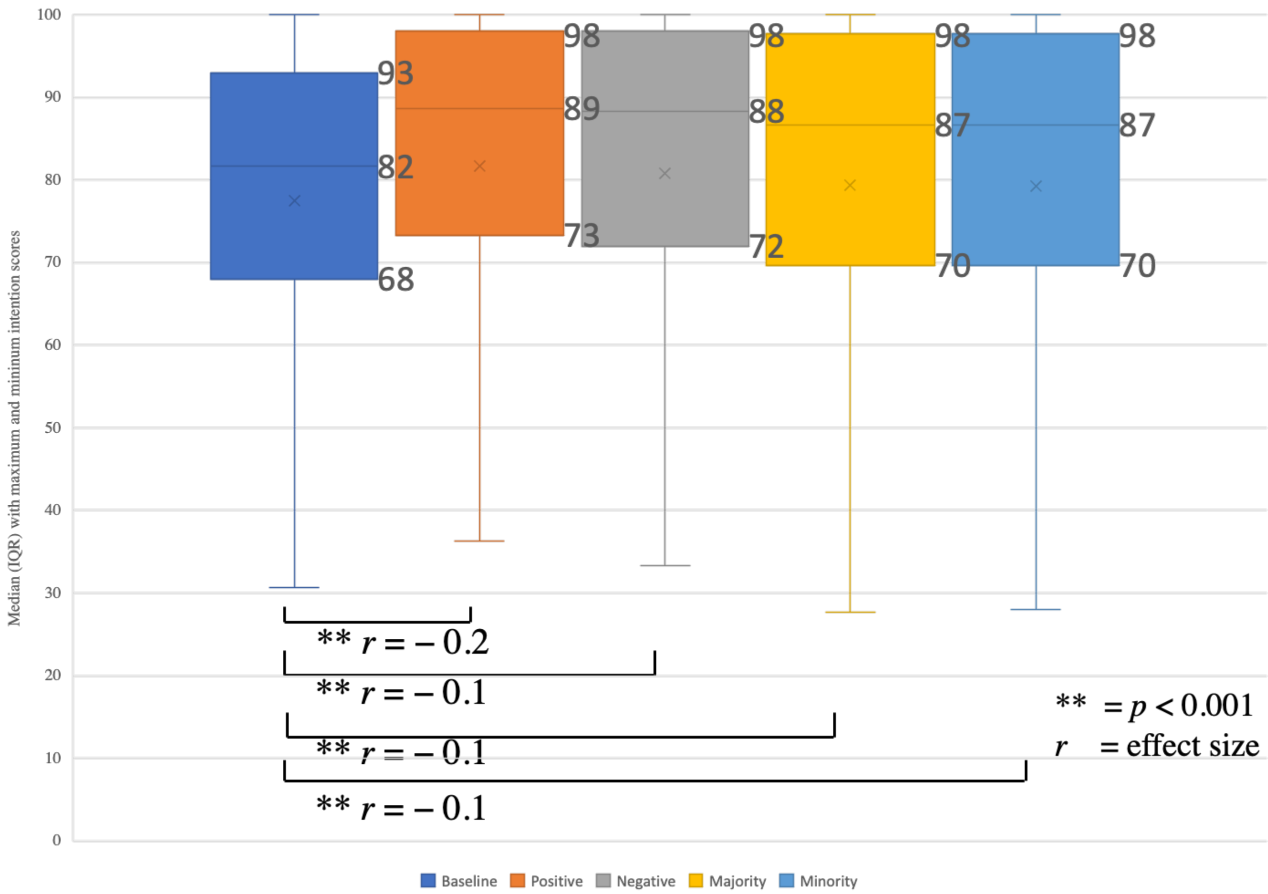


Figure 4-2: Participant-reported intention scores (range 1–100), presented as Median (IQR) with maximum and minimum values, at baseline and after exposure to the positive, negative, majority and minority descriptive norm message frames for the total sample (*N* = 1,319). Wilcoxon signed rank tests with Bonferroni adjusted *p*-values, and calculated effect sizes (*r*) between baseline and after the message exposures, are shown.

4.2.5 Differences in reported intention scores between the message frames

To understand the differences in the intention scores between each message exposure, a Friedman test was conducted, which showed a statistically significant difference between the intention scores after each message ($\chi^2(3, n = 1{,}319) = 94.224$, $p < 0.001$). The median values of the intention scores show small differences between the positive (*Mdn* = 89) and negative (*Mdn* = 88) message. The intention scores were lowest after exposure to the majority and minority framed messages (both *Mdn* = 87) (Figure 4-3). Post-hoc analyses using the Wilcoxon signed rank test and Bonferroni adjustments of *p*-values revealed differences in the intention scores between the positive and negative messages ($p < 0.01$) but no effect ($r = 0.0$), positive and majority norm messages ($p < 0.001$) with small effect ($r = 0.1$), positive and minority norm messages ($p < 0.001$) with small effect ($r = 0.1$), negative and majority norm messages ($p < 0.001$) with small effect ($r = 0.1$), and negative and minority norm ($p < 0.001$) with small effect ($r = 0.1$). There were no significant differences between the majority and minority norm messages ($r = 0.0$).

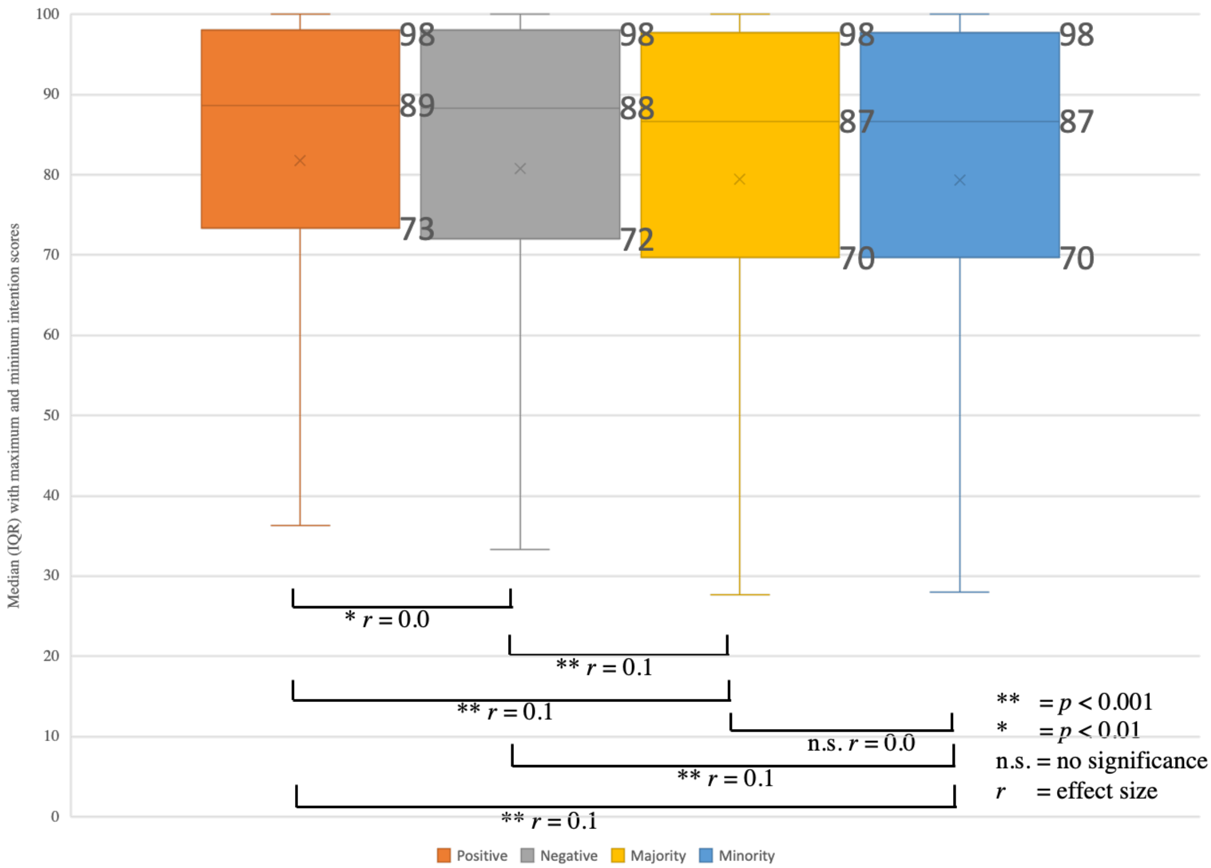


Figure 4-3: Participant-reported intention scores (range 1–100), presented as Median and IQR with maximum and minimum values, after exposure to the positive, negative, majority and minority descriptive norm messages for the total sample (N = 1,319). Wilcoxon signed rank tests with Bonferroni adjusted p-values, and calculated effect sizes (r) between each message, are shown.

4.3 Discussion

4.3.1 Purpose of this study

The study aimed to test whether there were differences in the reported intention to improve discretionary choice intake, after exposure to four different nutrition messages framed as (1) positive, (2) negative, and (3) majority and (4) minority descriptive norms, within a sample of Australian adults. Using a crossover trial design, this study measured intention to reduce discretionary choice intake at baseline, and after exposure to a randomised order of the four nutrition message frames. Findings showed that from baseline, all approaches to nutrition message framing resulted in a small increase in intention to reduce discretionary choice intake. Limited differences in reported intention were found on comparing the positive and negative messages together, and on comparing the majority or minority norm messages together. This study was conducted with the aim to strengthen the evidence base on nutrition message framing through a higher-quality study design and through testing a broader set of nutrition message frames against one another. However, the results from this study cannot indicate a definitive conclusion about whether nutrition messages based on attribute framing, rather than on social norm constructs, may be more persuasive communication strategies for changing dietary behaviour at the population level.

4.3.2 Effect of positive and negative message framing on intention

The positive (*Mdn* = 89, r = 0.2) and negative messages (*Mdn* = 88, r = 0.1) both increased intention from baseline (*Mdn* = 82). There was no difference in effect between the positive and negative message frames (r = 0.0). This result is similar to that of Vidal et al., who demonstrated that both positive and negative message frames influenced the willingness to follow dietary guideline recommendations (123). Similarly to the small differences achieved in the current results, Vidal et al. 2019) found that the willingness score achieved after the positive message (5.7 out of 7), although significant, was only slightly higher than the score achieved after the negative message (5.0 out of 7) (123). However, in contrast these findings, numerous studies have shown that a positive message was more influential on intention (118) and self-efficacy (101) than a negative message. One study demonstrated that a positive message increased intention only for participants with a lower baseline intake of fruit (118). Similarly, two other studies demonstrated that the positive message influenced only participants with high autonomy (121, 122). Again, the studies' results showed a small difference between the message frames. For example, de Bruijn et al. reported that median intention scores for fruit intake after the positive and negative messages were 1.8 and 1.7 (out of 3), respectively (118). Inconsistently with these studies, others have shown that a negative message may increase intention and healthier dietary behaviour to a greater extent than a positive message (93, 103, 111, 118, 121). As in the aforementioned studies, the associations related to the negative messages have been significant only for particular participants and only by a small difference. For example, the negative message resulted in more effect on intake of fruit for those with a higher baseline intake (118) or those with a higher baseline intention (111). The latter study's results showed that the negative message was slightly more effective than the positive, resulting in intention scores of 5.06 and 4.97 out of 7, respectively (111). Evidently, the message framing evidence base continues to be inconclusive, and results can be greatly moderated by participants' baseline characteristics.

It is postulated that, depending on baseline characteristics, such as the level of motivation, knowledge or involvement, people may be influenced differently by messages (87). Studies have previously indicated that those who are highly involved, knowledgeable or interested in a topic are more responsive to negative messages (48, 92, 118, 240). For example, Wansink and Pope reported that when people are highly knowledgeable about nutrition, such as females in a professional job, a negative message would be more effective, whereas for people with low involvement in the topic of nutrition, such as single men or those without a professional job, a positive message would be more effective (87). Since the general public may be less involved or knowledgeable about nutrition, positive message framing may be the suitable approach for communication at the population level. However, if there is opportunity to tailor nutrition message frames, using intention, knowledge, and/or involvement as baseline characteristics may inform which message frame would be more effective to use at the individual level.

Nevertheless, the effect on intention between the positive and negative messages was not meaningfully different. It may be that the hypothesis of health message framing does not apply for dietary behaviour. The hypothesis that health message framing has different effects on health behaviours led to the development of the prospect theory (88, 139), which was primarily tested by Rothman, Salovey and colleagues in the 1990s (48, 49). Most of the hypothesis testing has been conducted on promoting preventive health behaviours, for example, dental hygiene, which is mostly influenced by positive framing, or on detecting health behaviours, such as cancer screening, which is mostly influenced by negative framing (48, 49). A nutrition message framing hypothesis followed, that since healthy dietary intake is a preventive behaviour, positive messages would be most effective (85). However, testing these hypotheses on dietary behaviours has not resulted in concrete conclusions (85, 89). It may be that any approach to message framing, regardless of whether it is positive or negative, may be a sufficient strategy for improving dietary behaviour. This may also be true for descriptive norm message framing.

4.3.3 Effect of majority and minority norm message framing on intention

The study found that both the majority and minority descriptive norms resulted in the same intention score (*Mdn* = 87), which increased significantly from baseline (*Mdn* = 82, $r = 0.1$). There was no difference in effect between these messages. Previous meta-analyses have indicated that descriptive norm messages moderately influence dietary behaviour (51), and individual studies have also found majority norms (95, 125, 129) and minority norms (94) to be effective in comparison to control or health messages. However, a prior comparison of the effect between these messages on intention to improve dietary behaviour also resulted in small differences. Stok et al. found that participants who received the majority norm message reported a slightly higher intention (scored out of 5) for fruit intake (3.89 + 0.97) than participants who received the minority norm message (3.53 + 0.72) (94). Thus, the present study thus adds to the literature that the difference in effect between descriptive norms is minor.

4.3.4 Differences in effect between the message framing approaches on intention

All nutrition message frames resulted in a significant increase in intention scores, but limited effect was observed between the messages. This effect is line with earlier meta-analyses that have highlighted that message framing theory does not provide a consistent set of predictions on intention (85). However, the present findings may also reflect that the recruited sample was highly motivated. This study's sample reported a median baseline intention score of 82 out of 100, meaning participants may have been already intending to change their dietary behaviour since they voluntarily participated in the study. A high baseline intention has been common in interventions aiming to improve preventive behaviours, such as eating. One systematic review found that high baseline intention may limit the ability of studies to facilitate any more impact on intention or behaviour (241). Further, message framing research has found that higher baseline intention and healthier behaviour enhances the persuasive effects of framed messages (242). This raises concern because the studies to date may not be persuading the people who are most in need of dietary behaviour change (i.e. those who are less interested). A couple of recommendations have been made. The first is for future studies to recruit participants with low baseline intention prior to trying to change their behaviour (241). The second is finding ways to make nutrition messages more relevant for those with low interest at baseline (92). One approach may be to understand the health risk of each person and refer to that particular risk in a message (92), which could be why phenotype or genotype data have recently been communicated within nutrition feedback interventions (41). Another approach could be to incorporate the person's first name in the message, which may make the information seem more critical (243). Nevertheless, other reasons for the lack of effect between messages could relate to the study design. Therefore, the strengths and limitations of the present study need to be addressed to allow more transparent interpretation of its findings.

4.3.5 Strengths and limitations

This study is a unique contribution to the nutrition message framing literature since it compared positive, negative, majority and minority descriptive norms. This study has contributed to the evidence that message framing can be effective in increasing intention to change dietary behaviour; however, it revealed limited effects between message framing approaches. A strength of the study is the approach used to develop the measurement of the outcome variable, intention. The theory of planned behaviour (157, 210) and prior studies measuring intention after message exposures (118, 157) were used to inform the development of the intention questions. The dietary outcome, discretionary choices, was also clearly defined as per the ADGs (10). These factors increase the potential of this study to be replicable and comparable within a larger body of evidence. Another key strength of the study was the broad sample that was recruited. Unlike other studies in this field which were mainly conducted on young female students (51, 85), the study sample had a broader age range. Further, this study was conducted in a real-world, online setting, rather than a laboratory setting. This fact allows more applicable conclusions to be drawn. Last, in using a crossover trial, each participant acted as their own control, minimising the potential influence of confounding variables on the outcome (216). Nonetheless, crossover study designs do have limitations.

First, the sequence of messages may have affected the outcome (216). However, randomising participants to one of every possible sequence (24 sequences) of messages likely reduced the risk of potential sequence, allocation, or investigator bias (216). The second issue may be the carryover effect between treatments, which may have led to a cumulative impact on the outcome over the study period (227). To reduce carryover effects, washout activities were embedded between message exposures (217). To reduce bias in future trials of this kind, washout periods in between exposures could be extended. However, it is important to remember that the public is exposed to many other messages related to nutrition in their daily life, and an extended washout period could lead to uncontrolled study contamination. Further, it must be acknowledged that developmental testing of the nutrition messages before their application in the intervention could have improved the influence the messages had on participants. Message development testing prior to intervention is an important consideration for future messaging research.

A limitation associated with the outcome measure of intention is its negatively skewed distribution, which indicates measurement error. The skewed distribution may be due to participants answering every intention item with high scores and thus reaching the highest possible score, which led to a ‘ceiling effect’ (220), as commonly observed in psychological data (221). This effect may have left little range to indicate whether the participants’ true level of intention was accurately measured between message frames (220). Another important consideration of this study is the potential for false-positive results due to Type I error. First, a large sample was recruited into the study, which increased the statistical power. This may have been one reason that the small differences in intention scores between messages were statistically significant. Another reason may have been that numerous statistical tests were undertaken; because the data were skewed, non-parametric analyses had to be used, which did not allow adjustments to be made for the multiple comparisons (236). A Bonferroni correction was conducted to minimise the potential for Type I error. Nevertheless, the statistically significant results of the current findings should be interpreted with caution. Despite recruitment strategies to target more males, the final sample was not representative of the Australian population (191). This sample overrepresented females, those in the 31–70 age group, those in higher socio-economic areas of advantage and those residing in South Australia. Furthermore, there is potential for selection bias risk in the analytical approach taken in this study, as 88 participants were classified as survey non-completers and were not included in the final analysis. Therefore, caution must be taken in generalising these results. Last, the present study was designed to detect immediate change in intention, not long-term behaviour change. Nevertheless, it has been shown that these immediate changes predict behaviour after 4 weeks (244).

4.3.6 Implications for practice and future research

To the best of this PhD candidate’s knowledge, this study provides the first evidence of the effectiveness on intention to change discretionary choice intake, between four messages framed as positive, negative or majority and minority descriptive norms. All four message frames increased intention from baseline, but the differences between each message were limited. The study sample reported a high baseline intention, and previous research has reported that high baseline intention may increase the likelihood of message framing to be effective. This fact may explain why all message frames resulted in similar effectiveness in this study. Therefore, this study recommends that future studies screen a range of participants prior to recruitment in order to achieve a sample with varied levels of baseline motivation. A diverse range of baseline motivation levels can then allow subgroup analyses to be performed in order to understand whether nutrition message framing effects can be predicted by baseline motivation levels.

4.4 Summary and Chapter Conclusion

To address the evidence gap on which, out of the positive, negative, majority or minority descriptive norm message frames, is most effective in increasing intention to change discretionary choice intake as a proxy measure for dietary behaviour, a crossover trial was conducted. The findings portrayed that all nutrition message framing approaches resulted in increased intention, but limited differences in effect was observed between message frames. This study contributes to the inconclusive evidence that there may not be *one type* of message frame that would be most effective for everyone in a population. However, message framing effectiveness has been consistently moderated by individual characteristics, such as baseline intention, involvement and/or knowledge. Therefore, future research can test whether tailoring the nutrition message frame would result in more meaningful and applicable impact on dietary behaviour, at the individual level.

4.4.1 Bridging summary

This study found limited differences in effect between nutrition message frames on intention to change discretionary choice intake. The literature has indicated that effect is moderated by baseline characteristics, such as intention. Therefore, there could be potential in tailoring nutrition message frames using intention, to improve dietary behaviour. As reported in Chapter 3 on study methods, individual-level intention scores, collected for the crossover trial, were used to identify the tailored message frame that participants would receive in the RCT. Therefore, the next chapter will report the findings of the RCT that aimed to test *whether* delivering a tailored nutrition message frame to individuals affects dietary behaviour change.

CHAPTER 5 EFFECTIVENESS OF *SHIFTING MY NUTRITION SCORE IN 28 DAYS*: A RANDOMISED CONTROLLED TRIAL

5.1 Overview and Rationale

Recently, brief dietary feedback interventions have been developed with the aim to improve the diet quality of the population (30, 31, 34, 36). Dietary feedback is most commonly tailored to provide individuals with a message on key dietary components that can maximise overall diet quality improvement. The effect of this type of brief feedback has not been evaluated by Australian interventions (30, 31), but international studies have shown modest effects that range from a 2.6% (36, 39, 40) to 12% improvement in diet quality scores (34). Dietary feedback trials have been tailored to demographic, anthropometric or psychosocial characteristics (170) in addition to baseline dietary assessment as a behavioural characteristic (154, 171). Generally, tailored dietary feedback has been more effective in improving dietary behaviour, than providing general nutrition information, with a pooled effect size on diet quality improvement ranging from 0.12 to 0.18 (154) or a 0.25 to 0.30 serve size increase of vegetable intake (163, 171). Due to the modest effects achieved on diet quality to date, studies have called for well-designed, controlled feedback messaging interventions that focus on a broader range of dietary outcomes and provide more support for behaviour change (41).

Although dietary feedback interventions tailor which key diet quality component is presented in a message, the message is *framed* in the same way for everyone. However, researchers have suggested that interventions should not only frame the message appropriately, but also tailor the framing of the message to the recipient's characteristics (52, 53). Chapter 2 identified that discretionary choices can be the key component/food group that can maximise overall diet quality improvement for the majority of people. Therefore, tailoring how nutrition messages are framed for improving discretionary choice intake may enhance the effect achieved to date by feedback interventions. The narrative review in Chapter 1 (section 1.4.2) indicated that baseline intention was a predictor of message framing effectiveness and change in dietary behaviour (111, 113, 117, 118). Chapter 4 (section 4.3) discussed that there may be individual variations in response to nutrition message framing on intention. Thus, tailoring nutrition message frames using baseline intention could lead to larger effects than those that have been achieved by standard practice that uses non-tailored framing or 'generic' nutrition messages.

To design a feasible large-scale tailored nutrition message framing intervention, a brief online approach for intervention delivery can be time and cost effective (58, 160). Brief online interventions have shown promise in increasing fruit and vegetable intake (by 0.30 to 0.64 serves per day) or reducing the percentage of energy intake from fat by up to 8.0% (171). Further, it is recommended that interventions be designed using fundamental features, including the use of theory and specific BCTs to enhance behavioural support (173). However, to the candidate's knowledge, a feedback intervention has not yet been designed to include all the mentioned evidence-based fundamental features, such as using *online* and *brief* components with *tailored nutrition message framing* and using theory and additional BCTs for enhanced *behavioural support*. Therefore, this intervention design could be an innovative approach for enhancing the effects achieved by similar interventions to date.

This chapter reports on the RCT that aimed to address <u>thesis objective 3:</u> as stated in section 5.1.1. The detailed methods are reported in Chapter 3. The tailored message each individual received was based on their highest baseline intention score, as informed from data reported in Chapter 4. The results of the RCT are reported in section 5.2 of this chapter, a discussion of the study results is presented in section 5.3, leading to the chapter conclusion in section 5.4.

5.1.1 Chapter aim and objectives

To design, test and compare the effect of a brief online dietary feedback intervention '*Shifting My Nutrition Score in 28 Days*', between delivering a tailored nutrition message frame, and a generic nutrition message used in standard practice, on *improving discretionary choice intake*, after 28 days, in a sample of Australian adults. The secondary aim was to evaluate the acceptability of the intervention between the intervention groups.

1. To describe demographic, anthropometric, behavioural and psychosocial characteristics, and the discretionary choice intake of the Australian adults who participated in *Shifting My Nutrition Score in 28 Days.*
2. To analyse whether discretionary choice intake from baseline to post-intervention differed between intervention groups, and for the overall sample.
3. To evaluate whether the satisfaction with the intervention differed between groups, and to describe evaluation feedback received from the study sample.

5.2 Results

The characteristics of study participants and their flow through the study are shown using the CONSORT statement for reporting parallel-group randomised trials (231) to facilitate transparent reporting of the design, conduct, analysis and interpretation of RCTs. The reporting checklist can be found in Appendix 3. Then, the demographic and anthropometric self-reported measures are presented. The primary study outcome, discretionary choice serve intake after the intervention, is examined and presented. Next, the results of an analysis to evaluate the quantitative and qualitative processes are reported.

5.2.1 Participant flow through the study

The CONSORT flow diagram in Figure 5-1 shows that a total of 5,353 participants enquired about the intervention and were assessed for eligibility to participate in it. Among them, 64% of provided consent (N = 3,453) and were randomly allocated to the tailored intervention arm (n = 1,745), or the control arm (n = 1,708), and completed the baseline questionnaires (Figure 5-1). A total of 1,640 participants either did not continue to the eligibility stage or did not provide consent, and 260 did not meet inclusion criteria, with the most common reason being purposefully avoiding one or more core food groups (n = 147). The baseline survey was not completed by 355 participants in the tailored intervention group and by 348 in the control group. More participants in the tailored intervention group, than in the control group, were lost to follow-up (630 v. 544, respectively). Of the participants who finished the trial and started the follow-up survey, 2% did not complete the follow-up and process-evaluation measures. The final sample for analysis was 1,441, consisting of 45.6% in the tailored intervention group and 54.4% in the control group.

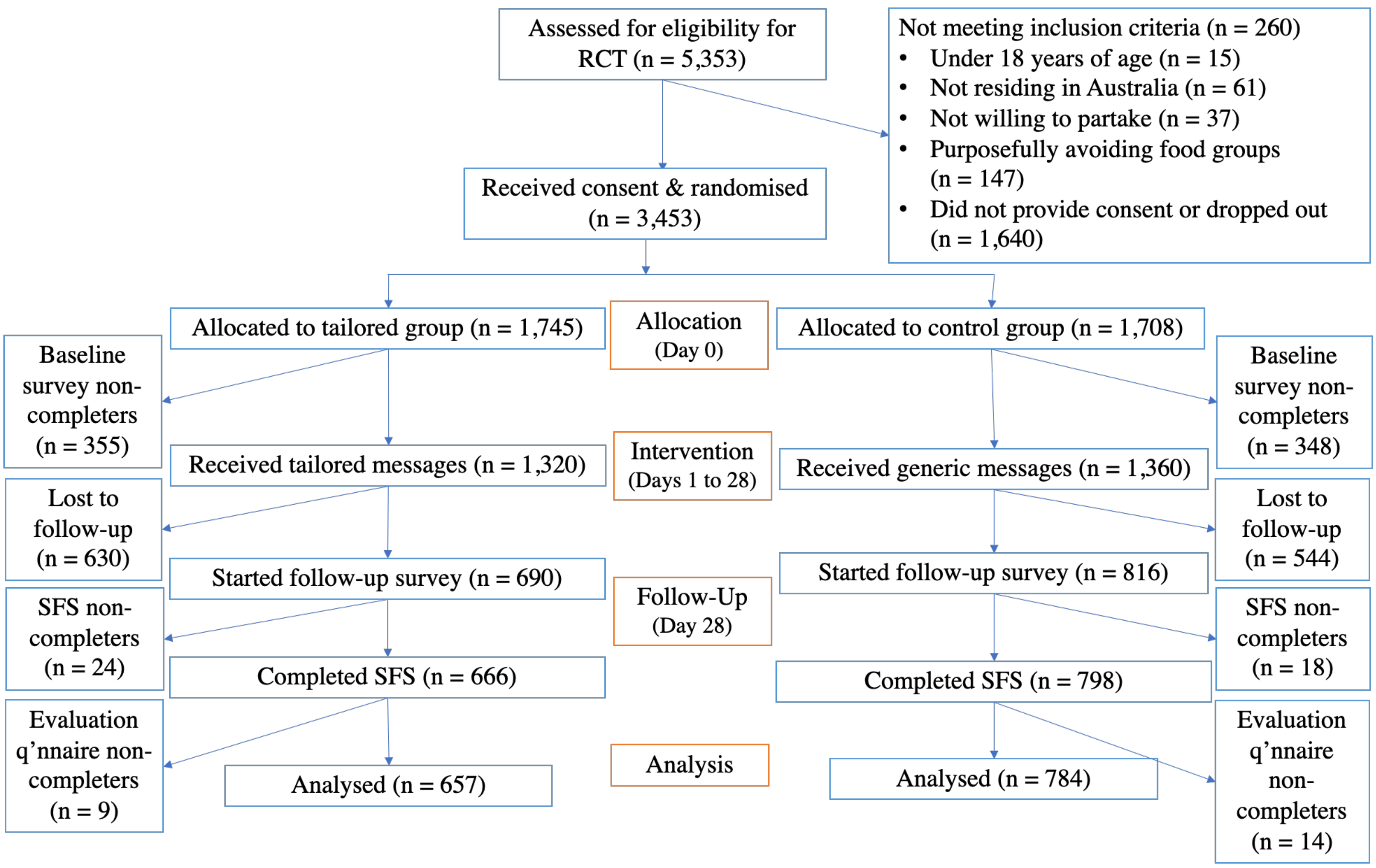


Figure 5-1: CONSORT flowchart of progress of participants through the randomised controlled trial from recruitment to analysis, by group allocation to either the tailored or the control group. SFS: Short Food Survey.

5.2.2 Participant characteristics at baseline

The majority of participants were female (77.3%), and the mean age of the sample was 50.8 ± 16.0 years. In both intervention groups, the female group had a higher representation than males, but this was not statistically significant. Between the categories of age groups, those in the 51–70 age group accounted for 43.6% of the proportion of the sample, followed by the 31–50 age group (33.6%). The sample comprised 13.0% in the 18–30 age group and 9.9% in the 71+ age group. The mean age was slightly higher in the control group (51.6 ± 16) than in the tailored intervention group (49.9 ± 15.8), but the difference was not significant. The mean BMI of the sample was 28.2 ± 6.3 kg/m^2. When BMI was categorised according to weight status categories, participants were evenly distributed across the healthy weight, overweight and obesity groups (33.3, 33.7 and 31.9% respectively). There was a slightly lower percentage of healthy weight participants in the control group than in the tailored intervention group (31.6 v. 35.3%, respectively), and a slightly higher percentage of participants in the obesity group in the control than in the tailored intervention group (33.4% v. 30.1%, respectively). The differences were all not statistically significant. Compared with the 2016 Census data (191), the study's total sample had a lower percentage of males, a higher proportion of people aged 51–70 years and a good representation of weight status distribution.

All Australian states and territories were represented, with most of the sample reporting South Australia as their state of residence (65.8%) followed by New South Wales (11.5%). Further, 8.4% resided in Victoria and 6.4% in Queensland. Less than 4% of the sample reported living in another state or territory (Western Australia, Tasmania, Australian Capital Territory or Northern Territory). The SEIFA distributions of the sample were skewed towards suburbs in the higher SEIFA quintiles, indicating socio-economic advantage. About 75% of the sample reported a postcode that placed them in the three highest quintiles, with 29.1% being in the highest quintile, whereas the remaining quarter of the sample lived in suburbs in areas with most socio-economic disadvantage (SEIFA quintiles 1 and 2). No statistically significant differences between groups were found. Population distribution by SEIFA quintiles of advantage/disadvantage in South Australia was derived to understand the comparability between the South Australian population and the study sample (Table 5-1). About 75% of the study sample were from the least disadvantaged areas by SEIFA score (quintiles 3 to 5), compared with 60% nationally represented from those categories.

For the psychosocial characteristics, capability, opportunity and motivation, a higher score meant that participants needed more support for these characteristics. Each domain measure was scored out of eight. Capability and opportunity had similar mean scores (2.1 ± 1.5, and 1.9 ± 1.6, respectively), and the mean score for motivation was 3.5 ± 2.1. The final psychosocial characteristic, intention to change discretionary choice intake, measured at baseline, had a median score of 80.7 (IQR = 66.3–92.2), where a lower score indicated lower intention and a higher score indicated higher intention. All psychosocial scores were not significantly different between intervention groups. For the behavioural characteristic—the mean diet score for the total sample—the score was 54.4 ± 10.5, out of a possible 100. This score was similar between intervention groups, with participants in the control group scoring 54.5 ± 10.4, and those in the tailored intervention scoring 54.2 ± 10.6.

Table 5-1: Baseline characteristics of participants (N = 1,441) who finished *Shifting My Nutrition Score in 28 Days*, presented as n (%) unless otherwise indicated; the demographic profile of the general Australian population taken from the 2016 Census data (191) and population weight statistics from the 2017-18 National Health Survey (5).

Characteristic	Total sample (N = 1,441)		Control group (n = 784)		Tailored intervention group (n = 657)		% of national population
Gender							
Male	327	(22.7)	183	(23.3)	144	(21.9)	49.3
Female	1114	(77.3)	601	(76.7)	513	(78.1)	50.7
Age (years)[1]	50.8	± 16.0	51.6	± 16.0	49.9	± 15.8	38.0 (median)
Age group (years)							
18–30	187	(13)	99	(12.6)	88	(13.4)	19.0
31–50	484	(33.6)	250	(31.9)	234	(35.6)	27.6
51–70	628	(43.6)	349	(44.5)	279	(42.5)	23.4
71+	142	(9.9)	86	(11.0)	56	(8.5)	10.7
BMI (kg/m^2)[1]	28.2	± 6.3	28.5	± 6.6	27.8	± 5.9	-
Weight status category							
Underweight	-		-		-		-
Healthy weight	480	(33.3)	248	(31.6)	232	(35.3)	31.7
Overweight	485	(33.7)	264	(33.7)	221	(33.6)	35.6
Obesity	460	(31.9)	262	(33.4)	198	(30.1)	31.3
State of residence							
New South Wales	166	(11.5)	90	(11.5)	76	(11.6)	32.0
Queensland	92	(6.4)	51	(6.5)	41	(6.2)	20.1
Australian Capital Territory	25	(1.7)	15	(1.9)	10	(1.5)	1.7
Northern Territory	7	(0.5)	5	(0.6)	2	(0.3)	1.0
Tasmania	28	(1.9)	18	(2.3)	10	(1.5)	2.2
Victoria	121	(8.4)	67	(8.5)	54	(8.2)	25.3
Western Australia	54	(3.7)	29	(3.7)	25	(3.8)	10.6
South Australia	948	(65.8)	509	(64.9)	439	(66.8)	7.2
Socio-economic status							
1 (most disadvantaged)	170	(11.8)	101	(12.9)	69	(10.5)	20.0
2	189	(13.1)	96	(12.2)	93	(14.2)	20.0
3	313	(21.7)	179	(22.8)	134	(20.4)	20.0
4	350	(24.3)	185	(23.6)	165	(25.1)	20.0
5 (least disadvantaged)	419	(29.1)	223	(28.4)	196	(29.8)	20.0

(continued)

Table 5–1 (continued): Baseline characteristics of participants (N = 1441) who finished *Shifting My Nutrition Score in 28 Days*, presented as *n* (%) unless otherwise indicated; the demographic profile of the general Australian population taken from the 2016 Census data (191) and population weight statistics from the 2017-18 National Health Survey (5).

Characteristic	Total sample (N = 1,441)		Control group (n = 784)		Tailored intervention group (n = 657)		% of national population
Psychosocial characteristics (range of score)							
Capability (0–8)	2.1	± 1.5	2.1	± 1.6	2.0	± 1.4	-
Opportunity (0–8)	1.9	± 1.6	1.9	± 1.6	2.0	± 1.6	-
Motivation (0–8)	3.5	± 2.1	3.5	± 2.1	3.4	± 2.2	-
Intention (1–100)[2]	80.7	(66.3–92.2)	80.7	(65.3–93.3)	80.7	(67.0–91.7)	-
Diet score (out of 100)[1]	54.4	± 10.5	54.5	± 10.4	54.2	± 10.6	-

Note:
[1]Reported as mean and standard deviation.
[2]Reported as median and interquartile range.
Age, calculated by subtracting year reported (2019) from participant-reported birth year.
BMI, Body Mass Index (kg/m^2) calculated from participant-reported height (cm) and weight (kg).
Weight status category is according to Body Mass Index (BMI) (kg/m2); Underweight: <18.5 kg/m^2; Healthy weight: 18.5–24.9 kg/m^2; Overweight: 25–29.9 kg/m^2; Obesity >30 kg/m^2.
Socio-economic status as indicated by national Socio-Economic Indexes For Areas (SEIFA) of relative advantage and disadvantage represented by matching participant-reported postcode (213).

5.2.3 Discretionary choice intake at baseline

The mean reported discretionary choice intake at baseline for the total sample was 4.2 ± 3.9 serves. The tailored intervention group had a higher reported discretionary choice intake at baseline (4.5 ± 4.4) than did the control (4.0 ± 3.5). An independent samples *t*-test showed a significant difference in mean baseline discretionary choice intake between the intervention groups (p = 0.015).

5.2.4 Tailored message received by intervention group

Within the tailored intervention group (n = 657), 30.3% (n = 199) received the positive message as their intervention, 27.7% (n = 182) received the negative message, 18.3% (n = 120) received the majority norm message and 23.7% (n = 156) received the minority norm message. A one-way ANOVA showed no significant differences in the post-intervention discretionary choice intake between participants in different tailored message groups (p = 0.695).

5.2.5 Effect of the intervention on discretionary choice intake

The ANCOVA model showed no significant effect on the post-intervention discretionary choice intake of the intervention group, adjusted for baseline discretionary choice intake: the adjusted discretionary choice intake mean was 3.2 serves for the tailored intervention group and 3.1 serves for the control group (adjusted mean serve difference between groups = 0.13, $p = 0.49$) (Figure 5-2).

For the overall sample, there was a significant difference in mean discretionary choice intake from baseline to post-intervention (4.2 ± 3.9, v. 3.1 ± 4.0, respectively, $p < 0.001$), with a partial eta-squared (ηp^2) and Cohen's *d* value of 0.28 (Figure 5-3).

5.2.6 Sensitivity analyses

ANCOVA was performed with and without identified outliers, resulting in very similar results between models. Further sensitivity testing was performed by excluding data points with reported discretionary choice intakes more than three standard deviations above or below the mean. The ANCOVA models revealed similar patterns, with a mean change in discretionary choice serve intake of 0.98 ($p < 0.001$) from baseline to post-intervention, and no between-intervention group difference ($p = 0.211$).

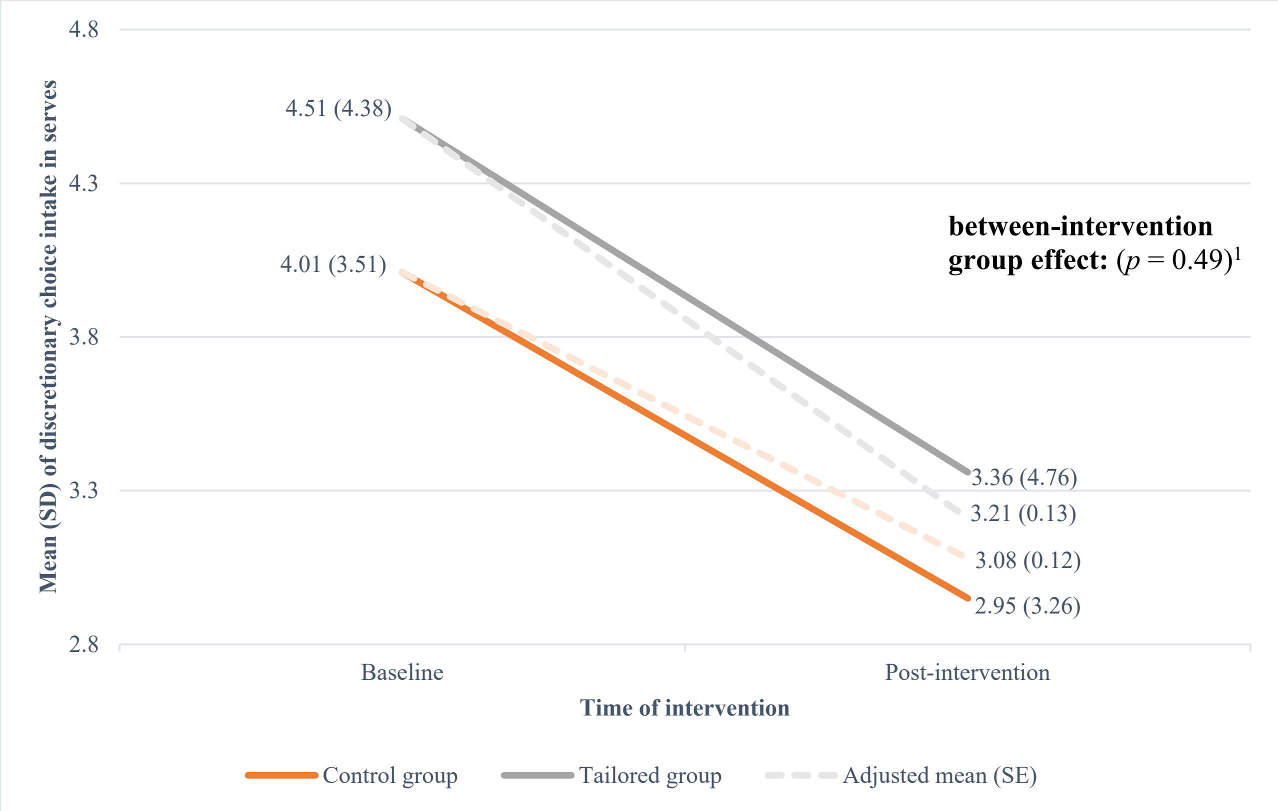


Figure 5-2: Mean (SD) and adjusted mean (SE) of discretionary choice intake in serves pre and post a brief online 28-day intervention, by control (*n* = 784) and tailored (*n* = 657) groups. [1] **Analysis of covariance with baseline intake as a covariate was used to calculate between-intervention group effect.**

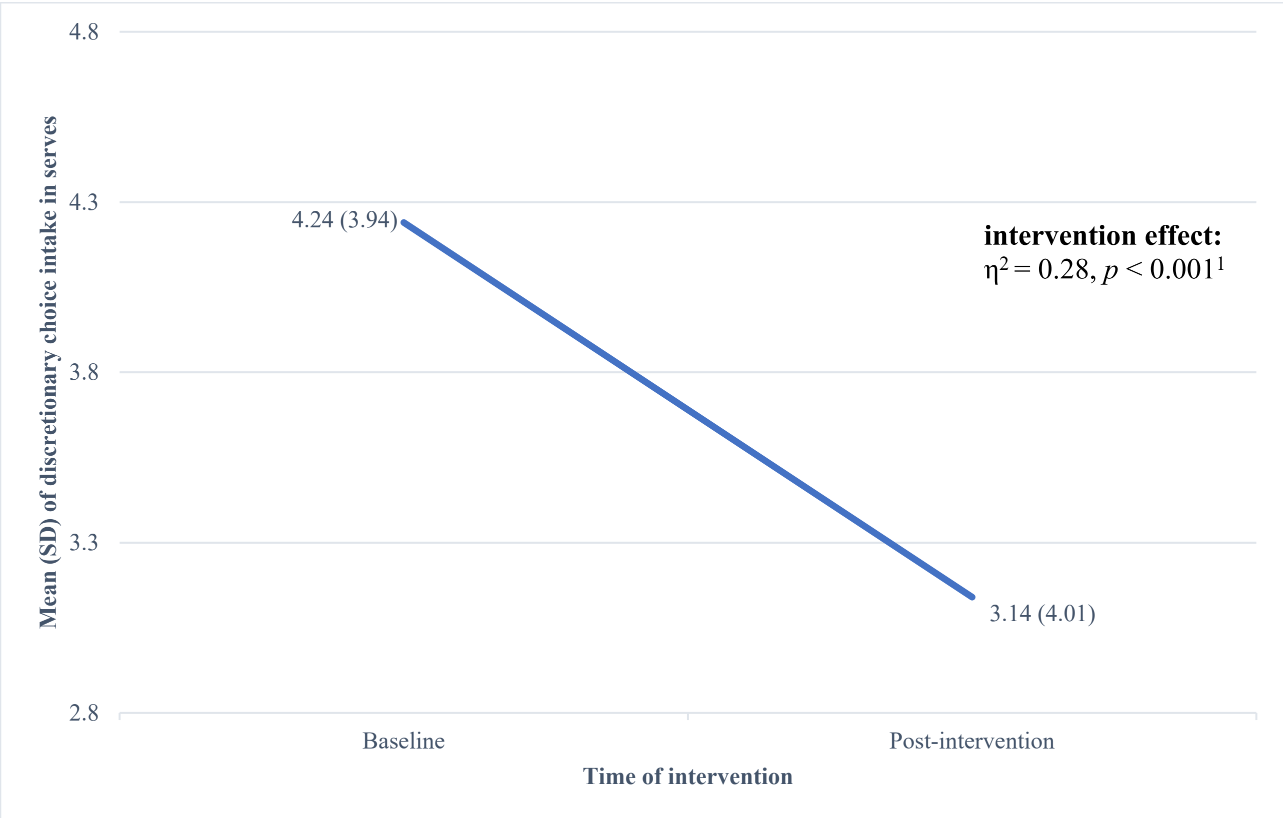


Figure 5-3: Mean (SD) of discretionary choice intake in serves pre and post a brief online 28-day intervention, for the overall sample (*N* = 1441). [1]**Analysis of covariance with baseline intake as a covariate was used to calculate intervention effect.**

5.2.7 Satisfaction with the intervention

To understand participants' perspective about intervention delivery, a process evaluation was conducted. The following section describes the between-group differences on reported agreement or disagreement with intervention satisfaction, agreement and engagement. For the expanded satisfaction terms, please refer to the methods in Chapter 3.

5.2.7.1 Satisfaction

On average, over half of the participants (56%) in the tailored intervention group agreed or strongly agreed that the intervention was satisfactory for the 10 items represented in Figure 5-4, in comparison with 48% participants in the control group. Approximately 9% more participants in the tailored intervention group, compared with the control group, reported they agreed or strongly agreed that the intervention was applicable ($\chi^2 = 9.9$, $p = 0.007$), motivating ($\chi^2 = 13.4$, $p = 0.001$), worthwhile ($\chi^2 = 10.2$, $p = 0.006$) and met expectations ($\chi^2 = 10.7$, $p = 0.005$). Further, 9% more participants in the tailored intervention group, than in the control group, agreed or strongly agreed that they were satisfied with the amount of emails received ($\chi^2 = 19.5$, $p = 0.000$), the frequency of contact ($\chi^2 = 22.2$, $p = 0.000$) and the overall intervention ($\chi^2 = 14.8$, $p = 0.001$).

An average of 18% of participants in the tailored intervention group, compared with an average of 23% in the control group, disagreed or strongly disagreed that the intervention was satisfactory (average of 10 items) (Figure 5-4). There were 8% or more participants in the control group who disagreed or strongly disagreed with the amount and frequency of emails received, and overall satisfaction. Slightly more participants (5% or more) in the control group disagreed or strongly disagreed with the intervention being applicable, motivating, worthwhile or meeting expectations. These results were all statistically significant (all $p < 0.05$).

On average, 29.3% of the control group and 26.4% of the intervention group felt neutral about the intervention. No significant in-between group differences were found on reported satisfaction regarding receiving intervention content by email, being online or wanting to change anything about the intervention.

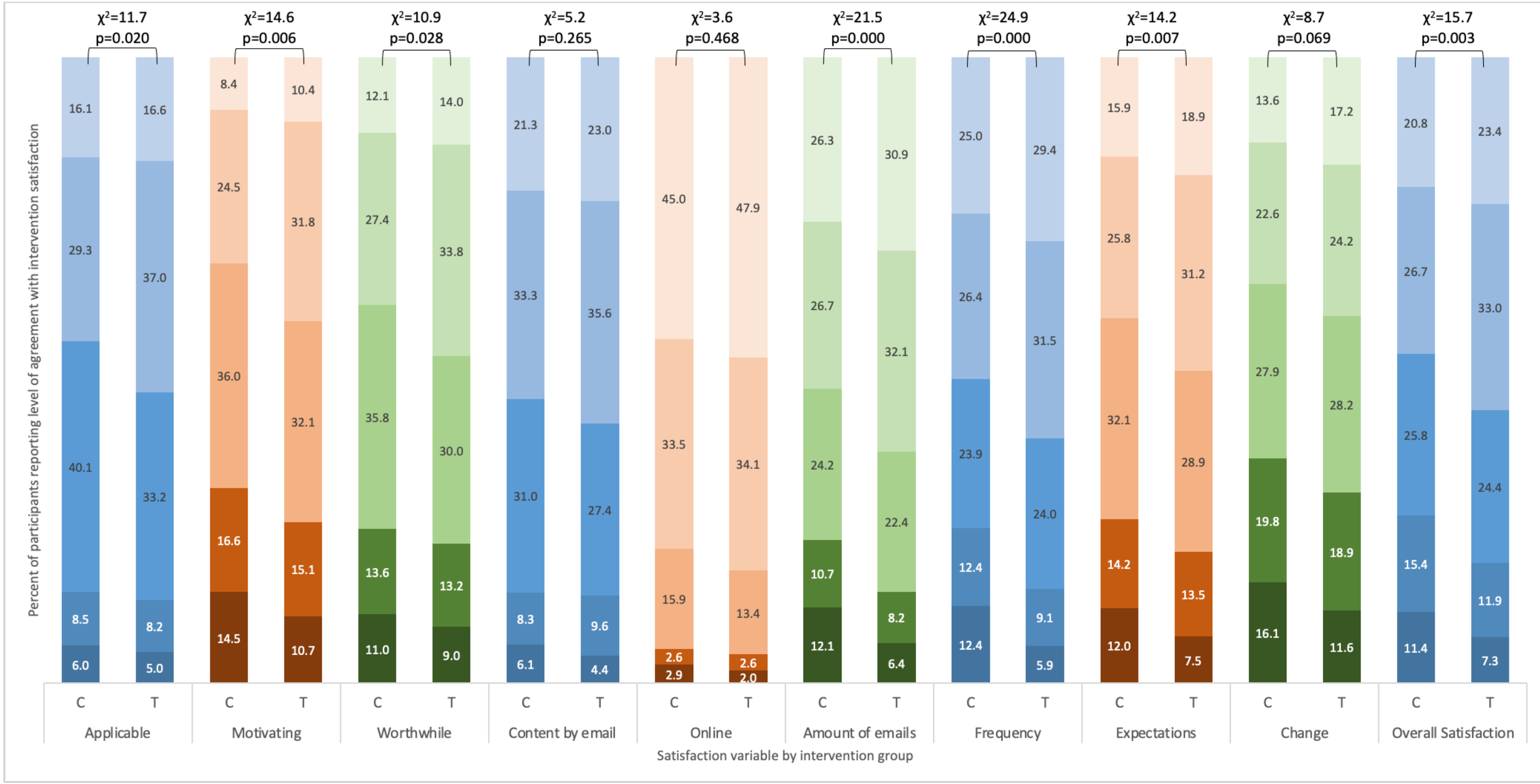


Figure 5-4: Level of agreement (1 = strongly disagree, darkest; to 5 = strongly agree, lightest) with intervention satisfaction between intervention groups. Pearson's chi-square (χ^2) and significance values are shown. ***C: Control group*** **(n = 784);** ***T: Tailored intervention group*** **(n = 657).**

5.2.7.2 Time demand

Regarding the time taken to conduct the intervention, more participants in the tailored intervention group (77.9%) than in the control group (74.4%) reported that the intervention took the right amount of time (Figure 5-5). Of the total sample, 20.9% reported that the intervention took too little time, and less than 5% reported it took too much time. Results between groups were not meaningful or statistically significant ($\chi^2 = 2.6$, $p = 0.272$).

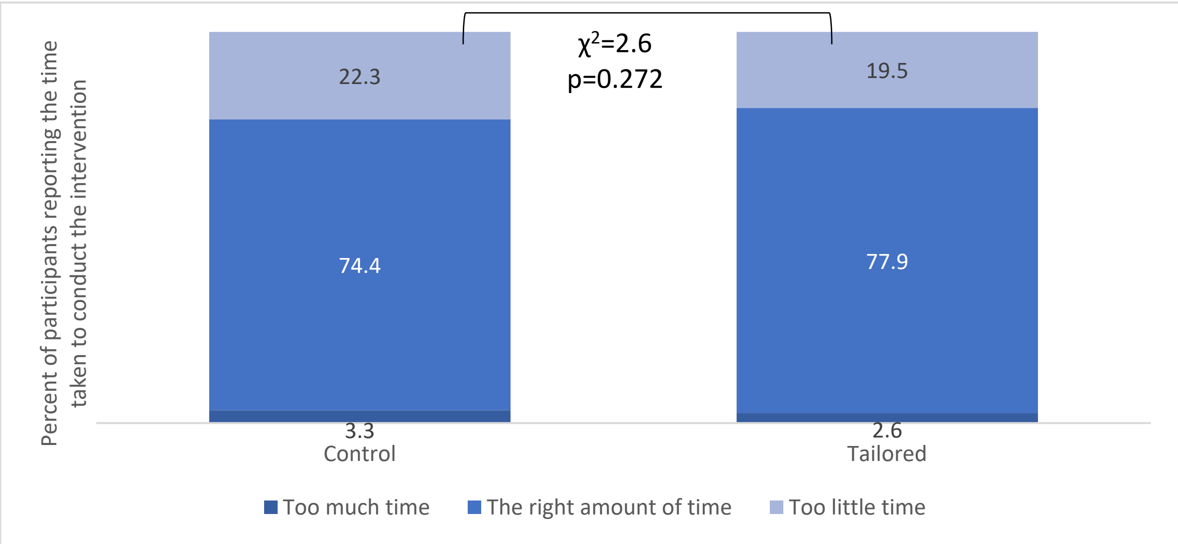


Figure 5-5: Reported time taken (time demand) to conduct the intervention between control group (n = 784) and tailored intervention group (n = 657). Pearson's chi-square (χ^2) and significance values are shown.

5.2.7.3 Engagement

Of the participants who opened (97.2%) and read (95.4%) intervention emails, slightly more participants in the control group (29.7%) opened and read the content at least once a day (an average of 28.8% participants opened, and 30.5% read, the emails). In comparison, 24.1% of the participants in the tailored intervention group (an average of 23.6% opened, and 24.7%, read the emails) (

Figure 5-6). More participants in the tailored intervention group (30.6%) than in the control group (24.9%) opened and read the content once a week. The differences between intervention groups for the frequency of opening ($\chi^2 = 11.9$, $p = 0.008$) and frequency of reading the emails ($\chi^2 = 9.7$, $p = 0.020$) were significant (Figure 5-6).

As shown in Figure 5-7, more participants in the control group (72.8%) than in the tailored intervention group (67.0%) reported spending less than 5 minutes reading the emails. More participants in the latter group (27.4%) than in the control group (21.0%) reported spending between 5 to 15 minutes reading the emails. Less than 2% of participants in both groups reported spending more than 15 minutes reading the emails. All results were not statistically significant (χ^2 = 7.9, p = 0.20).

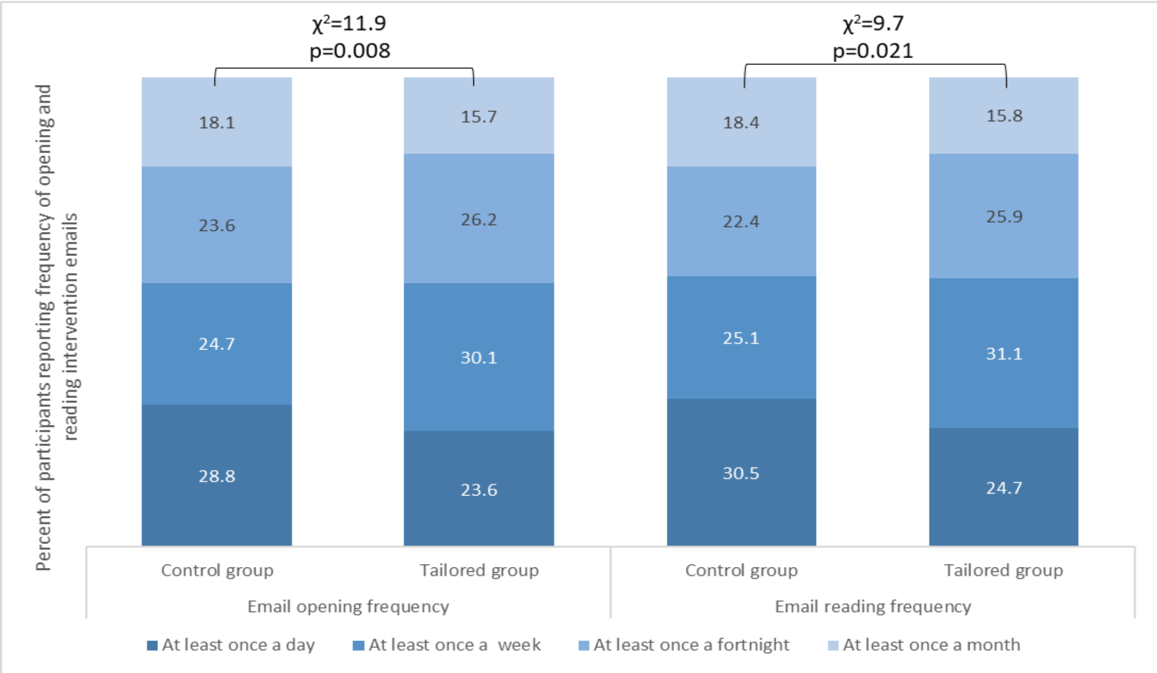


Figure 5-6: Reported frequency of opening and reading the intervention emails between control (*n* = 784) and tailored (*n* = 657) intervention groups. Pearson's chi-square (χ^2) and significance values are shown.

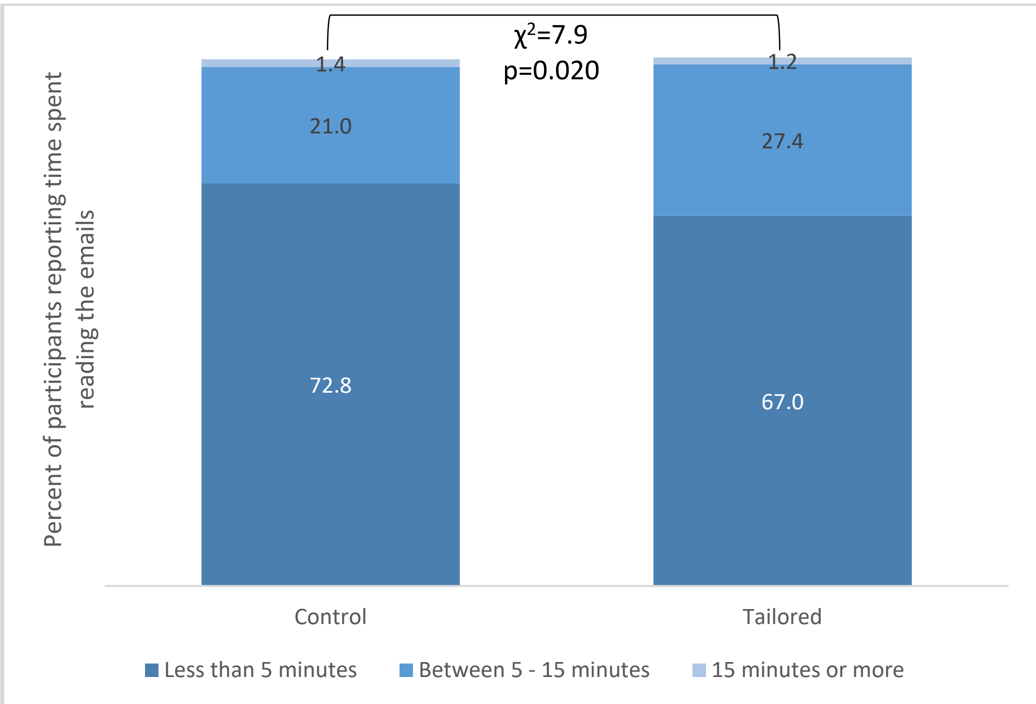


Figure 5-7: Reported time spent reading the emails between control group (*n* = 784) and tailored intervention group (*n* = 657). Pearson's chi-square (χ^2) and significance values are shown.

5.2.7.4 Evaluation feedback

Participant were asked open-ended questions about their reasons for not interacting with the intervention. Qualitative feedback was thematically analysed and is summarised in Table 5-2. Some examples of participant responses that gave valuable insights are also shown. The most common reported reasons for not interacting were missed emails, expecting more emails, lack of willpower and being too busy (Table 5-2).

Table 5-2: Summary of participant responses to open-ended questions about why they felt they did not interact with the intervention, or other comments, by intervention group (*N* = 532)*

Thematically sorted responses	Definition of theme	Control group (n)	Tailored intervention group (n)
Reasons for not interacting			
Missed emails in junk folder	Emails delivered to spam/junk folder and not obtained by participant	60	78
Expecting more emails	Expected to receive more than two intervention emails	64	48
Lack of willpower	Lack of willpower and high temptation to consume discretionary choices	32	29
Too busy	General day-to-day activity, which took away time from focussing on dietary behaviour	29	18
Needing more reminders	Two emails were not enough reminders to continue positive eating behaviour	21	18
Time of year (Christmas/holidays)	November to December are not ideal months to focus on improving dietary behaviour	19	14
Not applicable to eating habits	A false presumption that discretionary choice intake is high	10	7
No accountability	An online intervention does not have the same effect of accountability compared with a person/professional	6	8
Help with keeping record of progress	Receive a tool to record dietary behaviour throughout the intervention	4	-
No further information on how to change	No techniques provided on how to change the behaviour	3	-
Need more than online help	Additional face-to-face interaction or a phone call needed	2	-
Expecting a more personalised score	Expectation of tailored feedback on overall diet score	1	-
Content delivered through other media	Video/other imagery could lead to more engagement	1	2
Other (positive) comments			
Increased awareness of own eating habits	Reporting on dietary behaviour increased awareness for areas to improve	89	100
Informative	Valuable information on discretionary choice serving sizes that helped reduce intake	55	70
Unexpected weight loss	Weight loss achieved unexpectedly	6	11
Simplicity of repetition of the same message	A simple message used as a prompt helped remind about intervention goals	-	5
Subconscious motivation	Motivated to change dietary behaviours on multiple occasions in the day	-	6

Note:
*Not all participants responded to the open-ended questions, and some participant responses fell under more than one theme.

5.2.7.5 Reasons for not interacting

Participants reported *needing more reminders* and/or emails during the intervention. This feedback was somewhat in line with the *expecting more emails* theme. Some participants reported that if they had received more prompts, they may have had more assistance to eat less discretionary choices:

> Although I appreciate not getting spammed, I didn't actively think about my eating habits because I wasn't actively reminded to. So, I feel that the study would be more effective if I received reminders about how I can improve my eating habits at the start or end of every week instead of on a fortnightly basis. – **Female, control group**

> I think more frequent emails would have been good motivation and a reminder to make good food choices. – **Female, tailored intervention group**

Being *too busy* with general day-to-day activities and other priorities were reported to have taken time away from focussing on engaging with the intervention and changing dietary behaviour.

> I needed to be prompted to think about what I was going to eat more frequently. I read the emails but then put them to the back of my mind. Busy looking for work and other issues at the front of my mind. – **Female, control group**

> I have been very busy with moving house and work commitments; it's been hard to find time. – **Female, control group**

> I became very busy with work and doing a couple of 65-hour and 7-day weeks and having young kids at school and after school sports; I ran out of time to do anything else. – **Female, tailored intervention group**

Other participants' comments, which all indicated a positive interaction with the outcomes associated with participating in the study, are summarised in themes in Table 5-2. Examples of participant responses follow.

Participants reported that the intervention helped *increase their awareness of their eating habits*, through food intake reporting, using the information (in the tailored intervention) or being reminded about their food intake when receiving the half-way prompts:

> It got me thinking about what foods/drinks I put in my mouth, thank you :-) – **Female, control group**

> It made me realise how many discretionary foods I consume in a day. Many more than I thought. – **Female, tailored intervention group**

Some participants reported the *repetition of the message* as helpful to maintaining their high intention to eat less discretionary choices:

> Initially, I thought the study was too simple and too obvious. But I'm pleasantly surprised how this got me thinking about improving my diet. It's not pushy, it's not judgemental, but it makes me want to change … Thank you! – **Female, control group**

I did like the simple repeated message. It has made quite an impact ... The discretionary food I had eaten was a bit of a shock in quantity and frequency. I have definitely made some changes. – **Male, tailored intervention group**

5.2.7.6 *Mode of recruitment*

Participants were asked to report the method of recruitment into the study through selecting from a list of options and an open-ended response box. The most common recruitment method was social media with 89.3% participants hearing about the study from Facebook, LinkedIn, Instagram or Twitter (Table 5-3). More than half (56.1%) of the participants reported Facebook as the mode through which they heard about the study. There were no significant differences in the recruitment method between the intervention groups.

Table 5-3: Mode of recruitment into the study as reported by participants (*N* = 1,441)

Source of study recruitment mode	*n*	%
Paid Facebook ad through CSIRO page	809	56.1
LinkedIn CSIRO feed	419	29.1
CSIRO recruitment or website	84	5.8
Paid Instagram ad through CSIRO page	47	3.3
Word of mouth	42	2.9
Flinders University research studies website	16	1.1
Twitter CSIRO feed	12	0.8
Flyers on Level 7 of the South Australian Health and Medical Research Institute building	12	0.8

5.2.7.7 *Mode of delivery preference*

To understand whether participants would prefer the same or another method for future intervention delivery, they were asked to rank their preference for four delivery mode options. As shown in Figure 5-8, most participants (72%) indicated email being their first preferred mode, followed by a combination of email and SMS (18%). Moreover, 72% reported social media as being their least preferred mode. About 7% more participants in the control group indicated email as their first preference for intervention delivery ($\chi^2 = 12.0$, $p = 0.007$). However, no other statistically significant differences between groups were observed for the other delivery methods.

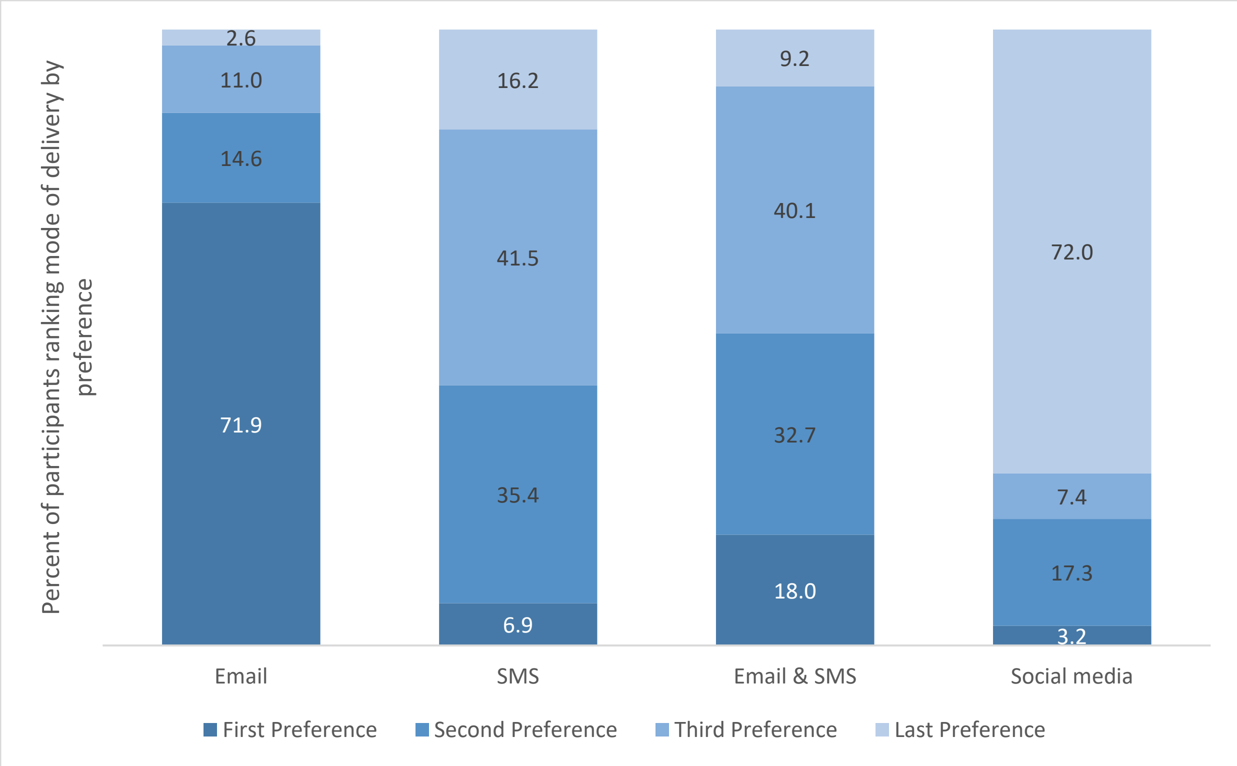


Figure 5-8: Participants' (*N* = 1,441) ranked preference from most preferred (=1, darkest) to least preferred (=4, lightest) method of intervention delivery. SMS: short message service.

5.2.7.8 Nutrition message frame preference (tailored intervention group only)

To understand whether participants in the tailored intervention group (n = 657) would prefer receiving the same or another type of message in a future intervention, they were asked to rank their preference from 'least preferred' (=1) to 'most preferred' (=5) type. All four messages trialled in Chapter 4 were displayed. Most participants (75%) reported they would prefer receiving the positive message first; the negative message frame (11%) was their second preference. In addition, 42% reported the minority norm message as being the least preferred message type (Figure 5-9).

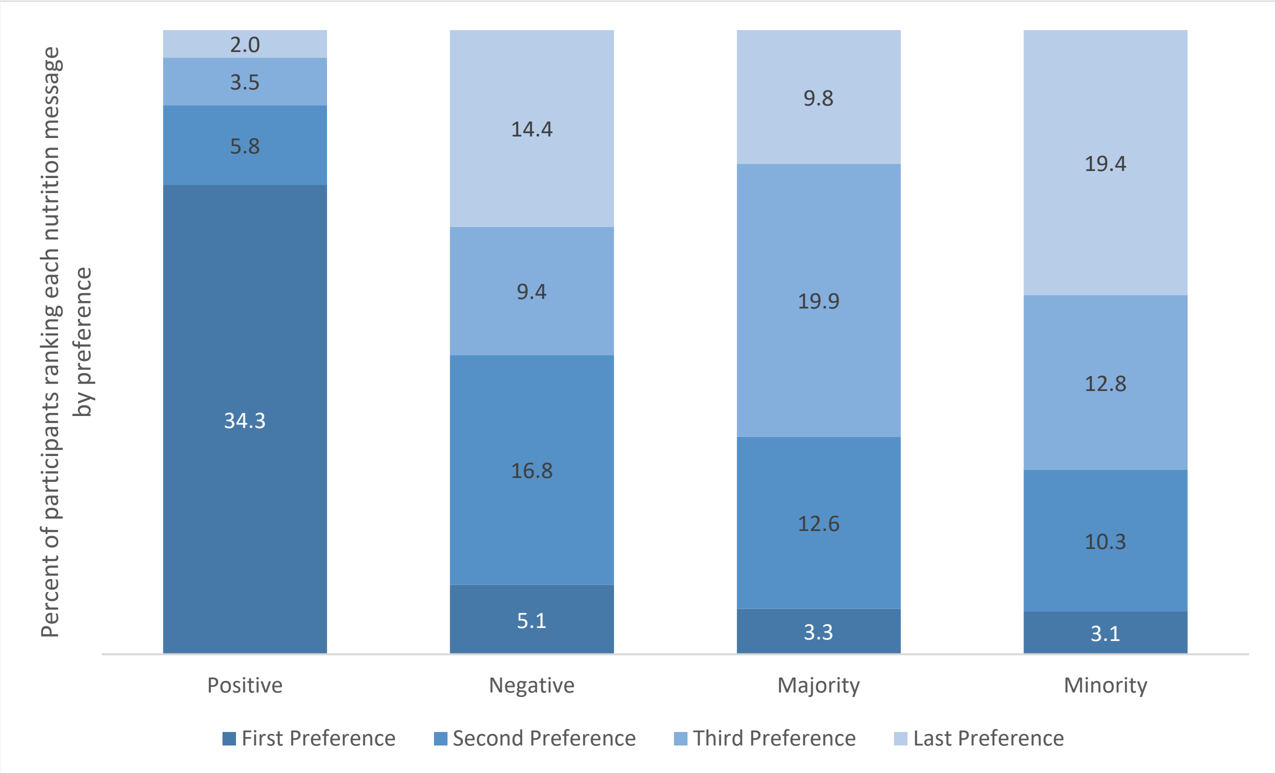


Figure 5-9: Participants in the tailored intervention group (n = 657) ranked preference from most preferred (=1, darkest) to least preferred (=4, lightest) nutrition message type.

5.2.7.9 Contamination

Participants were asked to report whether they sought extra help during the intervention period and to indicate the source of help. Of the total sample, 14.9% (n = 214) reported receiving dietary intervention outside of *Shifting My Nutrition Score in 28 Days*. Participants reported receiving extra dietary information through other online sources (n = 122), a weight-loss gym challenge (n = 31), advice from family or friends (n = 30) or a health professional (n = 29). The remaining sources of information were a food intake tracking mobile app; the CSIRO Low Carb Diet or Total Wellbeing Diet; recipe or health books; a Netflix documentary; or another diet regime (i.e. Weight Watchers) they followed. No significant differences in responses between intervention groups were found.

5.3 Discussion

5.3.1 Purpose of this study

The primary aim of this RCT was to compare the effect of *Shifting My Nutrition Score in 28 Days*—a brief online dietary feedback intervention—in delivering a tailored nutrition message frame with the effects of a generic nutrition message used in standard practice (control), on discretionary choice intake after 28 days, in a sample of Australian adults. The secondary aim was to evaluate the satisfaction with the intervention between the intervention groups. The study tried to address the evidence gap of whether nutrition message *frames*, tailored to individuals' baseline intention, would be more effective for improving dietary behaviour than generic dietary feedback messages. Findings demonstrated that delivering a tailored nutrition message frame did not lead to an enhanced reduction in discretionary choice intake than generic messages. Participation in either intervention group (tailored or control) resulted in a statistically significant and clinically important one serve reduction in discretionary choices. Higher participant satisfaction indicated they favoured the tailored intervention; however, time was a key barrier to engagement and interaction, regardless of intervention group. Findings imply that the fundamental evidence and theory-based features of the intervention were the drivers of short-term dietary behaviour change. Further study is needed to examine the longer-term intervention effects of tailored nutrition messaging interventions and whether this approach may lead to greater participant engagement and behaviour change impact over time.

5.3.2 Intervention effect on discretionary choice intake between groups

The current study tested a unique tailoring approach to delivering a dietary feedback intervention. Tailoring nutrition message frames, using baseline intention as a characteristic, was hypothesised to be more effective for improving dietary behaviour, than generic messages used in standard practice. However, the study found that between the tailored intervention and control groups, there was no significant difference in post-intervention discretionary choice intake, adjusted for baseline intake. This finding was unexpected, because although tailoring nutrition message frames has not been tested previously, the literature on the effects of nutrition message framing has consistently been predicted by the baseline level of intention. For example, Godinho et al. found that individuals with lower baseline levels of intention were not influenced by nutrition message framing, whereas for those with higher baseline intention, negative messages predicted an increase in fruit and vegetable intake (111). Other studies have shown similar predictions (111, 113, 117, 118). However, the current findings did not demonstrate agreement with this evidence.

Since tailoring can refer to any method for creating individualised communication (74), the effect of other approaches to tailoring have also shown promise in improving diet quality. Interventions that tailor feedback to baseline dietary assessment as a behavioural characteristic have resulted in more improvement in dietary behaviour than a control intervention that provides, for instance, general nutrition information. For example, tailored dietary feedback interventions have resulted in a reduction in saturated fat intake by 1.2% (39), a reduction of energy intake from discretionary choices by 8.3% (245) and an improvement in diet quality scores by 2.6% (36, 39, 40) and up to 12% (34). Of note, however, the control groups in previous studies have not tended to receive an intervention similar to that provided in the current study. Both groups (tailored and control) that participated in *Shifting My Nutrition Score in 28 Days* received similar intervention features. The features included two brief emails over 28 days, a personalised feature using participants' first name, which has been recommended for message impact (243), and key BCTs, such as the use of goal setting, self-monitoring and prompts (165, 172) for behavioural support. The use of the theory and evidence-based features for intervention design in both intervention groups could have been fundamental for the significant impact achieved on discretionary choice intake, regardless of the tailored nutrition message framing.

Irrespective of messaging approach, the intervention as a whole was able to significantly reduce discretionary choice intake by one serve, or by 22% throughout the 28-day intervention period. No other changes in food group intake were observed (data not shown). One serve of discretionary choices is approximately 600 kJ; therefore, this study was able to reduce the equivalence of two scoops of ice-cream, or 375 mL of a sugar-sweetened beverage or a small glass of wine (10). This study achieved a higher effect on diet quality than did the aforementioned recent tailored intervention trials conducted in Europe (36, 39, 40) and elsewhere (34, 245). Results from earlier meta-analyses of tailored online nutrition interventions also showed smaller effects on increasing fruit and vegetable intake by 0.24 serves, but no effect on reducing saturated fat (reduction by 0.24 g, $p = 0.7$) (163). Since the average diet quality of Australians remains alarmingly poor with 35% of their energy consumption from discretionary choices (14), the outcomes from this study are important at the population level.

A 2020 modelling study estimated the extent of impact that a reduction of one serve of discretionary choices, per week, would have on gaining health-adjusted life years and on saving healthcare costs over the lifetime of the 2010 Australian population (246). Substituting discretionary choices with a healthier option resulted in overall healthcare cost savings of AU$793.4 million; significant weight loss (by 0.21 kg); health-adjusted life years gains of 76,441; and reduced incidence of non-communicable diseases, such as ischaemic heart disease, stroke and cancer. It was also estimated that if no substitute food is consumed to replace the decrease in discretionary choice intake, the prevention of non-communicable diseases incidence would be even higher (246). *Shifting My Nutrition Score in 28 Days* was able to reduce discretionary choice intake at a level that can have substantial population-level health benefits. Nonetheless, it is important to explore the reasons for the interim null findings. One reason could be the sample's high baseline intention, as discussed in the next section.

5.3.3 Effect of high baseline intention

Participants in both intervention groups reported a high median baseline intention score of 81 out of 100 (Chapter 5). As per the theory of planned behaviour, a positive attitude towards a behaviour is essential for increasing intention, and thus allowing actual behaviour change (157, 186). This could be one reason for the lack of a statistically significant difference on the dietary outcome between both groups. Participants voluntarily participated in this study, and thus, they may have been already motivated to act on the intervention messages to improve their dietary behaviours (240). Results from the Food4Me trial support this argument because participants who received general nutrition information (control condition) showed a modest improvement over 6 months in their diet quality score (from 49.5 to 51.8 out of 100) on participating in the intervention (39). Evidently, by simply participating in a nutrition intervention, a drive for behaviour change is likely, and therefore, receiving any message may be just as beneficial as more enhanced interventions (247). It has been suggested that tailored interventions may require a greater level of tailoring, intensity or human interaction to be more effective than standard practice approaches, especially for less motivated participants (247); therefore, less complex interventions, such as *Shifting My Nutrition Score in 28 Days*, may be sufficient for a motivated sample. Therefore, this study recommends that future trials include samples with lower baseline intention to facilitate drawing clear conclusions on their effects (241). It may also be warranted to identify alternative ways to intervene for people with lower intention to change dietary behaviour, because it is unlikely that these groups will voluntarily participate in online nutrition interventions.

5.3.4 Between-group effect on satisfaction and engagement with the intervention

The engagement rates with the intervention were important features to consider for identifying ways to improve the long-term effectiveness of future interventions (176). Although there was no difference in impact between intervention groups, participant satisfaction favoured the tailored intervention, as evidenced by the process evaluation. In line with behaviour change theories (173, 188), this study's findings portray that the receipt of tailored message frames about the 'what' to do and 'why' to do it, and BCTs on 'how' to do it, may have led to higher participant satisfaction. Although the present study was designed to change short-term dietary behaviour, positive experiences with interventions have been associated with the higher likelihood of revisiting the intervention, leading to longer-term outcomes (248). Changes achieved in 4 weeks have previously predicted long-term behaviour change (41, 170, 171). From the process-evaluation results, it could be hypothesised that higher satisfaction may lead to sustainable engagement and longer-term behaviour change. Future research could explore whether a tailored intervention would produce enhanced longer-term effects in comparison to a generic approach. Understanding the reasons for the lack of interaction and engagement with interventions could also improve the future delivery of interventions.

5.3.5 Reasons for lack of interaction with the intervention

Participants commonly reported that missed emails or expecting more emails were reasons for not interacting with the interventions, which could be controllable factors in future interventions. In addition to these responses, a lack of willpower and time ('too busy') were key barriers to intervention interaction and engagement. These reasons could be associated with the 30% retention rate from baseline to post-intervention. In regard to time constraints hindering participants' ability to adhere to healthy dietary behaviours, the link between these factors has been well established (60, 249-251). The time needed to prepare food has previously been shown to reduce the probability of meeting fruit and vegetable recommendations of 8,319 Scottish women by 5.6% (60). Similarly, a secondary analysis of a food shopping nutrition education intervention showed that the perception of time constraint (i.e. 'I feel that vegetables are time-consuming to prepare') had a significant negative association with healthy dietary behaviour (249). In support of this finding, healthy food purchasing has been found to be negatively affected by long working hours, regardless of household income (250). For example, those from higher-income households purchase more discretionary meals outside of the home to save time on shopping and cooking, whereas those from lower-income households purchase more convenience foods in the supermarket to save time on cooking (250). Evidently, poor interaction with nutrition interventions is likely if time constraints are not carefully considered.

Some comments from the process evaluation were contradictive, in that the same participants who reported lacking time also indicated that more prompts or higher intervention intensity would have helped improve interaction. However, this intervention was purposefully brief to account for time availability. This contradiction could be explained by the literature on *perceived* time constraint, which has revealed the negative influence of this constraint on diet quality and healthy food purchases regardless of true time availability (251). This literature has suggested that perceived time constraint may be misaligned with reality since technology has actually allowed populations to have more free time. To reduce the subjectivity of this perception, the development and improvement of a time constraint measure as a part of food consumption surveys could clarify true time availability (251). This measure could then be used to identify how messages could be tailored depending on time; for example, providing time-poor participants from low-income households with ‘how’ messages on convenience foods to buy in the supermarket, while increasing time availability for participants by providing budget-friendly recipes for cooking. Improving the measure of time constraints could allow the right level of support to be provided by brief online feedback interventions.

5.3.6 Strengths and limitations

This study’s key strength is its novel approach of incorporating tailored nutrition message frames based on individual levels of intention, into a brief online feedback intervention, using an RCT design. Studies have previously tested the impact of tailoring intervention outcome (e.g. diet or physical activity, or both) based on a range of characteristics, including age, height, weight, gender, family history and prior weight-loss experience; baseline diet quality; and theoretical and psychological concepts, such as the stage of change, future physical activity and diet goals, stress management, attitudes, and sources of motivation (170). However, unlike this study, no studies have tailored a nutrition message on positive, negative, majority or minority framing using intention as a characteristic, to improve discretionary choice intake. This novel intervention led to a significant reduction in discretionary choice intake among a large sample, and it was strengthened by its strong use of evidence and theory. The robust, RCT design was recognised through multiple sensitivity analyses. Analyses showed that the pattern of results remained consistent regardless of the removal of extreme outliers, and by adjusting for baseline measures. The intervention also appealed to many people as evidenced by the large number of participants who enquired about the intervention (N = 5,353) and completed the study (N = 1,441). The RCT design and the moderate level of retention (30%) also optimised internal validity.

The high response to recruitment is encouraging as it supports that utilising recruitment strategies used in this study are effective for reaching adults for online interventions. Using social media advertisements specifically could be associated with a high level of recruitment success, as observed in earlier RCTs (235, 252). Although this mode of recruitment did attract a highly motivated sample, future studies could use social media for recruitment but target advertisements towards harder to reach audiences. For example, this could be by targeting advertisement towards people who are interested in, and interact with, social media posts related to fast-food outlets or discretionary choice-related recipes. However, if these audiences have no baseline interest in eating healthier, it may deter them from interacting with the study. The complexity of recruitment for research using more contemporary methods of promotion requires more research. The use of multidisciplinary experts is also important to help to identify ways to reach and intervene with individuals with poorer diets and lower intention to change their dietary behaviours.

As regards to the limitations, having a highly motivated sample was a key limitation of this intervention (241). Volunteer bias could have been a reason for the null findings between intervention groups (230). Each participant in the study saw the recruitment advertisement, acknowledged their desire to change their dietary behaviour and initiated the process to participate in the study. This active, rather than passive, recruitment may help to explain why both interventions were equally successful (253). Another important consideration of this study is the potential for false-positive results due to Type I error. The number of participants recruited for this study met the top range of the sample size calculation. This large sample recruited would have increased the statistical power of the analysis. To minimise statistical bias, effect sizes were calculated, to aid the interpretation of the magnitude of differences (96, 98).

Due to the substantial dropout rate throughout the study, the potential for selection bias must be acknowledged, since only the participants who completed the study were considered for analysis. An intention-to-treat analysis may have yielded an unbiased estimate of the efficacy of the intervention on discretionary choice intake, however, this analytical approach requires complete outcome data (254-256). Twenty-three participants had outcome data but were non-completers of the evaluation questionnaire, thus were not included in the final analysed sample ($N = 1,441$). Therefore, it is unlikely that adding these datapoints would have made a significant difference in the final results. Conducting exit interviews were not within the scope of this thesis, however, future research should endeavour to collect demographic data from participants who are lost to follow-up. This evidence is important to understand if there are systematic demographic or behavioural differences between study completers and dropouts to improve how and who interventions should target, as previous research has shown (169).

Since the study was very short in length, baseline intention could have played a large role in the observed behaviour change and confounded the true effectiveness of the intervention. This aspect limits the ability to generalise intervention effects. Nonetheless, on comparison with the national health survey data, similarities were observed with the current sample for eating discretionary choices beyond recommendations, whereby the baseline discretionary choice intake was about four serves in this study, and the current average energy intake of Australian diets is 35% discretionary choices (257). Further, in the large dataset of the CSIRO Healthy Diet Score from 2017 ($N = 145,975$), the mean overall diet score was 58.8 ± 12.9, which is somewhat similar to the current study sample's diet score of 54.4 ± 10.5. Therefore, baseline dietary data may lead to applicability to larger samples (30).

Next, although valid, reliable questionnaires were used in this study, data were self-reported, which may have resulted in reporting bias, social bias and measurement error (206). However, the anonymity ensured in online questionnaire completion may reduce perceived social judgement and may attenuate the potential risk of social desirability bias. Using the SFS allowed a whole of diet analysis, as opposed to other studies that have focussed on single-item measures, which limits the ability to assess overall compliance with dietary guidelines. Nonetheless, a limitation of using the SFS is the significant differences observed by developers who tested its validity against a 24-hour recall, indicating a potential limitation in its ability to estimate absolute food intakes (29). Since discretionary choice serves were summed from 11 items of the SFS, the cumulative effect of the reported intake could have led to potential overreporting/overestimating of intake through the assumption that each reported occasion of consumption was a serve of discretionary choices (600 kJ) stated in the ADGs (29). This information should be considered when interpreting the results, together with the fact that results may have been confounded with uncontrolled factors.

Another limitation is that about 15% of participants reported seeking dietary help outside of the intervention. The major source of contamination was from other online information sources. This is a key finding, indicating that future interventions need to find ways to either be more controlled to find true effectiveness, or incorporate data that consider the confounding effect of intervention contamination. Simultaneously, the intervention may have prompted participants to seek more dietary help externally, which could have led to additional positive outcomes. In future research, an additional survey item could be embedded to explore this further. Last, the evaluation analysis found that many participants did not receive their email or were expecting a higher number of emails. This fact could have produced non-usage attrition bias and flawed results, because participants may have filled in the follow-up data measurements without actually interacting with the intervention (165). Future efforts should ensure this information is objectively collected (i.e. through log-in metrics) for more transparent intervention evaluation (165).

5.3.7 Implications for practice and future research

To the best of the candidate's knowledge, this study provides unique evidence on the effectiveness of a brief online dietary feedback intervention that uses tailored nutrition message framing, on discretionary choice intake. In comparison to generic messages, there was no additional effect of tailored nutrition message framing using baseline intention as a characteristic. The design of the intervention delivered to both groups was evidence based and grounded by behaviour change theory, which may have been the fundamental features associated with intervention success. In addition, the baseline level of intention of the study participants was high, which suggests that they were motivated to change dietary behaviour regardless of message tailoring. A recommendation for future studies is to find ways to intervene for participants with lower intention, because these groups are unlikely to voluntarily participate in online nutrition interventions. Further, an alternate or additional control group (i.e., with no dietary intervention provided) may be another consideration for future similar research. The process evaluation indicated that participants were more satisfied with the tailored intervention; however, all participants reported time as a key barrier to intervention engagement. Since engagement has been associated with longer-term behaviour change, future interventions could test the impact of tailored interventions on behaviour change sustainability and compare the results with those obtained on using generic messages. Last, developing and embedding more rigorous time constraint measures into food consumption surveys may allow the right level of support to be provided by future interventions, by informing tailored nutrition messages that consider participant time availability.

5.4 Summary and Chapter Conclusion

This RCT was conducted to identify whether tailored nutrition message framing is more effective in improving dietary behaviour than are the generic messages used in standard dietary feedback interventions. The findings demonstrated that regardless of tailoring, participation in a brief online intervention resulted in a statistically significant and clinically important one serve reduction of discretionary choices. The online brief intervention design of both intervention groups was evidence based and grounded by behaviour change theory. These fundamental features for intervention design may have been the drivers of behaviour change, regardless of the messaging approach. Nonetheless, higher participant satisfaction favoured the tailored intervention. Further study is needed to examine longer-term outcomes and whether tailoring nutrition messages, with enhanced behavioural support, can retain more people and lead to more sustainable impact over time. In addition, since tailoring the nutrition message did not predict intervention effect on discretionary choice intake, it is important to identify other factors that do predict this effect. Moreover, other participant characteristics could be analysed to identify *for whom* is the intervention most effective.

5.4.1 Bridging summary

This study compared the impact of a brief online dietary feedback intervention that used tailored nutrition message framing or a generic message. The findings showed that regardless of message tailoring, a significant reduction by one serve of discretionary choices was achieved over 28 days. Overall, as a strategy, providing a nutrition message on discretionary choices, after a dietary assessment, and prompting behaviour change through two emails, is a promising short-term initiative for motivated individuals. Nonetheless, randomising participants to a tailored or a generic messaging approach did not predict change in discretionary choice intake. Examining the variation of discretionary choice change over the 28-day period may provide information on what other factors could predict intervention success. Other measured variables, such as demographic, anthropometric, behavioural or psychosocial characteristics, could be used to further understand who benefits most from an intervention of this type. The next chapter will discuss the characteristics associated with reduction in discretionary choice intake following the *Shifting My Nutrition Score in 28 Days* intervention.

CHAPTER 6 PREDICTORS OF DISCRETIONARY CHOICE INTAKE AFTER *SHIFTING MY NUTRITION SCORE IN 28 DAYS*: AN EXPLORATORY ANALYSIS

6.1 Overview and Rationale

In Australia, individuals derive about 35% of their total energy intake from the consumption of discretionary choices, and their average daily intake of these foods is more than twice the recommended serves (15, 257). This behaviour could be displacing the intake of core food groups (66). Therefore, intervening to reduce the intake of discretionary choices is important to help populations maximise diet quality improvements. Although almost every Australian adult would benefit from engaging in an intervention to reduce discretionary choice intake (63), some individuals will adopt, use and respond to interventions more than others (177). Hence, it is important to understand who these individuals may be. Observational studies have identified that participants with certain characteristics, such as being female, of older age and with a healthy weight, are more likely to comply with dietary guideline recommendations (discussed in Chapter 1, section 1.3). Similarly, cross-sectional and longitudinal studies have shown that gender and age characteristics predict dietary behaviour (4, 27, 68, 182, 183). However, limited research has been conducted on individual predictors of dietary behaviour following online dietary feedback interventions. To advance this research, data from the *Shifting My Nutrition Score in 28 Days* can be used to identify the participant characteristics that predict a reduction in discretionary choice intake, and the extent of such reductions. This information will allow future studies to investigate the reasons that such people respond, or do not respond, to these types of interventions, and allow future interventions to provide greater support for those who need it the most.

In summary, the gap in knowledge on *for whom* a brief online dietary feedback intervention is most effective needs to be filled in order to refine future interventions for those who need more support. Therefore, this exploratory analysis aims to address thesis objective 4: as stated in section 6.1.1. Chapter 3 reported the methods used in this study. Chapter 5 informed the definition of an improvement in discretionary choice intake diet quality as a one serve reduction. The results of the exploratory analysis are reported in section 6.2 of this chapter, a discussion of the study results is presented in section 6.3, and section 6.4 concludes this chapter.

6.1.1 Chapter aim and objectives

To determine participants' demographic, anthropometric, behavioural and psychosocial characteristics that predict (i) an improvement in *discretionary choice intake*, and (ii) compliance with the dietary guidelines for *discretionary choices*, after *Shifting My Nutrition Score in 28 Days*.

1. To explore the distribution of change in discretionary choice intake among those who participated in the intervention.
2. To describe the post-intervention reduction in, and compliance with the ADG for discretionary choice intake, by participants' demographic, anthropometric, behavioural and psychosocial characteristics.
3. To identify predictors of a reduction in, and compliance with the ADG for discretionary choice intake post-intervention, using participants' demographic, anthropometric, behavioural and psychosocial characteristics.

6.2 Results

The results presented in this chapter were prepared using the STROBE reporting statement (189) presented in Appendix 3. This study uses the pooled sample (N = 1,441) from the RCT reported in Chapter 5. First, the distribution of change in discretionary choice intake achieved from *Shifting My Nutrition Score in 28 Days* is presented. Then, the demographic, anthropometric, behavioural and psychosocial characteristics of the participants are described in Table 6-1. Next, the primary and secondary study outcomes and their predictors are reported.

6.2.1 Distribution of change in discretionary choice intake

The distribution of change in discretionary choice intake after participation in the *Shifting My Nutrition Score in 28 Days* intervention is shown in Figure 6-1. A large variation in the change in discretionary choice intake was observed from baseline to the post-intervention stage, ranging from a decrease of −25.7 serves to an increase of 16.8 serves.

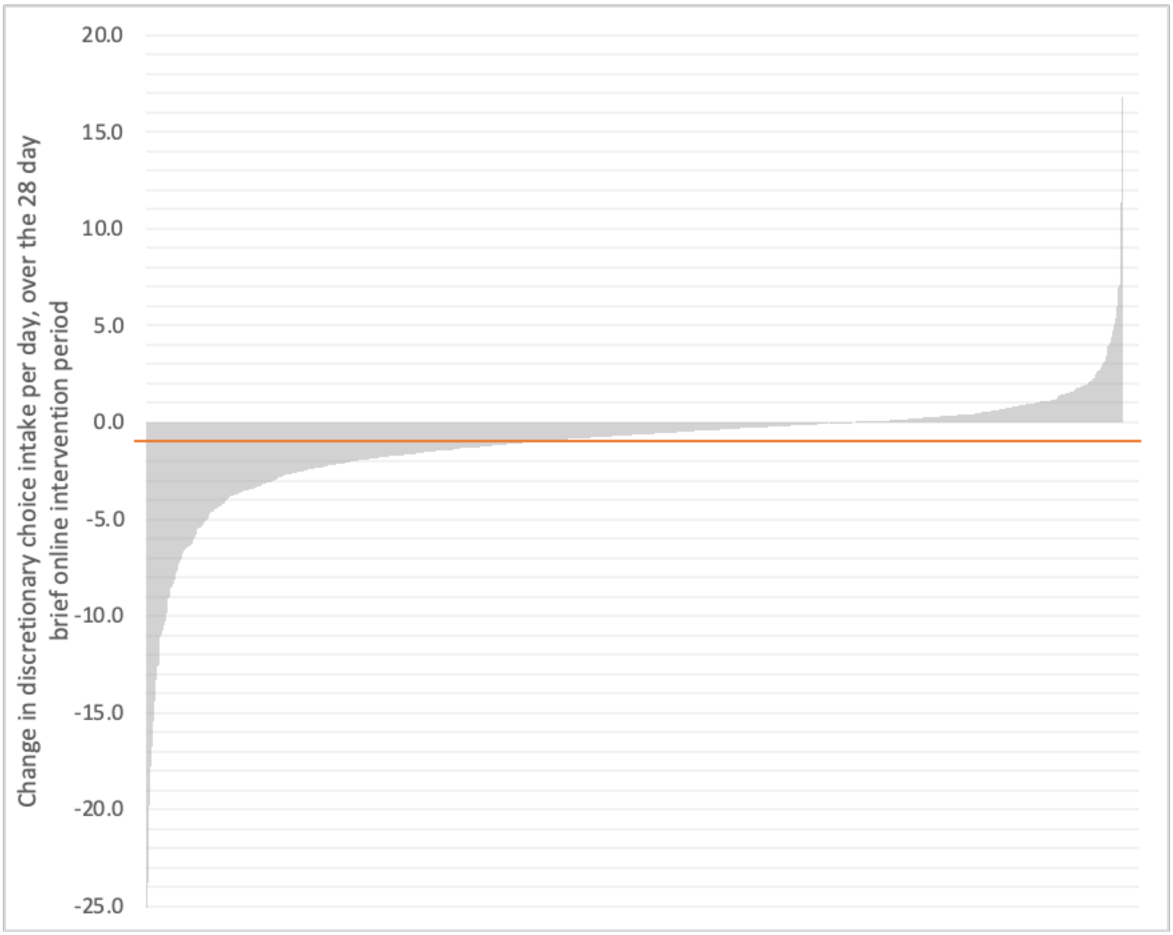


Figure 6-1: Distribution of change in discretionary choice intake on average, per day (sum score from the Short Food Survey) among the pooled sample (*N* = 1,441) from baseline to post-intervention (28 days). Data points below the orange line indicate participants who achieved a greater than one serve reduction in discretionary choice at the end of the intervention. Cases with an extreme discretionary choice serve change (*n* = 3) are not shown in this figure.

6.2.2 Description of outcomes

Two outcomes of interest were examined in this analysis: reduction in discretionary choice intake and successful compliance with the ADGs. The former was defined as the reduction of one serve or more from baseline to post-intervention. The latter was defined as the achievement by participants of post-intervention intake that was less than or equal to two to three serves, depending on gender and age (Chapter 3, section 3.4.6.2).

6.2.2.1 Reduction in discretionary choice intake

Participants were characterised using a range of demographic, anthropometric, behavioural and psychosocial variables, as shown in Table 6-1. The proportion of participants who reduced their discretionary choice intake by one serve or more was described relative to the observed proportion of participants who did not achieve this reduction. A higher proportion of participants in the obesity weight status group (36.9%) reduced their discretionary choice intake by one serve or more after the intervention. Further, a greater proportion of participants with higher levels of psychosocial measures, such as capability, opportunity, motivation and intention, reduced their discretionary choice intake by one serve or more. Regarding the behavioural measures, Table 6-1 shows that participants who reduced their discretionary choice intake by one serve or more had a higher baseline discretionary choice intake (6.3 ± 4.8). A higher proportion of these participants had a lower diet score (grouped into quintile 1 of diet score) relative to the participants who did not achieve this reduction. The only demographic variable that suggested a meaningful difference between groups was the SEIFA measure. A lower proportion (24.7%) of the participants who reported living in least disadvantaged areas of socio-economic status (i.e. quintile 5) reduced their discretionary choice intake by one serve or more.

6.2.2.2 Compliance with the dietary guideline for discretionary choice intake

The proportion of participants who complied with the dietary guideline for discretionary choices after the intervention were described relative to the observed proportion of participants who did not comply. Using the secondary outcome of this analysis, age group and weight status were the two demographic and anthropometric variables that showed a difference between participants who complied and did not comply with the dietary guideline. A higher proportion of participants in the 51–70 age group (48.5%) and in the healthy weight status group (36.1%) complied with the dietary guideline, compared with the proportions in the other age and weight status groups. A higher proportion of participants with high levels of intention, but low levels of capability and opportunity, complied with the dietary guideline after the intervention. In addition, participants with lower discretionary choice intake at baseline (2.7 ± 2.3) complied with the dietary guidelines after the intervention. A higher proportion of participants with a higher diet score (quintile 5 of diet score) complied with the guideline after the intervention, relative to the participants who did not. A lower proportion of participants in the 31–50 age group (28.2%), and in the obesity weight status group (26.7%), complied with the dietary guideline for discretionary choice intake after the intervention. For the other demographic variables, such as age and SEIFA, no meaningful differences between groups were observed.

Table 6-1: Baseline demographic, anthropometric, behavioural and psychosocial characteristics of the pooled sample of participants (N = 1,441) randomised to the brief online 28-day intervention; by participants who did and did not reduce discretionary choice (DC) intake by one serve or more; and by participants who did and did not comply with dietary guidelines for DC after the intervention. Results presented as n (%) unless otherwise indicated.

	Total N = 1,441 (%)		Reduced DC intake by one serve or more n = 576 (%)		Did not reduce DC intake by one serve or more n = 865 (%)		Complied with DC guideline n = 746 (%)		Did not comply with DC guideline n = 695 (%)	
Baseline DC intake[1]	4.2 ± 3.9		6.3 ± 4.8		2.8 ± 2.3		2.7 ± 2.3		5.9 ± 4.6	
Intervention group										
Control	784	(54.4)	313	(54.3)	471	(54.4)	431	(57.8)	353	(50.8)
Tailored	657	(45.6)	263	(45.7)	394	45.5)	315	(42.2)	342	(49.2)
Gender										
Male	327	(22.7)	133	(23.1)	194	(22.4)	158	(21.2)	169	(24.3)
Female	1114	(77.3)	443	(76.9)	671	(77.6)	588	(78.8)	526	(75.7)
Age group (years)										
18–30	187	(13.0)	113	(12.8)	74	(13.1)	98	(13.1)	89	(12.8)
31–50	484	(33.6)	275	(36.3)	209	(31.8)	210	(28.2)	274	(39.4)
51–70	628	(43.6)	386	(42.0)	242	(44.6)	362	(48.5)	266	(38.3)
71+	142	(9.9)	91	(8.9)	51	(10.5)	76	(10.2)	66	(9.5)
Weight status category										
Underweight	-	-	-	-	-	-	-	-	-	-
Healthy weight	480	(34.4)	166	(28.8)	314	(36.6)	269	(36.1)	211	(30.4)
Overweight	485	(33.7)	194	(33.6)	291	(33.7)	268	(35.9)	217	(31.2)
Obesity	460	(31.9)	212	(36.9)	248	(28.4)	199	(26.7)	261	(37.6)
Socio-economic status										
1 (most disadvantaged)	170	(11.8)	77	(13.4)	93	(10.8)	96	(12.9)	74	(10.6)
2	189	(13.1)	77	(13.4)	112	(12.9)	103	(13.8)	86	(12.4)
3	313	(21.7)	119	(20.7)	194	(22.4)	158	(21.2)	155	(22.3)
4	350	(24.3)	161	(28.0)	189	(21.8)	172	(23.1)	178	(25.6)
5 (least disadvantaged)	419	(29.1)	142	(24.7)	277	(32.0)	217	(29.1)	202	(29.1)

(continued)

Table 6-1 (continued): Baseline demographic, anthropometric, behavioural and psychosocial characteristics of the pooled sample of participants (N = 1,441) randomised to the brief online 28-day intervention; by participants who did and did not reduce discretionary choice (DC) intake by one serve or more; and by participants who did and did not comply with dietary guidelines for DC after the intervention. Results presented as n (%) unless otherwise indicated.

	Total N = 1,441 (%)		Reduced DC intake by one serve or more n = 576 (%)		Did not reduce DC intake by one serve or more n = 865 (%)		Complied with DC guideline n = 746 (%)		Did not comply with DC guideline n = 695 (%)	
Capability tertiles (out of 8; range)										
Low (3.0–8.0)	575	(39.9)	187	(32.5)	388	(44.9)	331	(44.4)	244	(35.1)
Med (2.0–2.0)	408	(28.3)	171	(29.7)	237	(27.4)	214	(28.7)	194	(27.9)
High (0.0–1.0)	458	(31.8)	218	(37.8)	240	(27.7)	201	(26.9)	257	(37.0)
Opportunity tertiles (out of 8; range)										
Low (3.0–8.0)	655	(45.5)	234	(40.6)	421	(48.7)	352	(47.2)	303	(43.6)
Med (2.0–2.0)	335	(23.2)	135	(23.4)	200	(23.1)	189	(25.3)	146	(21.0)
High (0.0–1.0)	451	(31.3)	207	(35.9)	244	(28.2)	205	(27.5)	246	(35.4)
Motivation tertiles (out of 8; range)										
Low (5.0–8.0)	514	(35.7)	175	(30.4)	339	(39.2)	306	(41.0)	208	(29.9)
Med (3.0–4.0)	474	(32.9)	190	(33.0)	284	(32.8)	232	(31.1)	242	(34.8)
High (0.0–2.0)	453	(31.4)	211	(36.6)	242	(28.0)	208	(27.9)	245	(35.3)
Intention tertiles (out of 100; range)										
Low (1.0–71.7)	481	(33.4)	173	(31.8)	308	(35.6)	227	(38.9)	254	(36.5)
Med (71.8–88.3)	486	(33.7)	220	(38.2)	266	(30.8)	229	(30.7)	257	(37.0)
High (88.4–100.0)	474	(32.9)	183	(30.0)	291	(33.6)	290	(30.4)	184	(26.5)
Diet score quintiles (out of 100; range)										
1 (21.1–45.5)	288	(20.0)	158	(27.4)	130	(15.0)	107	(14.3)	181	(26.0)
2 (45.6–51.4)	288	(20.0)	125	(21.7)	163	(18.8)	119	(16.0)	169	(24.3)
3 (51.5–56.6)	289	(20.1)	119	(20.7)	170	(19.7)	137	(18.4)	152	(21.9)
4 (56.7–63.2)	288	(20.0)	115	(20.0)	173	(20.0)	174	(23.3)	114	(16.4)
5 (63.3–90.6)	288	(20.0)	59	(10.2)	229	(26.5)	209	(28.0)	79	(11.4)

Note:
Data include the characteristics of the pooled sample, including participants randomised both to the intervention and control arms.
Complying with the dietary guideline for discretionary choices was defined according to the approximate number of additional serves recommended for different age groups and genders, found in the Eat for Health Educator's Guide (National Health and Medical Research Council, 2013). Participants were classified as meeting the recommendation if they consumed 3.0, 2.5, or 2.0 or fewer discretionary choice serves per day, dependent on gender and age.
[1]Reported as mean and standard deviation. *DC:* discretionary choices.
Age group categories consistent with nutrient reference values (194).
Weight status categories are according to Body Mass Index (BMI) (kg/m^2); Underweight: <18.5 kg/m^2; Healthy weight: 18.5–24.9 kg/m^2; Overweight: 25–29.9 kg/m^2; Obesity: >30 kg/m^2. Values for underweight sample (n = 16) not shown.
Socio-Economic Status is indicated by national Socio-Economic Indexes for Areas (SEIFA) of relative advantage and disadvantage represented by matching participant-reported postcode (213).
Capability, motivation and opportunity (COM) behavioural domain measures (each scored out of 8) categorised into data-driven tertiles. Intention to change score (range: 1–100) categorised into data-driven tertiles of scores. High tertiles indicate high levels of COM and intention at baseline.

6.2.3 Predictors of a reduction in discretionary choice intake

Multivariate analysis was used to identify predictors of reduction in discretionary choice, including a range of baseline demographic, anthropometric, behavioural and psychosocial characteristics. The associated odds ratios (OR) for reducing discretionary choice intake by one serve or more after a brief online 28-day intervention are shown in Table 6-2 with their 95% confidence intervals (CI) and significance values.

The odds of reducing discretionary choice intake were higher for participants who had a lower baseline discretionary choice intake and higher intention. For every additional serve of discretionary choices consumed at baseline, participants were 57% more likely to reduce their intake (OR 1.57, 95% CI [1.47, 1.68], $p < 0.001$). Participants with higher levels of intention at baseline were 41% more likely to reduce their discretionary choice intake by one serve or more (OR 1.41, 95% CI [1.02, 1.93], $p = 0.035$). Further, the odds of reducing discretionary choice intake by one serve or more were lower for participants who reported living in the least disadvantaged areas of socio-economic status—SEIFA quintile 5—than for those participants who reported living in the most disadvantaged areas (OR 0.63, 95% CI [0.41, 0.95], $p = 0.030$). Relative to participants with a lower diet score at baseline (quintile 1 of diet score), participants with a higher diet score at baseline (quintile 5) had a lower likelihood of reducing their discretionary choice intake by one serve or more (OR 0.51, 95% CI [0.33, 0.79], $p = 0.003$). The characteristics of participants reducing their discretionary choice intake by one serve or more did not statistically differ by other demographic variables, such as gender and age, nor by weight status, intervention group allocation and other psychosocial measures included in this analysis.

Table 6-2: Multivariate adjusted odds ratios of the sample (*N* = 1441) who reduced discretionary choice (DC) intake by one serve or more after the brief online 28-day intervention

Characteristics	**Odds of reducing DC intake by one serve or more**		
	OR	95% CI	*P*
Baseline DC intake[1]	1.57	1.47, 1.68	**0.000**
Intervention Group %			
Control (ref)	1	-	-
Tailored	0.86	0.67, 1.11	0.260
Gender %			
Male (ref)	1	-	-
Female	1.29	0.945, 1.759	0.108
Age group %			
18–30 (ref)	1	-	-
31–50	0.83	0.55, 1.25	0.375
51–70	1.03	0.68, 1.56	0.889
71+	1.15	0.66, 2.01	0.622
Weight status category %			
Healthy weight (ref)	1	-	-
Underweight	-	-	-
Overweight	1.14	0.84, 1.55	0.395
Obesity	1.02	0.73, 1.41	0.911
Socio-economic status (SEIFA Quintile) %			
1 (most disadvantaged) (ref)	1	-	-
2	0.65	0.40, 1.07	0.091
3	0.67	0.43, 1.05	0.078
4	0.90	0.59, 1.38	0.638
5 (least disadvantaged)	0.63	0.41, 0.95	**0.030**
Capability tertiles (out of 8; range) %			
Low (3.0–8.0) (ref)	1	-	-
Med (2.0–2.0)	1.21	0.86, 1.69	0.275
High (0.0–1.0)	0.96	0.68, 1.35	0.813
Opportunity tertiles (out of 8; range) %			
Low (3.0–8.0) (ref)	1	-	-
Med (2.0–2.0)	1.03	0.73, 1.46	0.870
High (0.0–1.0)	0.92	0.67, 1.28	0.632
Motivation tertiles (out of 8; range) %			
Low (5.0–8.0) (ref)	1	-	-
Med (3.0–4.0)	0.92	0.67, 1.27	**0.619**
High (0.0–2.0)	0.95	0.68, 1.34	**0.780**
Intention tertiles (out of 100; range) %			
Low (1.0–71.7) (ref)	1	-	-
Med (71.8–88.3)	1.47	1.08, 2.01	0.015
High (88.4–100.0)	1.41	1.02, 1.93	0.035
Diet score quintiles (out of 100; range) %			
1 (21.1–45.5) (ref)	1		
2 (45.6–51.4)	0.71	0.49, 1.04	0.078
3 (51.5–56.6)	0.74	0.50, 1.08	0.113
4 (56.7–63.2)	0.90	0.60, 1.33	0.581
5 (63.3–90.6)	0.51	0.33, 0.79	**0.003**

Note:
[1]*Continous variable. DC:* discretionary choices.
*Ref i*ndicates reference variable.
Age group categories consistent with nutrient reference values (194).
Weight status categories are according to Body Mass Index (BMI) (kg/m2); Underweight: <18.5 kg/m^2; Healthy weight: 18.5–24.9 kg/m^2; Overweight: 25–29.9 kg/m^2; Obesity: >30 kg/m^2. Values for underweight sample (n = 16) not shown.
Socio-Economic Status is indicated by national Socio-Economic Indexes for Areas (SEIFA) of relative advantage and disadvantage represented by matching participant-reported postcode (213).
P-values were derived from Wald test. **Values in bold font indicate significance at <0.05.**
Model fit statistics: X^2 (25, *N* = 1441) = 427.72, $p < 0.001$
Cox and Snell R^2 = 25.7% and Nagelkerke R^2 = 34.7%

6.2.4 Predictors of compliance with the dietary guideline for discretionary choice intake

The associated OR for compliance with the dietary guideline of discretionary choices after a brief online 28-day intervention are shown in Table 6-3. The odds of achieving compliance with the dietary guideline for discretionary choice intake after the intervention were lower for every additional increase in discretionary choice intake at baseline (OR 0.63, 95% CI [0.59, 0.68], $p < 0.001$). In other words, a lower intake of discretionary choice at baseline increased the likelihood of complying with guidelines after the intervention. Given that discretionary choice intake is a key part of the diet score to assess overall diet quality, a similar result was reported for diet score. Relative to participants with a lower diet score at baseline (quintile 1), participants with a higher diet score at baseline (quintile 5) had a higher likelihood of complying with the guidelines after the intervention (OR 1.57, 95% CI [1.02, 2.40], $p = 0.039$). Moreover, participants with higher levels of intention at baseline were 77% more likely to comply with the guidelines after the intervention (OR 1.77, 95% CI [1.30, 2.41], $p < 0.001$). In addition, the odds of compliance with the dietary guideline after the intervention were lower when participants were randomised into the tailored intervention group relative to the control group. Participants were also less likely to comply with the guideline if they had reported living in the least disadvantaged areas—SEIFA quintile 5—relative to SEIFA quintile 1 (OR 0.64, 95% CI [0.41, 0.98], $p = 0.039$). The characteristics of participants complying with the dietary guideline for discretionary choice intake after the intervention did not statistically differ by other demographic variables, such as gender and age, nor by weight status and other psychosocial measures.

Table 6-3: Multivariate adjusted odds ratios of the sample (*N* = 1,441) complying with the dietary guideline of discretionary choice (DC) intake after the brief online 28-day intervention

Characteristics	Odds of complying with the DC guideline				
	OR	95% CI			*P*
Baseline DC intake[1]	0.63	0.59	,	0.68	**0.000**
Intervention group %					
Control (ref)	1	-		-	-
Tailored	0.74	0.58	,	0.95	**0.019**
Gender %					
Male (ref)	1	-		-	-
Female	0.92	0.68	,	1.25	0.593
Age group %					
18–30 (ref)	1	-		-	-
31–50	0.86	0.58	,	1.28	0.458
51–70	1.23	0.82	,	1.84	0.324
71+	0.81	0.47	,	1.39	0.442
Weight status %					
Healthy weight (ref)	1	-		-	-
Underweight	-	-		-	-
Overweight	1.09	0.81	,	1.48	0.567
Obesity	0.80	0.58	,	1.10	0.168
Socio-economic status (SEIFA quintile) %					
1 (most disadvantaged) (ref)	1	-		-	-
2	0.99	0.60	,	1.63	0.966
3	0.66	0.42	,	1.03	0.066
4	0.68	0.44	,	1.06	0.088
5 (least disadvantaged)	0.64	0.41	,	0.98	**0.039**
Capability tertiles (out of 8; range) %					
Low (3.0–8.0) (ref)	1	-		-	-
Med (2.0–2.0)	1.04	0.74	,	1.46	0.804
High (0.0–1.0)	1.01	0.72	,	1.42	0.939
Opportunity tertiles (out of 8; range) %					
Low (3.0–8.0) (ref)	1	-		-	-
Med (2.0–2.0)	1.27	0.89	,	1.80	0.185
High (0.0–1.0)	0.97	0.70	,	1.34	0.835
Motivation tertiles (out of 8; range) %					
Low (5.0–8.0) (ref)	1	-		-	-
Med (3.0–4.0)	0.99	0.72	,	1.36	0.96
High (0.0–2.0)	1.26	0.90	,	1.76	0.18
Intention tertiles (out of 100; range) %					
Low (1.0–71.7) (ref)	1	-		-	-
Med (71.8–88.3)	1.18	0.87	,	1.59	0.298
High (88.4–100.0)	1.77	1.30	,	2.41	**0.000**
Diet score quintiles (out of 100; range) %					
1 (21.1–45.5) (ref)	1	-		-	-
2 (45.6–51.4)	0.91	0.62	,	1.33	0.609
3 (51.5–56.6)	1.01	0.69	,	1.49	0.947
4 (56.7–63.2)	1.55	1.04	,	2.31	**0.030**
5 (63.3–90.6)	1.57	1.02	,	2.40	**0.039**

Note:
Complying with the dietary guideline for discretionary choices was defined as the approximate number of additional serves recommended for different age groups and genders, found in the Eat for Health Educator's Guide (10). Participants were classified as meeting the recommendation if they consumed 3.0, 2.5, or 2.0 or fewer discretionary choice serves per day, dependent on gender and age.
[1]*Continous variable. DC:* discretionary choices.
Ref indicates reference variable.
Age group categories consistent with nutrient reference values (NRVs) (National Health and Medical Research Council and the New Zealand Ministry of Health, 2016)
Weight status categories are according to Body Mass Index (BMI) (kg/m2); Underweight: <18.5 kg/m^2; Healthy weight: 18.5–24.9 kg/m^2; Overweight: 25–29.9 kg/m^2; Obesity: >30 kg/m^2. Values for underweight sample (n = 16) not shown.
Socio-Economic Status is indicated by national Socio-Economic Indexes for Areas (SEIFA) of relative advantage and disadvantage represented by matching participant-reported postcode (ABS, 2016).
P-values were derived from Wald test. **Values in bold font indicate significance at <0.05**.
Model fit statistics: X^2 (25, N = 1441) = 460.7, p < .001.
Cox and Snell R^2 = 27.4% and Nagelkerke R2 = 36.5%

6.2.5 Sensitivity analyses

Sensitivity analyses were conducted to determine the level of impact of extreme outliers on the results. Extreme outliers were identified and removed if the reported discretionary choice intake was three or more standard deviations away from the sample mean, or if they were not deemed dietetically plausible (30 serves or more). The separate regression analyses performed after removing extreme values showed no substantial differences. The pattern of results was also similar when all predictors were treated as continuous variables (data not shown).

6.3 Discussion

6.3.1 Purpose of this study

This study aimed to identify participants' demographic, anthropometric, behavioural and psychosocial characteristics that predicted a (i) reduction in, and (ii) compliance with, the dietary guideline on discretionary choice intake after participating in *Shifting My Nutrition Score in 28 Days*. This study was conducted to add to the evidence about which individual characteristics predict greater improvement in dietary behaviours after participating in online dietary feedback interventions. Multivariate adjusted logistic regression models were used to predict the two outcomes. For the primary outcome, this study found that those with lower baseline diet quality, those with higher intention and those who reported living in more disadvantaged areas of socio-economic status were more likely to reduce their discretionary choice intake by one serve or more. For the secondary outcome, this study found that those with higher baseline diet quality, those with higher intention and those who reported living in more disadvantaged areas of socio-economic status were more likely to meet the dietary guideline recommendation for discretionary choice intake after the intervention. These findings have important implications for the future design of tailored online interventions, suggesting that baseline diet quality, intention and socio-economic status are important characteristics to consider in attempting to target individuals who need greater support for dietary behaviour change.

6.3.2 Baseline diet quality as a predictor

A lower overall diet quality score, and a higher intake of discretionary choices at baseline, were key predictors of participants who achieved a one serve or more reduction in discretionary choice intake after the intervention. This finding is common in previous studies that have examined improvements in the Healthy Eating Index score (258) and the Mediterranean diet score (259). In the Food4Me sample, those who had a baseline diet score of 46.5 out of 100 were more likely to improve their diet quality by 5% than were those who had a score of 54.6 (258). A lower baseline diet quality score was also a strong predictor of higher compliance with a Mediterranean diet after a 4-year RCT (259). However, females had a lower success rate. Zazpe et al. explained that the baseline diet quality of females, compared with that of males, was closer to compliance with Mediterranean diet guidelines, and thus, a higher diet score at baseline had lower association with diet quality improvement (259). A regression towards the mean could explain the results of the Zazpe et al. (259) and those of the current study. Despite statistically adjusting for the baseline dietary intake in this study, as previously recommended (237), the participants who had higher baseline discretionary choice intake possibly had a larger scope to reduce their intake. In contrast, participants who were consuming less discretionary choices at baseline, and thus had higher diet quality scores, were already more likely to comply with the dietary guideline about discretionary choice intake after the intervention. This finding means that the scope available to an individual for improving during an intervention needs to be considered.

Thus, baseline diet quality can be a strong predictor of intervention success. The implications of this finding could be important in future tailoring of dietary feedback interventions. Using baseline diet quality to tailor the intervention goal could result in larger intervention effects. For example, if an intervention aims to achieve compliance with dietary guidelines, then it could target individuals who already have high baseline diet quality—because these individuals are closer to meeting recommendations and the likelihood of success is greater for them than for those with low baseline diet quality. However, for individuals with low baseline diet quality, interventions could aim to improve the dietary behaviour by a small amount, that is, a one serve reduction in discretionary choices. This approach for intervention could lead to enhanced intervention effectiveness, tailored to all individuals with varying baseline levels of diet quality.

6.3.3 Baseline intention as a predictor

Baseline intention to change discretionary choice intake was a key predictor of the post-intervention outcomes of two studies. This was expected since intention was used as a proxy measure of behaviour to tailor the nutrition message frame provided by the intervention as per the theory of planned behaviour (157). Thus, the hypothesis that intention would lead to behaviour change was supported. Systematic reviews of nutrition intervention studies have found significant associations between intention and dietary behaviour (163, 260). One review showed that implementation intention is an effective tool for increasing the intake of healthy foods ($d = 0.51$) and can, by a smaller magnitude, help decrease the intake of unhealthy foods ($d = 0.29$) (260). Another systematic review examining online interventions found that participants who already have a high motivation to change may be more likely to both use the intervention and achieve positive change (163). Therefore, future researchers can be confident that high baseline intention improves diet quality. This finding strengthens the recommendation, reported in the preceding chapters, that future studies should find ways to intervene for samples with lower baseline intention, because these are the people in need of more behavioural support (241).

6.3.4 Socio-economic status as a predictor

Unexpectedly, this study found that participants who reported living in more disadvantaged areas were more likely to reduce discretionary choice intake and to also comply with the dietary guideline after participation in *Shifting My Nutrition Score in 28 Days*. Contrary to these findings, cross-sectional studies have consistently found that high socio-economic status predicts healthier dietary behaviours (27, 63, 201, 202). In particular, participants who have a higher income and who live in more advantaged areas have been associated with having better overall diet quality (261). Higher DGI scores have been significantly associated with higher SEIFA quintiles, especially among those aged less than 55 years (202) and those who are female (24). Comparably to the current study, a lower consumption of discretionary choices has been associated with living in the more advantaged areas, based on SEIFA quartiles (63). Given that the available body of evidence is all cross-sectional, more experimental research is still needed to identify how strongly socio-economic characteristics predict *change* in dietary behaviour after participation in dietary feedback interventions. The type of measure for socio-economic status is important to consider.

In this regard, this study used SEIFA, a measure calculated using participants' postcodes, to determine their socio-economic status, which is a common practice in similar studies (30, 33). However, it is important to note the elements that comprise this measure. First, SEIFA measures relative advantage and disadvantage at an area level, not at an individual level (262). This could mean that someone from a lower SEIFA area, regardless of whether they are highly educated or have high income, would still be defined as having low socio-economic status. Second, the most recent ranking of areas according to relative socio-economic advantage and disadvantage by the Australian census was conducted in 2016, which could now be outdated (213). Since 2016, areas in Australia could have undergone transition or gentrification, meaning a migration of higher-income households to lower-income neighbourhoods (262). These circumstances indicate that SEIFA may not measure the true level of an individual's socio-economic status. Findings from a recent study can be used to strengthen this argument. The study examined characteristics associated with compliance with dietary guidelines in more disadvantaged US neighbourhoods (263). It found that household income and food security were positively associated with complying with several dietary guideline recommendations (263). Evidently, participants with food security and higher incomes, regardless of SEIFA, may still be able to have healthy dietary behaviours. Thus, in addition to area-level socio-economic measures, individual-level indicators, such as income and education, should be used for predicting dietary health behaviours, as argued by Australian researchers (264). Measuring a range of socio-economic status indicators to predict dietary behaviour is also important since dietary behaviour can be complex and context specific (265). It is unlikely that any single intervention can measure all socio-economic indicators, because such an attempt may place a cognitive burden on participants. Therefore, as more experimental interventions measure and capture a range of socio-economic indicators, the combination of results may help to identify the indicators that most commonly and consistently influence dietary behaviour change.

Nonetheless, a reason for the association between belonging to a lower SEIFA area and intervention success is that *Shifting My Nutrition Score in 28 Days* was online and freely available. Regardless of socio-economic factors, online access is ubiquitous (161). Therefore, the intervention had the ability to reach and influence participants from a wide range of geographical areas. In addition, tailoring how nutrition messages are communicated to people in different socio-economic positions has been effective for translating dietary recommendations into practical, actionable advice (266). Focussing recommendations towards socio-economic subgroups of the population has also been more effective in changing dietary behaviours than providing general advice (267, 268). Thus, accessibility and tailoring are important intervention features for reaching and influencing participants from a range of socio-economic areas.

6.3.5 Demographic and anthropometric variables

The univariate analysis used in this study revealed that the discretionary choice intake after the intervention somewhat differed between age groups and weight status categories. In comparison to the other age groups, a higher proportion of the 51–70 age group complied with the dietary guideline after the intervention. In comparison to the other weight status categories, a higher proportion of those in the obesity group reduced discretionary choice intake by one serve or more, but a lower proportion of the obesity group complied with the dietary guideline for discretionary choices after the intervention. However, on adjusting the logistic regression model for multiple variables, the age and weight status variables were not statistically significant predictors of post-intervention discretionary choice intake. Contrary to these results, cross-sectional studies have found that being female, of older age and in a healthy weight range are well-established predictors of better diet quality (4, 27, 68). Longitudinal studies have also found associations between these characteristics and improved dietary behaviour over time (182, 183). A recent study found that being female and of older age predicted greater diet quality improvements after an online dietary intervention (258). A possible explanation of the present study's findings is that, as aforementioned, the sample had a high baseline intention median score of 81 out of 100. This may have been the variable that strongly predicted intervention effectiveness over and above demographic characteristics. Nonetheless, considering the contradictions between this study and previous literature, more interventions are needed to identify whether demographic or anthropometric characteristics predict a change in diet quality after dietary feedback interventions.

6.3.6 Strengths and limitations

The strength of this study is its contribution to knowledge in identifying predictors of change in discretionary choice intake after a brief online 28-day intervention that uses nutrition messaging to support behaviour change. In addition to the novel findings that raise new research questions, a key strength was the robustness of the study, which was confirmed through multiple sensitivity analyses. The pattern of results remained consistent regardless of the removal of extreme outliers using two approaches (+/− 3 SD and biological plausibility). Results were consistent whether participant characteristics were categorical or continuous in the model. The model also adjusted for multiple baseline measures, which may have reduced the bias associated with regression to the mean (237). However, despite this adjustment, it is important to interpret the current findings from the perspective that the participants with poorer baseline diet quality may have had more scope to improve their discretionary choice intake than the participants with healthier baseline diet quality.

The limitations reported in the previous two chapters are applicable to this study. Specifically, it is important to acknowledge that the sample is not generalisable to the wider Australian adult population (191). Therefore, caution should be exercised if generalising beyond this sample. In addition, volunteer bias associated with the self-selected participation of healthier individuals and sampling error are likely, and may have contributed to a sample distribution that differed from the Australian population (230). Moreover, the measurement limitations in this study should be acknowledged, such as the use of the intention measure and the SEIFA indicator for socio-economic status. A limitation associated with the intention measure was its negatively skewed distribution, which indicates measurement error (Chapter 4). Since most participants had high baseline intention, the predictive power of this variable should be interpreted with caution. In addition, SEIFA may not consider individual-level factors (262), and thus, measuring other indicators of socio-economic status to understand their influence on dietary behaviours, at an individual level, may be a more suitable approach (264). Nonetheless, the optimal number of data measurements needed without the risk of participant burden should be considered in future research.

6.3.7 Implications for practice and future research

This study adds important insights to the body of evidence since it is one of the first studies to identify predictors of diet quality improvement after a brief online dietary feedback intervention. The study found baseline diet quality to be a key predictor for improving the post-intervention discretionary choice intake and compliance with dietary guidelines. This information could be used for future nutrition message tailoring. That is, the extent of a dietary outcome that an intervention aims to achieve could be tailored based on baseline levels of diet quality. For example, interventions that aim to improve participants' compliance with dietary guidelines can target those who already have healthier baseline diet quality, while aiming for smaller, more achievable improvements in their dietary behaviour for those with poorer diet quality. This study also found that high baseline intention was a strong predictor of improved behaviour, taking into account the sample's high baseline intention. Voluntary participation in online dietary interventions mostly attracts an already motivated sample; therefore, future experimental studies should confirm whether intention predicts behaviour in a sample with a broader range of baseline intention. The finding that participants living in more disadvantaged areas were more likely to improve their dietary behaviour was unexpected and could be related to the limitations associated with using area-level SEIFA. Future research should explore how different individual-level socio-economic characteristics could predict the effectiveness of brief online dietary feedback interventions. Last, since demographic predictors of diet quality have mostly been based on cross-sectional evidence, a larger body of experimental trials is still needed to identify whether demographic, anthropometric or behavioural characteristics predict a *change* in diet quality after brief online dietary feedback interventions.

6.4 Summary and Chapter Conclusion

To address the evidence gap on which individual characteristics predict improvement in diet quality following brief online dietary feedback interventions, this exploratory study was conducted. It aimed to identify participants' demographic, anthropometric, behavioural and psychosocial characteristics that most likely predicted a reduction in, and compliance with, the dietary guideline of discretionary choice intake after the *Shifting My Nutrition Score in 28 Days* intervention. Findings indicated that lower diet quality and high intention at baseline predicted a reduction in discretionary choice intake, whereas higher diet quality and high intention at baseline predicted the compliance with the dietary guideline for discretionary choice intake after the intervention. Since high baseline intention can be associated with improved dietary behaviours, future trials should focus on recruiting a less motivated sample. People with lower motivation may also have poor dietary behaviours and be more in need of intervention support. Nonetheless, further experimental research is needed to confirm which participant characteristics predict a *change* in dietary behaviour after online dietary feedback interventions.

6.4.1 Bridging summary

This chapter aimed to identify the participant characteristics that predict a change in discretionary choice intake following a brief online dietary feedback intervention. A reduction in discretionary choice intake was predicted by a higher baseline discretionary choice intake and an overall lower diet quality score, as well as a higher baseline intention score. This chapter presented the results from the final study conducted for this thesis. The next chapter will integrate the results of the preceding chapters within the context of wider research and will conclude with recommendations for future research that aim to advance the field of tailored nutrition messaging in brief online dietary feedback interventions.

CHAPTER 7 DISCUSSION AND CONCLUSION

7.1 Overview

The aim of this thesis was to design and test a brief online dietary feedback intervention with tailored nutrition message framing and enhanced behavioural support, for improving the diet quality of Australian adults. To address this aim, four key questions were explored: *What* should be the priority dietary target to maximise diet quality improvement (Chapter 2)? *How* should nutrition messages be framed in a brief online dietary feedback intervention (Chapter 3 and 4)? *Whether* an intervention using tailored nutrition message frames is more effective than using a generic nutrition message, and to what extent (Chapter 5)? *For whom* is the intervention most effective (Chapter 6)?

This chapter is organised as follows. In section 7.2, the key findings and contribution to knowledge are summarised. In section 7.3, the findings are discussed within the context of the evidence gaps identified in Chapter 1, which informed the development of the thesis aim. The overall strengths and limitations of the thesis are addressed in section 7.4, and future research and implications for practice are proposed in section 7.5. Finally, section 7.6 concludes the chapter and this thesis.

7.2 Summary of Findings

7.2.1 Summary of the four key thesis findings

The four key findings of this thesis are as follows. To address the literature gap on whether dietary targets need to differ for population subgroups, Chapter 2 reported a secondary analysis of diet quality that was performed using a complex segmentation of a sample of more than 200,000 Australian adults. The first key finding was that regardless of the segmentation approach used (i.e. regardless of whether gender, age, weight status or baseline diet quality characteristics were used to classify participants into subgroups), the discretionary choices food group was the priority dietary target. This finding informed the selection of discretionary choices as the target dietary behaviour for the subsequent research in this thesis. Further, Chapter 4 examined the effect of nutrition message framing on the intention to reduce discretionary choice intake. More than 1,300 Australian adults reported their intention after exposure to positive, negative, majority or minority descriptive norm framed nutrition messages. The analysis of their responses led to the second thesis finding—all four message types increased intention from baseline; however, between-message differences were limited in the sample that already had high baseline intention.

Next, Chapter 5 aimed to determine whether adding a tailored nutrition message frame, based on the message associated with an individual's highest intention, would enhance the effectiveness of a generic message used in brief online dietary feedback interventions (standard practice). For this purpose, such an intervention, titled *Shifting My Nutrition Score in 28 Days*, was used. The related analysis revealed the third key finding, namely, that for a sample with high baseline intention, the effect on discretionary choice intake did not differ between delivering tailored message framing with enhanced behavioural support, and a generic message. Both the tailored and generic messaging approaches did result in a significant and clinically meaningful average reduction in discretionary choice intake, of one serve. In addition, the process-evaluation results reported in Chapter 5 demonstrated that participants were more satisfied with an intervention that delivered tailored messages with enhanced behavioural support; however, time was a key barrier to engagement and interaction, regardless of intervention group. To the best of the candidate's knowledge, this is the first study to incorporate theoretically derived nutrition message frames, individually tailored to influence intention, into a brief online dietary feedback intervention.

Further, there is limited knowledge on which individual characteristics predict effect after a brief online dietary feedback intervention. Since tailoring a nutrition message was not a significant predictor of intervention effect, Chapter 6 explored other potential characteristics. The findings suggest that for a sample with high baseline intention, a lower diet quality at baseline was associated with a greater likelihood of a one serve or more reduction in discretionary choice intake, whereas a higher diet quality at baseline increased the likelihood of compliance with the dietary guideline recommendations for discretionary choices after the intervention. Thus, the fourth key finding was that baseline diet quality was a key predictor of intervention effect. The next section discusses the contribution of this thesis to the literature.

7.2.2 Original contribution to knowledge of this thesis

The original contribution to knowledge of this thesis is that it may not be necessary to tailor nutrition message frames and provide enhanced behavioural support as part of brief online feedback interventions aiming to reduce discretionary choice intake. This knowledge is context specific to a sample with high baseline intention, using an evidence-based and theoretically grounded brief online dietary feedback intervention.

Although tailoring a nutrition message with enhanced behavioural support did not improve the effect on the dietary behaviour of the intervention group compared with a control group, the intervention (*Shifting My Nutrition Score in 28 Days*), regardless of the messaging approach adopted, did result in a significant reduction in the discretionary choice intake. Multiple factors may explain this result. One reason may be the novelty of the priority dietary target: discretionary choices. The findings related to this target are discussed in the next section.

7.3 Discussion of Findings

7.3.1 Impact of discretionary choices as the priority dietary target

In Australia, excessive discretionary choice intake is ubiquitous (15, 63, 257) and can displace the intake of the healthy core food group (66). Thus, this thesis identified the discretionary choices food group as the priority dietary target for the *Shifting My Nutrition Score in 28 Days* intervention. In addition, there is novelty in targeting discretionary choices in interventions, since many similar initiatives have focussed on fruit and vegetables (41, 134, 153, 163, 165, 171). This thesis found that, regardless of the type of messaging approach used, participants' discretionary choice intake significantly reduced after the intervention. Moreover, as revealed in Chapter 5, participants reported that the provision of information on discretionary choices was new and interesting. Thus, a message recommending a change in this more novel dietary target may have resonated with all participants, which possibly explains the limited between-group effect.

Choosing to focus on one dietary target in *Shifting My Nutrition Score in 28 Days* was supported by evidence (160, 166) and theory (173). The BCW framework indicates that targeting one behaviour at a time in interventions is more effective than targeting multiple behaviours simultaneously (174, 175). Although targeting discretionary choices led to success in both intervention groups, the effect may have been enhanced had, within discretionary choices, a specific *food* target been selected. Discretionary choices include a broad set of foods and beverages that individuals consume during multiple meal times, not just as snacks (63, 269). The main contributors to discretionary choice intake are 'cakes, muffins, scones, cake-type desserts, pastries' followed by 'alcoholic beverages', with more than 13% of Australians in every adult age group consuming these choices (63).

In addition, the type of discretionary choices eaten differs depending on baseline diet quality. For example, those consuming low quantities of discretionary choices (i.e. those with higher diet quality) are likely to eat sugar, honey and syrups, and sweet biscuits, whereas those consuming high quantities (i.e. those with lower diet quality) more often consume pastries, cakes and alcoholic beverages (63). Owing to these differences in the intake of this single food group, it is important to improve the understanding of consumption types and the patterns of discretionary choices. Therefore, to increase the likelihood of diet quality improvement after an intervention, the discretionary choice intake could be analysed as a dietary pattern in itself. By adopting this approach, studies could identify the types of foods that need to be prioritised for different population subgroups. Nevertheless, reducing discretionary choice intake should become more of a priority in efforts aiming to improve diet quality, using 'eat less' nutrition messages, as discussed in the following section.

7.3.2 Shifting focus to 'eat less' nutrition messages

Shifting My Nutrition Score in 28 Days delivered nutrition messages framed in different ways, in aiming to persuade participants to reduce ('eat less') their discretionary choice intake. Chapter 4 showed that after testing positive, negative, majority and minority nutrition message frames, intention increased significantly from baseline, but when the effects on discretionary choice intake of message frames were tested in Chapter 5, no between-group difference was observed. All 'eat less' messaging approaches resulted in a significant decrease in intake. Despite the no between-group effects, the process evaluation indicated that participants reported a higher preference for the positively framed message than the other messages (Chapter 5). The findings from this thesis suggests that 'eat less' messages that use any approach may be effective, but the public prefers a positive message frame. Nevertheless, more research is needed to identify other ways of communicating a more persuasive 'eat less' message in order to enhance the effect of dietary feedback interventions.

This thesis used an 'eat less' messaging approach, although most tailored (41) and brief (171) dietary interventions, and large-scale campaigns (77, 268, 270), have focussed on the 'eat more' core food groups as a means to improve population-level diet quality. A likely reason for the popularity of 'eat more' messages relates to the public's communication preference (163). Recent Australian reports revealed that the public may be more attracted to solutions framed in terms of creating something good, rather than stopping something bad (137, 138). Further, there are other challenges associated with the applicability of 'eat less' messages for discretionary choices. This food group is readily available and convenient to consume, and the formulation of added sugar, fat and salt results in most people desiring to consume these foods (271) from a young age (200). The competing factors associated with the availability of, and the desire for, discretionary choices may explain why only a few messaging interventions (272) and large-scale campaigns (91, 273) have addressed this food group. Next, the *Shifting My Nutrition Score in 28 Days* intervention was able to reduce discretionary choice intake by one serve, or 22% (Chapter 5). That is, this intervention achieved a higher effect than other online dietary interventions, which achieved a modest increase in fruit and vegetable intake by 0.24–0.34 serves (163, 171). The success of this intervention indicates that it is time to shift the focus of messages to 'eat less' behaviours. Easily applicable 'how to' messages should also be identified to allow the public to overcome the environmental challenges associated with reducing discretionary choice intake.

In addition, delivering different 'eat less' nutrition messages, tailored or generic, in the *Shifting My Nutrition Score in 28 Days* intervention all led to a significant reduction in discretionary choice intake. The advantage associated with generic messages is that they can be delivered at the population level, using large-scale dietary feedback interventions or public health campaigns, without the need for tailoring the message frame. However, from the population-level perspective, using one nutrition message frame for everyone has had limited impact on dietary behaviour change (76, 274, 275). As an example, public health nutrition campaigns that included simple call-to-action, or 'what' messages, such as the 'Go for 2 & 5' campaign have significantly increased awareness about healthy dietary behaviours (77). Regardless, the effect of this campaign on dietary behaviour was a small average daily net increase of 0.8 serves of fruit and vegetables per day (or 11.4% total increase) over 3 years (270). Thus, although generic messages can reach a large population, increasing their effectiveness in terms of improving dietary behaviour is a challenge. Therefore, other types of 'eat less' messages could be tested in future feedback interventions.

As regards the small effect on dietary behaviours of population-level nutrition messages that target a broad food group, such as fruit and vegetables, it could be related to the challenge associated with reshaping the food environment to help consumers eat more of those food groups (276). Notably, messages that relate to a specific food or nutrient, which include 'swap' and 'how to' elements, allow the public to perceive the dietary advice as achievable (84, 277) and have resulted in more awareness and behavioural impact. To clarify, one example is the 1996 '1% or less' campaign in West Virginia, US, which increased low-fat milk sales from 29% to 46% in a month, with higher consumption rates maintained 6 months later (77). Hence, instead of communicating a message about changing consumption of the whole 'dairy' food group, the campaign specified the food that needs to be changed to a specific alternative. The campaign's success was likely associated with the ease of applying the message—by the industry reformulating the food, by large-scale interventions being able to focus messages on that food and by consumers finding it easy to make the swap at the individual level (278). Thus, ways to easily apply a message about a specific type of discretionary choice should be explored further.

In summary, discretionary choices are an important food group on which to focus interventions. Since this food group includes a broad set of foods and beverages, further research is still needed towards establishing more specific discretionary choices that can be prioritised for different population subgroups. Further, the thesis findings indicated that researchers need not avoid using 'eat less' messages, as long as they communicate this using a positive message frame, since this was the preferred communication style reported by the prior research (163) and participants in the process evaluation (Chapter 5). Prioritising more specific foods in dietary feedback interventions, may allow 'eat less' nutrition messages to communicate a specific swapping strategy, allowing the information to be applicable on a large scale. In addition to the need to test other nutrition messages that may further persuade individuals to improve their dietary behaviour, it is important to understand how to tailor these messages for added effect. Next, the approach adopted in this thesis for tailoring nutrition message is discussed.

7.3.3 Effect of tailoring nutrition messages using baseline intention

This thesis adopted the approach of tailoring nutrition message frames, using baseline intention, as a way to deliver an individual-level dietary feedback intervention, but in a scalable manner. The results from this intervention showed that tailoring nutrition messages on intention did not enhance the effect that could be achieved by generic messages used in standard practice. Thus, using intention as the characteristic to tailor the messages may have limited the intervention effect. Although Chapter 6 demonstrated that high baseline intention predicted change in discretionary choice intake, a result that was supported by the theory of planned behaviour (157), participants already had high baseline intention with a median score of 82 (out of 100). The intention measurement was also negatively skewed, indicating that the participants' true level of intention may not have been accurately captured. Nevertheless, recruitment efforts for the *Shifting my Nutrition Score in 28 Days* intervention seemed to attract and engage a highly motivated sample. This means that the effect of simply participating in a dietary intervention may have led to behaviour change, as observed in related studies (39). This view is also supported by the similar proportion of participants in both intervention groups who reported opening and reading the intervention emails regularly (Chapter 5). Therefore, the thesis findings demonstrate that for a highly motivated sample, baseline intention may not be an ideal characteristic for tailoring nutrition messages. Instead, there may be potential in using the behaviour itself, namely, baseline diet quality, as the tailoring characteristic in future dietary feedback interventions.

7.3.4 Using baseline diet quality for tailoring dietary targets and nutrition messages

Baseline diet quality could be used as a tailoring characteristic in dietary feedback interventions aiming to reduce discretionary choice intake. Chapter 2 identified more variation in the rank order of diet component scores when individuals were placed into subgroups according to baseline diet quality scores. However, no variation was shown by demographic characteristics, such as gender, age or weight status. Further, Chapter 6 found that those with the lowest diet quality scores were more likely to reduce their discretionary choice intake by one serve following the intervention. It was also found that those with the highest diet quality were more likely to comply with the dietary guideline recommendations for discretionary choices. Again, gender, age or weight status characteristics did not predict this outcome. These results are supported by prior studies that found associations between poor baseline diet quality and a higher likelihood of improved overall diet quality (258, 259). This finding suggests that baseline diet quality could be the one simple characteristic to use for tailoring dietary targets and nutrition messages.

As mentioned in section 7.3.1, discretionary choices can include a broad set of foods and beverages, and people eat different types of food at different times of the day. Since it may be possible to use baseline diet quality to subgroup a population into high or low discretionary choice consumers, identifying the type of discretionary choices that these subgroups consume may also be possible. Thus, an intervention could be tailored to address the type and/or eating episode of the discretionary choices that must be prioritised. As discussed in Chapter 6, baseline diet quality could be used to tailor the intervention goal. For example, an individual with low diet quality who is a high consumer of discretionary choices may have an intervention tailored to achieve any improvement towards compliance with the dietary guidelines. A ‘swap’ message could be tailored to the discretionary choice type and/or eating episode they need to prioritise first. This swap message should be applicable to the type and/or eating episode; for example, if takeaway food is eaten for dinner, the message should suggest an alternative dinner takeaway option (i.e. one that provides more core foods) as opposed to a less achievable goal, such as cooking a meal from scratch. However, someone with a higher diet quality, who is, for example, one serve away from achieving compliance with the dietary guidelines, may have an intervention message tailored on swapping that one specific food, to allow them to achieve compliance. This same approach could be applied to incrementally target other food groups to achieve overall diet quality improvement. As examined in Chapter 2, interventions can start with discretionary choices, and then move to healthy fats, dairy, fruit and vegetables. Thus, testing the use of baseline diet quality as an individual-level tailoring characteristic does warrant further exploration.

It is also important to consider what other features could have led to the success of *Shifting my Nutrition Score in 28 Days.* Regardless of the tailoring approach, a similar proportion of participants in both intervention groups reported opening and reading the intervention emails regularly (Chapter 5). Owing to this similar level of engagement, participant interaction may have been because of the behavioural support delivered by the intervention.

7.3.5 Behavioural support using Behaviour Change Techniques

The BCTs used to design the intervention may have contributed to the intervention effect. The *Shifting My Nutrition Score in 28 Days* targeted one priority dietary target, but it was also important for the intervention to embed BCTs in support of changing this behaviour. Three BCTs were the same in both the tailored and generic nutrition messaging intervention groups. These were goal setting, self-monitoring and using prompts or cues, which have all been associated with the dietary intervention effect (165, 172). Self-monitoring has shown consistent positive effects for participants involved in brief interventions (171, 279). Participants’ completion of a detailed dietary questionnaire, in this case the SFS, may, in itself, have resulted in a simple but intensive act of dietary behaviour reflection (279). As stated in the Chapter 5 process evaluation, about 200 participants (out of 1,441) reported increased self-awareness about eating habits, which could be considered a simple dietary change intervention in itself (279). Further, using prompts is an important BCT to ensure that participants continue to feel supported and engaged to change their behaviour, as well as to complete follow-up measurements. This was a consistent recommendation in the systematic reviews on tailored dietary feedback trials, which were synthesised in Chapter 1 (41, 170, 171). Using two prompts throughout the *Shifting My Nutrition Score in 28 Days* intervention was informed by these systematic reviews, which found this 'dose' to be associated with improved dietary behaviours (41, 170, 171). However, an 'optimal' dose still needs to be established for effective behaviour change and longer-term engagement (167). In summary, since goal setting, self-monitoring and using prompts have previously been associated with improved dietary behaviours, and were used in both *Shifting My Nutrition Score in 28 Days* intervention groups, these BCTs could have been fundamental factors for the success of the intervention.

Nevertheless, the provision of enhanced behavioural support through additional BCTs in the tailored intervention group did not improve intervention effectiveness. Chapter 6 identified, among other predictors, that participants in the control group were more likely to comply with dietary guidelines after the intervention than were those in the tailored intervention group. Two reasons may account for this surprising result. One is that these participants had an average discretionary choice serve intake closer to the guideline recommendations. The other reason is that the tailored intervention provided nine BCTs to enhance the support for reducing discretionary choice intake. Thus, participants in the tailored intervention group could have felt overwhelmed by the number of BCTs they received, which likely increased the sense of demand on ways to change behaviour (280), specifically since the sample was already motivated. Although this thesis carefully chose BCTs associated with previous dietary behaviour change success (171), the added number of BCTs did not enhance intervention effect; thus, the ideal number of BCTs to use in dietary interventions remains unknown. Further research is needed to identify the appropriate number of BCTs, to avoid overwhelming participants while still providing enough support. Until then, interventions may prefer to test giving one BCT at a time, incrementally, to work towards changing dietary outcomes.

Consequently, to reduce the potential sense of demand associated with delivering a large number of BCTs simultaneously (280), incremental delivery of the BCTs may be more appropriate (281, 282). Several interventions that have delivered behaviour change tasks incrementally, instead of simultaneously, have shown greater intervention effect and retention (283, 284). This process has been termed as a 'stepped care' approach and has resulted in more engagement with interventions (285). In the future, a stepped approach could be embedded by incrementally focussing on one dietary target (i.e. one type/eating episode of a discretionary food, as described in section 7.3.4) and delivering a specific ‘swap’ or ‘how to’ message using the appropriate BCT. This approach would replace that of targeting one whole food group and providing too many ‘how to’ messages at once. Starting with a low-intensity, simple behaviour change request in this manner, may allow participants to feel rewarded when they achieve the first goal, engaging them to then move to the next goal—incrementally building motivation and confidence (285). In this regard, this thesis has clearly portrayed that enhanced behavioural support using nine BCTs simultaneously may not lead to added intervention effect on diet quality. Hence, it may be more suitable to provide BCTs incrementally for sustainable dietary behaviour change.

In summary, discretionary choices are an important food group to address in future efforts aiming to improve diet quality. However, tailoring messages to target a more specific discretionary food or beverage, using baseline diet quality, may lead to more applicable, effective nutrition messages. Moreover, using the appropriate BCT to support the behaviour change related to that specific dietary target may result in more engagement from individuals than providing too many behaviour change tasks. Future research that builds upon the thesis findings may enhance the effect of brief online tailored dietary feedback interventions that aim to improve diet quality on a large scale.

7.4 Overall Thesis Strengths and Limitations

The strengths and limitations of each thesis component are discussed in the corresponding chapter. In this section, the strengths and limitations in relation to the overall body of research are discussed.

7.4.1 Strengths

The new knowledge that this thesis has contributed to the body of online dietary feedback nutrition intervention evidence is its key strength. Several novel design features and intervention components were tested. To the candidate’s knowledge, to date, no study has tested the effects of positive, negative, majority and minority norm framed messages, tailored them to individuals and compared the results on discretionary choice outcomes.

Another strength is that this thesis used the best available evidence and rigorous data-driven approaches in generating new findings. Using theory and behavioural frameworks to develop a robust intervention, tested through strong study designs, such as the crossover and RCT, was also a strength. Using an online software to automate the tailored messages provided by intervention emails in order to allow the intervention to be brief, both from the delivery and receiving ends, was a strength. This automation also allowed the intervention to be less time and cost intensive, and feasible for a large sample.

In all the studies in this thesis, large databases were used, which allowed complex analyses to be conducted to answer questions in depth. In the study presented in Chapter 2, complex segmentation of the sample into subgroups of up to 132 categories using multiple variables was performed. The use of a large sample size of about 1,400 individuals in the remaining studies made it possible to predict the participant characteristics, among the multiple categories considered, which are likely to ensure success from participating in an intervention. This information can guide future interventions to target the right audiences.

Conducting an impact and process evaluation added further insight to the quantified change in behaviour. Not all studies of this type have reported intervention evaluation measures (165). In this study, the process evaluation indicated that participants in the tailored intervention group were more satisfied with the brief online, tailored messaging approach than the control group. This more qualitative insight is important since higher satisfaction with an intervention in the short term could lead to greater engagement and more sustainable behaviour change over a longer term—a finding that warrants confirmation.

Throughout the thesis, data were collected on intention and dietary behaviours through valid and reliable tools, which was a key strength in the field of nutrition messaging, given that prior research made limited use of valid and reliable tools. Last, for reporting the studies conducted in this thesis, highly transparent intervention designs were used, which involved the registration of study protocols and the use of the CONSORT (216, 286) and STROBE statements (189) to facilitate transparent study reporting, and the CHERRIES checklist of information to include when reporting online surveys (232).

7.4.2 Limitations

The limitations associated with each individual study are discussed in detail in the preceding chapters. This section addresses the limitations found across the thesis for consideration in developing and testing further brief online and tailored dietary feedback interventions.

First, participant recruitment was conducted through social media and an existing volunteer database for nutrition trials. Participants who may have already been interested in nutrition were exposed to the study advertisement and voluntarily consented to participate in the study. This factor could explain the highly motivated samples included in the crossover trial and RCT. Next, although more than 5,000 participants were recruited, the retention rate was only 30%, which means that caution should be exercised in generalising the findings to a broader population. The data collected could possibly be analysed further to identify the characteristics of the participants who dropped out, which would help future studies to maximise retention and thus improve the generalisability of results. Future studies should also seek to narrow down the target of social media advertisements to try to recruit a greater proportion of individuals with lower motivation, and/or find communication strategies to attract them into these types of studies. It is critical to discover how to involve a range of people in dietary interventions, to maximise the improvement of diet quality on a population level.

In addition, the use of intention as a characteristic to tailor an intervention may have been a limitation for two reasons. First, although theory suggests that intention is a proxy for behaviour change (157), the literature suggests that many other psychosocial characteristics, such as the stage of behaviour change (155) and the level of knowledge or the interest invested in a topic (87), may be other predictors for testing nutrition messaging influence. Second, the data collected from participants resulted in a negatively skewed outcome measure. Since intention was used to indicate the effect of messages in Chapter 4 and to tailor the nutrition message frame for the main intervention testing in Chapter 5, there was potential for bias. A 'ceiling effect' was introduced, leaving little range to indicate whether the participants' true level of change had been accurately measured (220). To overcome the negative skew of this outcome, non-parametric data analysis approaches were used. These statistical approaches may have resulted in limited ability for flexible modelling to adjust for confounding factors. However, the crossover design, in that each participant acted as their own control, may have controlled for confounders to some degree (216, 226). Regardless of potential intention measurement errors, the sample may simply have been highly motivated. This factor alone may have resulted in limited differences in effect between intervention groups.

Owing to the sample size that was needed, and the large project requirements to fit into the PhD timeline, a decision was made to conduct an RCT with a nested crossover study design in order to recruit participants once. Upon reflection, the use of a crossover analysis may have been preferable in a standalone study, as opposed to nested within the RCT. First, if the crossover trial were standalone, the limitations associated with the intention score as a tailoring characteristic mentioned in the previous paragraph and section 7.3.3 could have been considered. This approach would have allowed this thesis to identify other participant characteristics associated with message effects that may have otherwise been used as the tailoring approach in the RCT. Second, participants in the tailored intervention group in the RCT had pre-exposure to all the messages from the crossover trial, before continuing into the RCT. This pre-exposure may have led to contaminated results. It may also have made the intervention too overwhelming for those participants. A phenomenon termed 'message fatigue' (287), in which individuals become tired of prolonged exposure to similarly themed messages, may have occurred. Upon reflection, conducting the crossover trial, with longer washout periods and on a separate sample from the RCT, may have led to more indicative, uncontaminated and less-biased data.

It has been postulated that sustained long-term change after nutrition interventions is difficult to achieve, and in the context of weight management, adherence tends to decline after a month (154). The barriers reported in earlier studies are the lack of time, motivation and social support; the need to fulfil other demands; and emotional availability (154). Because of the time constraints related to conducting this PhD project, the inability to follow-up the long-term behaviour change effects was a key limitation. In light of participants who received the tailored messages reporting being more satisfied with the intervention (Chapter 5), they may have further decreased their discretionary choice intake or at least sustained their behaviour change had the intervention been for a longer period. Since positive experiences with interventions are associated with a higher likelihood of revisiting the intervention (248), this underlines the importance of identifying the features that lead to greater satisfaction, and whether these can result in longer-term engagement and effectiveness.

The potential for selection bias must be acknowledged for the analysis conducted in Chapters 4 and 5, due to the substantial dropout rates in the studies. An intention-to-treat analysis may have produced unbiased assessments of the efficacy of the messaging intervention (254, 256). However, outcome data was not available for study non-completers, meaning the intention-to-treat could not be possible (255). Alternative strategies to imputing outcome data for those lost to follow-up include using multivariate analysis to predict the most likely outcome, imputation of outcomes by carrying the last known outcome status forward and analysis of best-case and worst-case scenarios (256). However, this advanced statistical approach was beyond the scope of the thesis but should be considered in future similar research. Finally, since only two and 23 participants in Chapters 4 and 5, respectively, had outcome data but were non-completers of the surveys, it is unlikely that adding these datapoints would have made a significant difference in the final results. In the future, exit interviews should be conducted to understand the characteristics of participants who are lost to follow-up and thus develop more targeted interventions (169).

The overall generalisability of the samples recruited for this thesis, to the Australian population, are limited. Despite the efforts to recruit more males, approximately 70% of the samples were female, and their average age (a mean of approximately 51 years) exceeded the current national median age (38 years) (191). The study samples consisted of approximately 30% from higher socio-economic areas of advantage, compared with 20% of the South Australian population residing in these areas. Samples that are biased towards females, middle-aged adults and those with a higher socio-economic status are common in nutrition and health research. This fact demonstrates a need to intervene for a less motivated sample, males, those in younger age groups and those from lower socio-economic areas of advantage (41). A suitable approach could be co-designing interventions (288), using both experts and consumers, to provide insight into finding ways to intervene for those who need the most help for improving diet quality.

7.5 Future Implications

7.5.1 The future of nutrition message framing in tailored dietary feedback interventions

The future implications of each thesis component are discussed in the corresponding chapters. This section provides the main recommendations for future research and practice developed from the key thesis findings.

There may be nutrition message frames, other than the ones tested in this thesis, that could improve the influence of dietary feedback interventions. In trying to identify a way to improve the effectiveness of nutrition messages at the individual level, this thesis found that the effects of positive, negative or descriptive norm framed nutrition messages on intention did not differ (Chapter 4), but participants reported a preference for a positively framed message that communicated the benefits of a dietary behaviour (Chapter 5). Therefore, for a population, using a positively framed 'eat less' message may be a starting point. However, trying to persuade individuals to change behaviours associated with a whole food group, such as decreasing the intake of all discretionary choices or increasing the intake of fruit and vegetable food groups, involves a more complex set of behavioural changes than simply swapping one type of food, for example, full-fat to low-fat milk (see the example in section 7.3.2). In addition to communicating the positive health outcomes associated with a behaviour, communicating applicable behavioural strategies, such as *swapping* specific types of discretionary foods or beverages, for healthier alternatives, may lead to more successful outcomes.

Modelling studies have tested the effect of swapping strategies to reduce discretionary choice intake (246, 289). Reducing this intake by one serve and replacing it with a healthier alternative can lead to significant reductions in both disease burden and healthcare costs (246). Nevertheless, these results were specific to the type of discretionary choice modelled. For example, swapping sugar-sweetened beverages with coffee, tea or milk had a higher effect than swapping sweet biscuits with a healthier option, such as fruit (246). Similarly, an earlier modelling study showed that swapping discretionary choices with core foods resulted in an acceptable impact on improving nutrition intake (289). Although a public messaging campaign using 'swap' messages did not achieve high impact in 2016 (274), the new available evidence (290) and the knowledge developed from this thesis, signal that 'swap' messages for discretionary choices should be further tested. This type of messaging will not only apply to individuals but also allow more large-scale interventions to focus messages on swapping the most common discretionary choice that is eaten in excess, and may inform the industry to reformulate that food.

Theoretically framing the nutrition messages positively, but also embedding a behavioural 'swap' component in the messages, could be a starting point for more effective dietary feedback. Given that this thesis found that participants were more satisfied with the tailored intervention, testing ways to further enhance the impact of tailoring the nutrition message delivered through feedback is warranted. This thesis found that baseline intention may be an unreliable measure to use for tailoring an intervention for people who are motivated to change their dietary behaviour. However, baseline diet quality predicted the likelihood of achieving the desired behaviour change, following any nutrition message. Therefore, instead of using a psychosocial characteristic, such as intention, using a behavioural characteristic, such as baseline diet quality, to tailor nutrition messages may be a better approach. Future dietary feedback interventions should consider using baseline diet quality to tailor feedback on more specific foods and/or eating episodes, as opposed to a whole food group. For example, instead of messages that simply communicate 'eat less discretionary choices', a swapping strategy, tailored to what the individual is already eating, could be more achievable. This message could be more specific to the food and eating episode, such as 'swap the chocolate you eat in the afternoon for a handful of trail mix'. Identifying the appropriate number of BCTs to support the behaviour change related to that specific dietary behaviour also needs exploration. Overall, tailored feedback should communicate the dietary target clearly, tailoring it to the specific food that an individual is consuming in excess, and present a message on 'how to swap' that food to a realistic alternative. This approach may lead to more applicable, achievable dietary behaviour changes, and enhance diet quality improvement.

7.6 Conclusion

Diet quality in Australia is poor. Specifically, the Australian population's discretionary choice intake is excessive and is displacing the intake of healthy core food groups—these are the diet quality factors associated with the national disease burden. This thesis developed a brief online dietary feedback intervention, using tailored message framing with enhanced behavioural support, to improve Australian adults' diet quality by reducing their intake of discretionary choices. A strong evidence base and theoretical concepts for nutrition messaging were used for designing this novel intervention. This original contribution of this thesis to knowledge is that, in a highly motivated sample, it may not be necessary to tailor nutrition message frames and provide enhanced behavioural support, for reducing discretionary choice intake. However, the intervention did result in a significant, clinically meaningful one serve reduction in discretionary choice intake.

In the designed intervention, an attempt was made to tailor nutrition messages using baseline intention. This attempt did not enhance the effect on diet quality improvement. Thus, to enhance future intervention effects, nutrition messages should be tailored using a measure other than intention. This thesis proposed that baseline diet quality could be a suitable characteristic to use in tailoring nutrition messages. The population may prefer a nutrition message that is positively framed. Therefore, for individuals, this positive message can communicate 'how to swap' a specific food that is tailored to their baseline diet quality assessment. A 'swap' message on targeted foods may not only be easily applied by individuals, but also by industry in reformulating the foods that are commonly eaten in excess. Therefore, further research is required on refining nutrition messages that engage and persuade more Australians to improve their diet quality. Communicating for impact requires interventions to deliver more persuasive 'eat less' messages, in order to reduce discretionary choice intake and thus improve diet quality—a goal that must be a national priority because it will contribute to the future health outcomes of all Australians.

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APPENDIX 1 OUTPUTS AND EXPERIENCES ARISING DURING CANDIDATURE

Internships:

World Health Organization internship, 2020

During the height of the COVID-19 pandemic, I used my passion for linking sustainability, food systems, biodiversity, and climate change to nutrition. I facilitated advocacy, communication and partnerships on WHO's nutrition and food safety strategies, guidance and tools with United Nations Agencies, professional communities, governments and intergovernmental organisations with the aim of increasing impact at the country and global level.

Australian Science and Media Centre internship, 2018

Upon receiving expert comments about a variety of scientific topics, I had the role to ensure the information were comprehensible, in order to send them out to journalists. Improving expert comments by replacing jargon to easily communicated sentences to wider audiences allowed me to enhance my communication skills to a lay audience. I also was able to work on multiple media releases and increase my knowledge on how to 'sell' a scientific story to a journalist and a lay person. This experience allowed me to better understand which types of story pitches journalists are looking for, which enhanced my ability to ensure more stories were communicated well to increase the interest of journalists.

CSIRO Research Dietitian internship, 2018

This opportunity allowed me to be a part a multi-sectorial team of dietitians, epidemiologists, nurses, doctors and project managers. During the internship, I had the opportunity to work on a clinical trial assessing the effects of different types of fats on biochemical markers. My role was to collect dietary data, prescribe a suitable meal plan, and ensure all participants were following dietary protocol in line with study criteria. This experience taught me to use clinical data collection software. It also allowed me to apply my knowledge on measuring and assessing dietary intake.

Publications related to the thesis:

- Hendrie GA, Lyle G, Mauch CE, Haddad J, Golley RK. (2021). Understanding the Variation within a Dietary Guideline Index Score to Identify the Priority Food Group Targets for Improving Diet Quality across Population Subgroups. International Journal of Environmental Research and Public Health, 18(2):378.

Conference presentations related to the thesis:

- Haddad, J. Hendrie GA, Dickinson K, Golley RK. (2021). Testing the effect of a brief, online and tailored intervention on dietary behaviours of Australian adults: A Randomised Controlled Trial. American Society of Nutrition. Virtual (oral).

- Haddad, J., Hendrie GA, Dickinson K, Golley RK. (2021). The influence of different nutrition messages on intention to reduce unhealthy food consumption: a randomised crossover trial. International Congress of Dietetics. Cape Town, South Africa, virtual (oral).

- Haddad, J., Hendrie GA, Golley RK. (2019). Identifying a tailoring approach for a large-scale dietary feedback intervention. Dietitians Association of Australia 36th National Conference, Queensland, Australia (oral).

Other publications:

- FAO, IFAD, UNICEF, WFP and WHO, The State of Food Security and Nutrition in the World 2020. Jul 13, 2020.

- World Health Organization, Guidance on Mainstreaming Biodiversity for Nutrition and Health. Jun 5, 2020. Geneva, Switzerland.

- World Health Organization, Mobilizing ambitious and impactful commitments for mainstreaming nutrition in health systems: nutrition in universal health coverage – global nutrition summit. May 29, 2020. Geneva, Switzerland.

- Haddad, J., Ullah, S., Bell, L., Leslie, E., & Magarey, A. (2018). The Influence of Home and School Environments on Children's Diet and Physical Activity, and Body Mass Index: A Structural Equation Modelling Approach. Maternal and child health journal, 22(3), 364–375.

Other presentations:

- Haddad, J. (2020). Spokesperson on behalf of the World Health Organization Nutrition and Food Safety Department. Walk the Talk event, virtual.

- Haddad, J. (2020). Invited speaker. Dietitians Association of Australia 37th National Conference, virtual.

- Haddad, J. (2017). Invited speaker. Pint of Science in collaboration with CSIRO. Adelaide, South Australia.

APPENDIX 2 DETAILED SUMMARY OF THE NUTRITION MESSAGE FRAMING STUDIES

Table A2-1: Experimental studies identified on impact of positive or negative message frames on intention or motivation to change, or actual dietary behaviour, including covariate effect on messages

Ref. Author Year Country	**Message conditions Study design Theory**	**Population: N; Age Mean ± SD years; % Female Setting**	**Outcome: Intention/Intake Food**	**Statistical method Covariates**	**Key results**	**Quality Appraisal Key limitations**
Churchill & Pavey 2013 UK (122)	P v. N BWS, PPT Prospect Theory	177; 21.5 ± 5.9; 59% LB	Intake FV	ANOVA, Hierarchical multiple regression analysis Baseline FV consumption; Self-reported autonomy; Age; BMI.	Ø of message frame on FV intake (p = 0.121). Autonomy moderated the relationship of message frame and intake. For high autonomy only: FV > after the P message (β = 0.44, p = 0.001) v. N message; NS for low autonomy (β = 0.12, p = 0.363).	W Limited generalisability No information on participant selection/flow Small sample
Cohen et al. 2017 US (101)	Frame (P v. N) × Regulatory Fit Theory orientation (approach v. avoidance) BWS, PPT	76; 52.8 ± 13.2; 87% RW, Community mHealth	Motivation General healthy eating (diet confidence)	Chi-squared tests and ANOVA Baseline dietary self-efficacy 'diet confidence'	Interaction between frame and match: avoidance-oriented individuals receiving matched, N-framed messages had < dietary self-efficacy (M = 4.01 ± 0.79) than the other groups (M = 4.12 ± 0.62), p = NS. More engagement from participants receiving the positive message than from those receiving the negative message (8% difference).	W Limited generalisability: focus on a disadvantaged, racial minority group
de Bruijn & Budding 2016 The Netherlands (117)	Frame (P v. N) × Temporal context (short- v. long-term consequences) × Consideration of future consequences (present v. future) BWS, PPT Prospect Theory	278; 28.6 (SD NR); 58.9% RW, internet	Intention and resolve (motivation under consideration of competing goals) Fruit	ANCOVA Self-efficacy, Involvement, Personal relevance	Ø for resolve: no sig. effects of any of the factors or interaction between the four conditions (all p > 0.073). Ø for intention: no sig. effect of any factors. Interaction between frame and temporal context: Intention > after P-framed message × long-term consequences v. P-framed message × short-term consequences (ΔM = 0.58, p = 0.043, (d = 0.42) or when long-term consequences × N-framed message (ΔM = 0.70, p = 0.016, d = 0.50). Intention > when a N-framed message × short-term consequences v. N-framed message × long-term consequences (ΔM = 0.61, p = 0.048, d = 0.48).	M Small sample size in each condition Single self-reported measures for fruit without reporting of validity or reliability

Ref. **Author** **Year** **Country**	**Message conditions** **Study design** **Theory**	**Population:** **N; Age Mean ± SD years; % Female** **Setting**	**Outcome: Intention/Intake** **Food**	**Statistical method** **Covariates**	**Key results**	**Quality Appraisal** **Key limitations**
de Bruijn et al. 2015 The Netherlands (118)	Frame (P v. N) × Descriptive norms BWS, PPT	177; 36.8 ± 12.9; 76.3% RW, online	Intention and intake Fruit	ANCOVA gender, age, self-efficacy	Ø for message frame or norm type on intention (all $p > 0.29$). For H fruit consumers, intention > following N-framed message (Madj = 1.5; SE = 0.13) v. L consumers (Madj, 1.3; SE, 0.073), $p = 0.03$, n2 = 0.03. Change not sustained at 1-week follow-up. For L fruit consumers, intention > following P-framed message (Madj, 1.4; SE, 0.08) v. H consumers (Madj, 1.2; SE, 0.11), NS. No effect of type of message frame/norm on 1-wk follow-up intention. Fruit intake > in those exposed to a P-framed message (Madj = 1.2; SE = 0.13) v. N-framed message (Madj = 0.7; SE = 0.15), $p = 0.03$, n2 = 0.03.	M No control group Limited generalisability Food intake measure not valid/source not described
Dijkstra et al. 2011 The Netherlands (92)	Study 1: Frame (P v. non-gain v. N v. non-loss) × Outcomes (presence v. absence) BWS, PPT Regulatory Focus and Prospect Theories	144; 21.1 ± 3.1, 44.7% LB	Intention FV	ANCOVA Baseline intention	Type × Valence-interaction was significant, $p < 0.05$, n2 = 0.036. Ø for persuasiveness between P and N ($p = 0.18$). The P was more effective than the non-P ($p < 0.05$). The P was more effective than the non-N ($p < 0.05$). Intentions were significantly stronger when the message described the presence of outcomes v. absence. $p < 0.05$, n2 = 0.04.	W No available sample numbers or score measures (means) for study groups No selection information/flow of subjects into study
	Study 2: Increased level of threat of the message and introduced personalisation	198;23 ± 8.9; 64% LB			When messages not personalised = in the P and N statements Ø for intention. When personalised, the P message led to a significantly > intention to consume more fruit v. N-framed message ($p < 0.05$). Within the N-framed message, personalisation led to a significantly < intention ($p < 0.05$).	
Gerend & Maner 2011 US (103)	Frame (P v. N) × Emotional state (fear v. anger) BWS, PPT Prospect Theory	133; Age NR; 77%. LB	Intake FV	ANOVA/ANCOVA Gender, trait anger, trait anxiety, baseline FV intake	At baseline, mean FV = 2.1 servings per day. Ø gender effect. Fear condition: Those who read the N-framed pamphlet reported eating more servings of FV per day (Madj = 3.54; SE = 0.3) than those who read the P-framed pamphlet (Madj = 2.69; SE=.29), $p < 0.05$, partial n2 = 0.33. Anger condition: Those who read the P-framed pamphlet (Madj = 2.93; SE=.30) reported eating (marginally) more FV per day than those who read the N-framed message (Madj = 2.22; SE=.29), $p = 0.10$, partial n2 = 0.022.	W No group sample numbers reported. FV intake based on self-reported single-item measure. Limited generalisability
Gerend & Shepherd 2015 US	Study 1: P v. N BWS, PPT Prospect Theory	69; 19 ± 1.1; 100% LB	Intention and intake Dairy: Calcium foods	Chi-square and T-tests	Intention: Ø of frame among participants with H baseline dietary calcium intake. For L baseline dietary calcium intake (1 SD below the mean), the P-framed message > intentions v. N-framed message, $\beta = -0.43$, $p = 0.008$, partial $r = -0.33$.	W No control group, small sample

Ref. Author Year Country	Message conditions Study design Theory	Population: N; Age Mean ± SD years; % Female Setting	Outcome: Intention/Intake Food	Statistical method Covariates	Key results	Quality Appraisal Key limitations
(104)	Study 2: Replicated findings from study 1 with a larger sample and assessed effects of the framing on calcium-related behaviour over time	213; 19 ± 1.6; 100%			Intake: H dietary calcium at baseline > dietary intake at follow-up, β = 0.57, $p < 0.001$, partial $r = 0.54$. Ø of frame among participants with L baseline dietary calcium intake. Among participants with H baseline dietary calcium intake, the P-framed message > dietary calcium intake at follow-up v. N-framed message, β = −.20, $p = 0.020$, partial $r = 0.16$.	M No control group, not generalisable
Godinho et al. 2016 Portugal (111)	Frame (P v. N) × Outcomes (presence v. absence) BWS, PPT Prospect Theory	180; 23 ± 4.9; 84% LB	Intention and intake FV	Hierarchical linear regression	Message framing not significant predictor of FV (all $p > 0.70$). The N-frame > FV intake among those who had H baseline intentions (β = −.17, $p = 0.03$). N-frame > FV intake post-intervention as baseline intentions increased, β = −.192, $p = 0.058$. At lower levels of motivational orientation (prevention-focussed individuals), FV intake > after N-frame (β = −.23, $p = 0.03$). At higher levels of motivational orientation, the message frame not a predictor of FV intake (β = 0.16, $p = 0.13$): for increasingly promotion-focussed individuals, N- and P-framed messages were equally effective in promoting FV intake.	M Limited generalisability because most participants were female, highly educated
Latimer et al. 2008 US (106)	Prevention-focussed (protect) 'N' v. Promotion-focussed (enhance/ optimise) 'P' BWS, PPT Regulatory Focus (RF) Theory	518; 50.4 ± 14.4; 73% RW, community	Intake FV	Hierarchical regression analyses Baseline FV, intentions and self-efficacy	Ø of messages on FV intake (all $p \leq .13$). Promotion-focussed 'P' message for promotion-focussed participants > more likely to meet the '5 A Day' v. prevention-focussed 'N', OR = 1.09, 95% CI [0.99–1.19] $p = 0.07$. Prevention-focussed message for prevention-focussed participants > more likely to meet the guideline v. promoters, OR = 0.89, 95% CI [0.79–1.01] $p = 0.08$.	M Highly motivated sample, educated, not generalisable

Ref. Author Year Country	Message conditions Study design Theory	Population: N; Age Mean ± SD years; % Female Setting	Outcome: Intention/Intake Food	Statistical method Covariates	Key results	Quality Appraisal Key limitations
Mollen et al. 2016 The Netherlands (116)	Frame (positive v. negative) × Norm (injunctive v. descriptive) with picture type (i.e. fruit, candy, neutral) and direction (i.e. push, pull). BWS, PPT Prospect Theory	Study 1: 73; 21.48 ± 21.6; 82% LB	Intention Appetitive Motivation Choice: Healthy (fruit) v. unhealthy (candy) foods	RM ANOVA/ MANOVA Self-efficacy and intentions	Injunctive: stronger motivation for fruit & candy (Madj = 36.14), v. non-food items (Madj = 5.36), NS. Descriptive: appetitive motivation for food items lower (Madj = 16.03) v. non-food items (Madj = 22.86), NS. Injunctive condition: appetitive motivation for fruit v. candy higher in the N- v. the P-frame, NS. Descriptive condition: appetitive motivation for fruit v. candy stronger in P- v. the N-frame; NS. Appetitive motivation > for fruit in both the N injunctive and the P descriptive norm v. control conditions. Ø effects of framed injunctive and descriptive norm messages on self-reported attitudes, self-efficacy and intentions regarding fruit and candy consumption.	M Not generalisable to real-world settings
		Study 2: 190; 21.79 ± 4.5;75% LB	Intake Healthy (fruit) v. unhealthy (candy) foods	RM ANOVA/ MANOVA Processing measures and subjective experiences	Participants exposed to an N-framed injunctive norm about disapproval of unhealthy food ate more fruit than candy (p = 0.016, η2 = 0.04) v. all other conditions. Ø between the P-framed descriptive norm condition and the control condition for fruit intake. Ø between the N-framed injunctive and positively framed descriptive norms and the control condition for candy intake. P-framed descriptive norm leads to more fruit chosen (Madj fruit = −0.02; Madj candy = −0.19), v. N-framed descriptive norm (Madj fruit = −0.31; Madj candy = 0.24), d = 0.33. More fruit chosen after an N-framed injunctive norm (Madj fruit = 0.44; Madj candy = −0.16), v. with P-framed injunctive norm (Madj fruit = −0.03; Madj candy = 0.34), d = 0.57.	
Pavey & Churchill 2014 UK (121)	Frame (P v. N) × Prime (autonomy, neutral, heteronomy) BWS, PPT Prospect and Self-Determination Theories	Study 1: 152; 27.4 ± 6.6; 79% LB	Intention and intake DC: High-calorie snack	ANOVA/ANCOVA Baseline: intentions, snacking behaviour and autonomy	Autonomy-primed participants: P message = higher follow-up intentions (M = 4.24) than N (M = 2.80), p = *I*.005, n2 = 0.13. Neutral- and heteronomy-primed participants: Ø between P-framed and N messages, all p > 10. Autonomy-primed participants: P message = less snack consumption (M = 3.29) at follow-up v. N message participants (M = 4.16), p = 0.054, n2 = 0.06. Of the heteronomy-primed participants, P message reported greater snack consumption (M = 3.80) at follow-up v. N message (M = 2.83), p = 0.035, n2 = 0.07.	W Small sample, mostly female. Sample numbers of study groups unavailable

Ref. Author Year Country	Message conditions Study design Theory	Population: N; Age Mean ± SD years; % Female Setting	Outcome: Intention/Intake Food	Statistical method Covariates	Key results	Quality Appraisal Key limitations
		Study 2: 243; 27.4 ± 6.6, 46% LB		Age, gender, BMI, baseline: snacking behaviour, intentions and autonomy	For overweight (BMI > 25) participants only: Autonomy-prime: P message > intentions v. N message participants, *p* = 0.038, n2 = 0.02. Heteronomy-prime: P message < intentions v. N message participants, *p* = 0.032, n2 = 0.02. Reading N message: autonomy-prime participants reported marginally < intentions than heteronomy-prime, *p* = 0.053, n2 = 0.02. Autonomy-prime: P-framed message > intentions v. N-framed message, *p* = 0.011, n2=.04. N message < intentions than heteronomy-prime participants, *p* = 0.011, n2 = 0.04 Heteronomy-prime: P- framed message participants reported > snacking v. N message, *p* = 0.025, n2 = 0.03. Reading P message: autonomy-prime message reported marginally < snacking v. heteronomy-prime message, *p* = 0.059, n2 = 0.02. In both studies, when autonomy was highlighted, the P-framed message resulted in stronger intentions to avoid high-calorie snacks, and lower self-reported snack consumption after 7 days.	
Pham & Mandel 2016 US (105)	Study 1: 3 messages (one-sided positive v. one-sided negative v. neutral) × Dietary restraint (continuous) BWS, post-test	380; NR Age/Gender LB	Perception (Thoughts) DC: Unhealthy Food	Multiple regression analysis	Dieters who saw the N message scored higher on reactance v. dieters who saw the P message (*b* = 2.36, *p* < 0.05) or the neutral message (*b* = 2.33, *p* < 0.05).	W Unstandardised results No means or SDs of results Insufficient sample reporting
	Study 2: 2 messages (one-sided negative v. one-sided positive) × Dietary restraint (continuous)	397; NR Age/Gender LB	Intake DC: Cookies	Multiple regression analysis Hunger	Dieters who saw the N message consumed more cookies v. those who saw the P message (*b* = 9.05, t(392) = 3.11, *p* < 0.01). NS effect among non-dieters (*b* = 0.90, *p* = 0.76).	

Ref. Author Year Country	Message conditions Study design Theory	Population: N; Age Mean ± SD years; % Female Setting	Outcome: Intention/Intake Food	Statistical method Covariates	Key results	Quality Appraisal Key limitations
	Study 3: 3 messages (one-sided negative v. one-sided positive v. two-sided message) × Dietary restraint (continuous)	324; NR Age/Gender LB	Intake Choice: Five healthy snacks (e.g., whole wheat crackers) and five unhealthy snacks (e.g., cookies).	Multiple regression analysis Hunger	Dieters in the P and two-sided message significantly predicted number of unhealthy snacks chosen (b = 22.61, p < 0.05, and b = 24.37, p < 0.001). Dieters who saw the N message chose more unhealthy snacks than dieters who saw the P message (b = 22.32, p < 0.01). Dieters who saw the two-sided message chose fewer unhealthy snacks than dieters who saw the N message (b = 23.62, p < 0.001). NS among non-dieters (all p > 0.20).	
Vidal et al. 2019 Uruguay (123)	P v. N with images v. control BWS, PPT	201; 25.6 ± 6.4; 58% LB	Intake Choices of 8 healthy and unhealthy snack foods.	Chi-square	P- v. N-framed messages resulted in significantly more willingness to follow FV recommendations (5.7 v. 5.0, p < 0.001). P- and N-framed messages resulting in more product choice including nutritional warnings for sugar v. control (66% v. 40%, p = 0.039). Ø between P- v. N-framed. Control group selected *alfajor* (14%) (featured warnings for sugar and saturated fat) and cookies (15%) (featured warnings for sugar, total and saturated fat) more often than those in P- (6 and 2% respectively) or N messages (3 and 3% respectively), p < 0.05. N-framed group selected a cereal bar that did not feature any warning (25%) significantly more often than P and control (14% and 15%, respectively)	M Convenience sample – highly educated No individual variables used as covariates Generalisability of results is limited
Wirtz & Kulpavaropas 2014 US (102)	Frame (P v. N) × [narrative, non-narrative] × Message frame [gains, losses]) BWS, post-test. Prospect Theory	72; 40.6(SD NR); 65%. RW, outdoor festival	Intention General healthy eating	ANOVA/MANOVA	Ø between narrative and non-narrative messages (all p-values > 0.40). Message engagement > for N-frame (M = 1.9 ± 1.37) v. P-frame (M = 0.6 ± 2.93) (p = 0.02) [d = 0.56] Attitude > for P (M = 5.8 ± 1.29) v. N-frame (M = 5.0 ± 1.61) p = 0.03 [d = 0.54] Intention > for N (M 6.1 ± 0.79) v. P-framed (M = 5.3 ± 1.31) (p = 0.01) [d = 0.74].	W Convenience sample recruited at an outdoor festival No control group No pre-test data collected
Yan 2015 US (93)	Frame (advantage v. disadvantage) × Ambivalence (univalent or ambivalent) BWS, PPT Heuristic-systematic model framework	256; 19.9 ± 1.28; 61% LB	Attitudinal ambivalence/ univalence (feeling) DC: junk food	ANOVA Cognitive elaboration (critical thinking); perceived frame valence	Ambivalent group: reported > intention to eat less junk food after the disadvantage frame (M = 1.29 ± 0.98) v. advantage frame (M = 0.56 ± 0.92); p < 0.001, d = 0.77. Univalent group: NS attitude mean difference between the advantage frame (M = 1.37 ± 1.42) v. disadvantage frame (M = 1.41 ± 1.31) p = 0.87	M Generalisability is limited No participants flow through study Not valid food intake measure

BWS = between-subject ; PPT = pre/post-test; LB = Lab based; RW = real world; Ø=no between-group differences, >=led to higher, <=led to lower; v = compared with; *P* = *P*ositive, *N* = *N*egative; DC = Discretionary choices, FV = Fruit and vegetables; L = low consumers, H = high consumers; Partial η2 (eta-squared): proportion of variance accounted for by some effect; partial *r* = partial correlation coefficient. W = Weak, M = Moderate, S = Strong.

Table A2-2 Experimental studies identified on impact of descriptive norm frames on intention or motivation to change, or actual dietary behaviour, including covariate effect on messages

Author Year Country Ref.	Message Control Study Design Theory	Population: N, Age Mean ± SD years, % Female Setting	Outcome: Intention/Intake Food	Statistics used Covariates	Key results	Quality Key limitations
Collins et al. 2019 UK (128)	Descriptive majority v. health message BWS, PPT	Study 1: 704; 19.6 ± 2.95; 52.7%	Purchasing Meals containing vegetables	Chi-square tests	Social-norms intervention was associated with an increase in purchases of vegetables (from 63% to 68% of meals; OR 1.24, CI [1.03–1.49]), which was sustained after intervention (67% of meals; OR 0.96, CI [0.80–1.15]). There was no effect of the health message (75% of meals at baseline, and 74% during the intervention; OR 0.98, CI [0.83–1.15]).	W No descriptive results, such as mean and SD data Sample not generalisable: selection bias
		Study 2: 481; 20.75 ± 4.10; 64.7% RW: On-university campus canteen	Purchase Side portion of vegetables		There was an increase in the proportion of meals purchased with additional portions of vegetables from the baseline after both the social norm (22.9% of meals with vegetables at baseline, rising to 32.5% during the intervention; OR 1.62, CI [1.27–2.05]) and health message (rising from 43.8% at baseline to 52.8%; OR 0.59, CI [0.46–0.75]). The increase was not sustained for the social norm intervention (22.1%; OR 0.59, CI [0.46–0.75]), but was sustained for the health intervention (48.1%; OR 0.83, CI [0.67–1.02]), post intervention.	
Croker et al. 2009 UK (130)	Majority norm v. cost v. health BWS, PPT	1083; 51.5 (SD NR); 54% RW: national data base	Intention FV	Paired *t*-tests; RM ANOVA gender, education, baseline FV intake	Baseline FV intake Male(M)=3.29, Female(F)=3.71/day. Intention to eat more FV rated > for M (partial $n^2 = 0.023$) for health message, followed by social norm, cost and control condition, v. F (partial $n^2 = 0.003$). *Intention for FV between M v. F:* control: 3.31 v. 4.07 ($p < 0.005$); health: 4.7 v. 4.12, NS; cost: 3.66 v. 4.14, NS; norm: 3.94 v. 3.92 ($p < 0.005$) M intentions in the norm condition (M = 3.9 portions) v. control condition (M = 3.3 portions) ($p = 0.001$). Ø in M intentions between control, health value ($p = 0.06$) or the cost ($p = 0.07$) messages.	W Sequential, not randomised allocation of participants to groups Messages could have differed in influence due to their wording. 'Intended' increase in consumption may have inflicted existing dietary optimism (especially among females). No descriptive results such as mean and SD data

Author Year Country Ref.	Message Control Study Design Theory	Population: N, Age Mean ± SD years, % Female Setting	Outcome: Intention/Intake Food	Statistics used Covariates	Key results	Quality Key limitations
Kothe & Mullan 2014 Australia (120)	Attitude (relationship between behaviour & health); subjective norm (provide information about others' behaviour/approval/social comparison), & perceived behavioural control (instruction) v. control RCT Theory of Planned Behaviour	180; 18.84 ± 1.3; 83 RW: Community	Intake FV	ANOVA/RM ANOVA	Control: FV intake baseline v. post-intervention: 4.59 ± 2.22 v. 5.02 ± 2.10, NS. TPB: FV intake baseline v. post-intervention: 4.69 ± 1.92 v. 5.31 ± 2.08. [d = 0.25] No main intervention effect of condition for any stage of intervention. TPB constructs associated with intention at baseline and follow-up. NS correlation between changes in reported intention and FV consumption, and with attitude/perceived behavioural control. Change in intention was significantly associated with change in subjective norm, $\beta = 0.39$, $p < 0.01$.	M Intention to consume fruit and vegetables was already high at baseline; indicating pre-existing motivation to change Self-report bias of FV through non-validated measures
Lindsey LLM 2017 US (110)	Persuasive message based on: attitude v. subjective norm v. control BWS, PPT Theory of Reasoned Action	276; 20 ± 1.9;67.4% RW: Online	Intake FV	Confirmatory factor analysis	Control baseline intake: 2.74 ± 2.22 v. follow-up 4.15 ± 5.44 (↑1.41 serve). Attitude message: baseline intake: 3.21 ± 2.2 v. follow-up 4.18 ± 2.5 (↑0.97 serve). Subjective norm: 3.01 ± 2.9 v. 3.95 ± 3.61 (↑0.94 serve) NS Ø between control/attitude and subjective norm. Higher attitude toward increased FV intake correlated with higher subjective norm, and the greater the intention will be to increase consumption of fruit and vegetables. Persuasive subjective norm message influenced participants' attitudes (r = 0.42), family (r = 0.34) and close friends (r = 0.19).	M Young student population recruited, not generalisable Data collection measures used for the control group may have served as a persuasive intervention and flawed between-group results
Mollen et al. 2013 US (107)	Descriptive majority v. injunctive × healthy behaviours v. unhealthy behaviour; v. control BWS post-test	231; 20.1 ± 2.5; 51% RW: on-campus food-court	Purchase & intake Salad v. burger	Hierarchical logistic regression analysis	NS Ø between injunctive healthy norm and control on salad ($\beta(0.70)=1.03$, p = 0.14) Choosing a salad more likely in the healthy descriptive norm condition than in the unhealthy descriptive norm condition (β (1.09) = 2.52, $p < 0.05$) and control (β (0.70) = 1.40,$p < 0.05$) Choosing a salad more likely in the injunctive norm condition v. unhealthy descriptive norm condition (β (1.09) = 2.15, $p < 0.05$). Social norm condition NS predictor of burger choice, p = 0.79.	M Only one-fifth of the participants reported having observed the posters Researchers not blinded to the conditions of the course of the study

Author Year Country Ref.	Message Control Study Design Theory	Population: N, Age Mean ± SD years, % Female Setting	Outcome: Intention/Intake Food	Statistics used Covariates	Key results	Quality Key limitations
Payne et al. 2015 US (108)	Study 1: Message detailing number of produce items purchased (i.e. descriptive norm) at particular stores (i.e. provincial norm) for intervention v. control store	971,706 individual grocery store transactions. Age and gender NR RW: Supermarket	Spending Produce (fruit and vegetable)	ANOVA, *t*-tests	Intervention stores with placards resulted in a significant increase in produce spending per day per person (+16% $p < 0.01$) v. control store (+4%; NS).	W Not known when intervention's placards start to reduce impact on produce purchasing Should not assume extra produce purchasing is extra produce consumption—therefore, measuring of FV intake would be useful
	Study 2: Expanded the placard intervention to two additional stores BWS post-test	252,115 for store 1 and 323,574 store 2 Age and gender NR RW: Supermarket			Produce spending, but not total spending, for store #1 significantly increased by 12.4% ($P < 0.001$) compared with baseline. Produce, but not total spending for store #2 significantly increased by 7.5% ($P < 0.01$).	
Robinson et al. 2013 UK (131)	Descriptive majority v. health message v. control BWS, PPT	129; 22.4 ± 4.5; 65% LB	Choice/intake 3x high-calorie snack foods, 3x healthy foods: fruit and vegetable items	ANOVA; Hunger; BMI; dietary restraint; and age	Health and the social norm message condition < high-calorie snacks, compared with the control message condition (36% and 28%, both $P < 0.05$) (social norm: 30 ± 21 g v. 23 ± 20 g v. 42 ± 38 g, $P < 0.05$). [***d* = −0.39** between social norm and control] Ø for fruit and vegetable intake (social norm: 103 ± 74 g v. health: 85 ± 58 g v. control: 970 ± 63 g, $P > 0.05$). NS for total snack intake in social norm (207 ± 122 kcal) but health condition decreased snack intake (165 ± 103) kcal v. control: 266 ± 210 kcal), ($p < 0.05$).	M Findings not generalisable to real-world settings
Robinson et al. 2014 UK (95)	Study 1: Descriptive majority (referent group) v. Health message	77; 19.6 ± 2.6; 83% LB: Posters and flyers	Intake FV and unhealthy snacks	ANOVA; baseline hunger, cognitive restraint and BMI	Ø between condition or usual vegetable intake, (all *p*-values > 0.25). For habitual L consumers, norm condition (67.0 ± 46.7 g) > vegetables v. health condition, (32 ± 32.0 g) ($p < 0.05$). [***d* = 0.87**] % of meal made of veg = 38.0 ± 18.5 for norm condition, v. 21 ± 15.3 for health condition ($p < 0.05$) [*d* = 1.00] For habitual H consumers, Ø NS between the message conditions in selecting grams of vegetables (46.0 ± 46.1 v. 62.1 ± 56.1); or % meal from vegetables 31.2 ± 28.0 v. 37.0 ± 22.0 (*p*-values > 1.0).	M No control Generalisability is limited: participants were mostly female students, of high socio-economic status, and mostly in the healthy weight range Norm messages tested

Author Year Country Ref.	Message Control Study Design Theory	Population: N, Age Mean ± SD years, % Female Setting	Outcome: Intention/Intake Food	Statistics used Covariates	Key results	Quality Key limitations
	Study 2: Descriptive majority v. Injunctive norm v. Health message BWS, PPT	75; Age NR; 88% LB: Posters			For descriptive norm, L consumers selected higher proportions of FV 71.4 ± 53.4 g than the health condition 23.3 ± 31.3 ($p < 0.05$) [$d = 1.1$] and the injunctive norm 21.8 ± 25.0 ($p < 0.05$). The injunctive and health conditions did not differ ($p = 1.0$). Descriptive norm selected fewer high-calorie food 5.6 ± 9.3 g than the health condition 24.2 ± 21.3 g [$d = −1.13$] ($p < 0.05$); and the injunctive norm 13.9 ± 8.7 g did not differ from the health condition ($p = 0.23$). For H consumers, Ø and food selection: FV grams: descriptive = 79.6 ± 62.9; injunctive = 47.4 ± 38.1; health = 69.1 ± 70.2 (all $p > 0.3$).	against similar audience, not a wider reference group (e.g. a wider population)
Stok et al. 2012 The Netherlands (94)	Study 1: Majority norm v. Minority norm × identifying with the referent group (similar to participants)	102; 22.5 ± 5.4; 83% LB: on computer	Intention FV	ANOVA/MANOVA Age, gender, fruit consumption and identification	Majority norm participants reported higher fruit intake intentions than minority norm participants (3.89 + 0.97 v. 3.53 + 0.72) [$d = 1.14$] Norm information influenced intentions when participants strongly identified with the referent group ($p = 0.028$) but not when identification was moderate/weak (all $p > 0.4$). Majority high identification: 4.25 ± 0.87 v. moderate 3.79 ± 1.00 [$d = 0.49$]. High-identification majority: 4.25 ± 0.87 v. minority: 2.88 ± 0.88 [$d = 1.56$] Only minority norm/high-identification participants differed from all other participants with significantly lower fruit intake intentions (mean Δ > 0.749, all p = 0.03). All other participants' intentions did not differ (all $p < 0.165$).	M No control condition. No measure of whether participants believed the information they read
	Study 2: Majority v. minority descriptive norm messages × high v. low identification referent groups BWS, PPT The focus theory of normative conduct & Identity theory	119; 21.7 ± 2.9; 78% LB	Intake FV	ANOVA Age, gender, baseline fruit intake intention and intake	Significant effect of normative information on fruit intake change, $p = 0.020$. Significant effect of majority norm on fruit intake change in both identification groups; but minority norm/high-identification participants consumed significantly less fruit (mean Δ > −0.38, all $p < 0.04$). Minority norm/high-identification participants and majority norm/high-identification participants did not significantly differ from participants in the control condition (mean Δ < 0.30, all p > 0.130). Fruit intake increased by 0.3 portion of a fruit per day in majority norm/high-identification participants—and decreased by the same 0.3 portion per day in minority norm/high-identification v. control (NS). $d = 0.45$ (majority norm) and $d = 0.47$ (minority norm).	Cover story may have manipulated results, because control condition also increased fruit intake
Thomas et al. 2016 UK	Descriptive majority v. liking norm v. variety	353; 21.5 ± 0.2; 72% LB	Intake Vegetables/variety	Mixed ANOVA to analyse food intake	Ø delay exposure (all $p > 0.05$). Ø between message type, nor any main effect of delay, for any of the foods except broccoli. Ø messages for the L consumers [Neutral Control = 82.1 g, Vegetable Variety condition = 125.8 g,	M Relatively small numbers of participants in each group, and therefore, caution is

Author Year Country Ref.	Message Control Study Design Theory	Population: N, Age Mean ± SD years, % Female Setting	Outcome: Intention/Intake Food	Statistics used Covariates	Key results	Quality Key limitations
(125)	condition v. health message v. control × immediate v. delayed exposure RCT			(questionnaire) with food type (veg v. non-veg intake); delay; message type; and habitual veg consumption	Health = 101.3 g, Descriptive Norm = 89.9 g, and Liking Norm = 101.4 g; p = 0.1]. Ø messages for the H consumers [Neutral Control = 143.7 g, Vegetable Variety conditio$n$ = 114.6 g, Health = 130.1 g, Descriptive Norm = 136.7 g, and Liking Norm = 114.8 , p = 0.5]. Habitually L consumers increased their consumption of broccoli in the vegetable variety [17.0 ± 4.6, d = 2.90] and liking norm [15.2 ± 4.2, d = 2.24] conditions relative to habitual L vegetable consumers in the neutral control condition [2.7 ± 4.1] (p < 0.05). Liking norm only resulted in increased broccoli intake compared with neutral condition, but no other vegetable differences for descriptive norm/health message.	warranted in interpreting these results
Thomas et al. 2017 UK (129)	Descriptive majority Within-group, PPT	1585; 98% <60years old; 53% (all observations) RW: Workplace restaurant	Purchase Vegetables	Pearson's chi-square	Meals purchased with veg 60% preintervention to: 64% during the intervention (OR 1.2, 95% CI [1.1,1.3]) p < 0.01 67% to post-intervention (OR 1.2, 95% CI [1.0,1.3]) p < 0.01	W Actual consumption was not measured, only purchases Period only for 2 weeks at each phase
Verkooijen et al. 2015 The Netherlands (119)	Descriptive majority norm × baseline fruit intake v. control BWS, PPT	Study 1: 163; 21.9 ± 5.46; 82%	Intake Fruit	A repeated measures ANOVA	Low baseline consumers (1.10 ± 0.63) increased consumption at follow-up (1.47 ± 1.00, p = 0.008, d = 0.44); and those who consumed above average at baseline 3.16 ± 1.33 decreased consumption at follow-up 2.48 ± 1.40, p = 0.002 - d = 0.47. Same pattern was observed for the no-message condition. Message condition (descriptive norm v. control) showed no main effect, p = 0.679.	M No effect of the social norm messages beyond mere regression to the mean
		Study 2: 119; 21.6 ± 3.8; 87% LB	Intake Unhealthy snacks		Both in the descriptive norm, 2.70 ± 0.93 v. 1.64 ± 1.26 (p < 0.001) d = 0.88, and in the control condition, 2.24 ± 0.63 v. follow-up 1.73 ± 0.97(p = 0.035) d = 0.47, average snack consumption decreased among students with higher snack intake at baseline. Ø between descriptive norm condition (Mdiff = −0.198, p = 0.123) and in the control condition (Mdiff = –0.275, p = 0.198), of students with lower baseline unhealthy snacks consumption.	

BWS = between-subject; PPT = pre/post-test; LB = Lab based; RW = real world; Ø = no between-group differences, >=higher, <=lower; v = compared with; DC = Discretionary choices, FV = Fruit and vegetables; d = Cohen's effect; Partial η^2 = partial eta-squared; partial r = partial correlation coefficient. W = Weak, M = Moderate, S = Strong.

Table A2-3: Experimental studies identified on impact of other types of messages

Ref. Author Year Country	Message Control Study Design Theory	Population: N, Age Mean ± SD years, % Female Setting	Outcome: Intention/Intake Food	Statistics used Covariates	Key results	Quality Key limitations
Appleton, KM 2016 UK (126)	Body image related 'Eat fruit and help your waist' v. public health message 'Eat fruit and help your heart' (positive frame) BWS post-test	166; 20.6 ± 1.9; 79% LB	Intention and intake (immediate and subsequent) Choice: Fruit; fruit-based biscuit bars and unhealthy biscuit bars	Multiple linear regression Gender, age, usual motivation through appearance or health-based concerns; liking for fruit; usual fruit and past fruit consumption; attitudes towards fruit consumption; perceived behavioural control	Immediate fruit selection > after appearance- (43%) v. health-based poster (30%) (β = 20.24, $p = 0.01$) adj for previous fruit consumption and liking. Unhealthy biscuit bars chosen more frequently after health- v. the appearance- based (27 v. 15%) message. Subsequent fruit intake was > after the appearance- (2.8 ± 2 portions/d) v. health-based poster (2.1 ± 1.3 portions/d) (β = 20.22, $p = 0.03$) [$d = 0.41$]; this effect became NS after adj participant characteristics (β = 20.15, $p = 0.10$).	M No control condition Low generalisability
Carfora et al. 2017 Italy (112)	Regret 'Think about regret that you could experience if this week you exceed the recommended portion of processed meat' v. control RCT Theory of Planned Behaviour	244; 19.37 ± 1.5; 50% LB	Intention and intake Processed meat	ANOVA; baseline intention, affective and instrumental attitudes, subjective norm, perceived behavioural control, age	Intention pre- v. post-intervention: Regret condition: 3.83 ± 1.77 v. 4.47 ± 1.68; Control condition: 3.84 ± 1.45 v. 3.60 ± 1.70 ($p < 0.008$, np2 = 0.06) [$d = 0.51$]. Pre- and post-intervention intake: Regret: 3.13 ± 3.63 v. 1.74 ± 1.84; Control: 3.32 ± 2.18 v. 3.29 ± 2.61 ($p < 0.001$, np2 = 0.14) [$d = −0.68$]. Significant mediators: anticipated regret, instrumental attitude and baseline intention (β-0.11; 95% CI [−0.35; −0.01]).	M Low generalisability Message was a part of a larger text messaging intervention, which could have influenced the study outcome
Doerksen & Estabrooks 2007 US (62)	Benefits/Risks/Strategies v. control RCT Social Cognitive Theory	60; 41.4 ± 13.1; 75% RW: Community	Intake FV	MANOVA; self-efficacy 'the belief in capabilities'; outcome likelihood, outcome value 'as the beliefs about the consequences of an action'	FV servings intake pre- v. post-intervention: Intervention: 5.5 ± 0.50 v. 6.4 ± 0.49 Control: 5.4 ± 0.52 v. 5.3 ± 0.52, $p < 0.05$ [$d = 2.17$]. *Fruit* intake pre- v. post-intervention: Intervention: 1.9 ± 0.30 v. 2.4 ± 0.33 Control: 2.2 ± 0.33 v. 2.2 ± 0.35; NS *Vegetable*: 4.6 ± 0.54 v. 4.9 ± 0.52. Control: 3.2 ± 0.58 v. 3.1 ± 0.56, $p > 0.05$ [$d = 3.33$]. No covariates mediating effect, all $p > 0.05$. Higher frequency of read messages (7+ times) increased number of servings of F&V by two per day (+1.99) v. low frequency of messages read (0.02 servings; $p < 0.10$).	M Possible confounding effect of high motivation at baseline due to already being in a physical activity program

Ref. Author Year Country	Message Control Study Design Theory	Population: N, Age Mean ± SD years, % Female Setting	Outcome: Intention/Intake Food	Statistics used Covariates	Key results	Quality Key limitations
Godinho et al. 2015 Portugal (113)	Risks/Resources (‘Fear/Persuasion’) v. Planning ‘Action planning’ v. Control × Mismatch on HAPA behaviour change stage (intention) RCT Health Action Process Approach (HAPA)	203; 22.2 ± 5.6;87.3% LB	Intention and intake FV	RM ANOVA	Non-intenders had increased self-efficacy after Fear message (matched) from pre- (4.23 ± 1.29) to post-intervention (5.11 ± 0.97, p < 0.001; n2 = 0.22), v. Planning (mismatched) and Control (all p > 0.10). Intenders had increased self-efficacy following Planning message (matched), from pre (4.75 ± 1.32) to post-intervention (5.54 ± 0.93, p < 0.00; n2 = 0.20), but NS change following Fear (mismatched) and Control (all p > 0.10). Non-intenders in Fear message group had higher intention to increase FV (M = 5.09) than those in Planning (M = 4.53) [d = 0.61] and control (M = 4.10, p-values < 0.008, d = 0.19). Ø for FV intakes between Fear, Planning and control groups (M = 1.83 v. 1.69 v. 2.06) at follow-up (change from baseline NR).	M Generalisability limited: majority female, university students FV intake self-reported using only two items, possible recall-bias
Mattavelli et al. 2017 Italy (114)	Self-referencing [pair green vegetables with self] v. control; persuasive message [positive health and physical appearance] v. control BWS post-test The Associative and Propositional Evaluation model	273;66(SD NR); 58% RW: Internet	Explicit attitude Vegetables	Hierarchical multiple regression Explicit attitude, implicit attitudes and readiness to change	Message condition and participants’ pre-existing attitudes were significant predictors towards positive attitudes for green vegetables (p-values < 0.05). Participants exposed to the persuasive message > positive explicit attitudes towards green vegetables (6.90 ± 1.84) v. control (6.44 ± 1.82). NS interactions among implicit attitudes and the message conditions and pre-existing attitudes in predicting explicit attitudes (p = 0.704). Participants who received the persuasive message were more inclined to change behaviour v. control (6.10 ± 2.32 and 5.67 ± 2.20, respectively).	W Descriptive values (mean and SD) not reported No details of recruitment strategies
Werle & Cuny 2012 France (115)	Image of food (burger) with or without a health message BWS, PPT	131; 20 ± 0.8;67.7% LB	Feeling Choice of DC (sundae) v. fruit	Logistic regression analysis BMI, gender and hunger	In the presence of sanitary ‘health’ message, choice of fruit reduced (18% with v. 35% without, B = −0.897; p = 0.03). Negative concepts associated more easily to the burger image when the advertisement was presented without the sanitary message (M = 681 ms; SD = 153) v. with message (M = 769 ms; SD = 201). (ms = Stimulus Onset Asynchrony).	W Possible contamination with previously being exposed to the intervention message No details of recruitment strategies

Ref. Author Year Country	**Message Control Study Design Theory**	**Population: N, Age Mean ± SD years, % Female Setting**	**Outcome: Intention/Intake Food**	**Statistics used Covariates**	**Key results**	**Quality Key limitations**
						Limited reporting for reproducibility
Williams-Piehota et al. 2006 US (109)	Complex/multifaceted (statistics) v. Simple/straightforward (no statistics) × High or low cognitive needs (need for cognition (NFC): think deeply about issues) BWS, PPT	517; 47.6 ± 14.8; 72% RW: Community	Intention and intake: immediate and future FV	Generalised linear regression models	Immediate: Participants receiving complex messages > intake (4.03 ± 1.50) v. simple messages (3.75 ± 1.31), $p < 0.06$ [***d* = 0.20**]. High NFC > intake (3.99 ± 1.43) v. low NFC individuals (3.72 ± 1.37), $p < 0.06$ [***d* = 0.20**]. Participants who received the complex messages reported consuming 0.24 more servings of fruits and vegetables/day v. those who received the simple messages (β = 0.12, $p < 0.05$). Future: high NFC individuals reported higher intakes (4.24 ± 1.55) v. low NFC individuals (3.96 ± 1.48), $p < 0.01$ [***d* = 0.18**]. Participants who received the complex messages > intakes (4.41 ± 1.74) than those who received the simple messages (3.99 ± 1.34), $p < 0.01$ [***d* = 0.27**].	M Generalisability of participants The use of a single-item measure of self-reported fruit and vegetable intake

BWS = between-subject; PPT = pre/post-test; LB = Lab based; RW = real world; Ø = no between-group differences, >=higher, <=lower; v = compared with; DC = Discretionary choices, FV = Fruit and vegetables; Partial η2 (eta-squared): proportion of variance accounted for by some effect; partial *r* = partial correlation coefficient. W = Weak, M = Moderate, S = Strong.

APPENDIX 3 RESEARCH REPORTING CHECKLISTS

Table A3-1: Completed STROBE checklist for Chapter 2.

STROBE Statement—Checklist of items that should be included in reports of cross-sectional studies (189)

	Item no	Recommendation	Reported in thesis section
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	n/a
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	n/a
Introduction			
Background/ rationale	2	Explain the scientific background and rationale for the investigation being reported	1.3, 2.1
Objectives	3	State specific objectives, including any prespecified hypotheses	1.8, 2.1.1
Methods			
Study design	4	Present key elements of study design early in the paper	2.2.1
Setting	5	Describe the setting, locations and relevant dates, including periods of recruitment, exposure, follow-up and data collection	2.2.3, 2.2.4
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	2.2.4
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders and effect modifiers. Give diagnostic criteria, if applicable	2.2.4
Data sources/ measurement	8	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	2.2.4
Bias	9	Describe any efforts to address potential sources of bias	2.2.4, 2.2.5
Study size	10	Explain how the study size was arrived at	n/a
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	2.2.7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	2.2.7
		(*b*) Describe any methods used to examine subgroups and interactions	2.2.7
		(*c*) Explain how missing data were addressed	2.2.5
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	n/a
		(*e*) Describe any sensitivity analyses	n/a
Results			
Participants	13	(a) Report numbers of individuals at each stage of study—e.g. numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up and analysed	2.2.3
		(b) Give reasons for non-participation at each stage	2.2.3
		(c) Consider use of a flow diagram	
Descriptive data	14	(a) Give characteristics of study participants (e.g. demographic, clinical, social) and information on exposures and potential confounders	2.3.1

	Item no	Recommendation	Reported in thesis section
		(b) Indicate number of participants with missing data for each variable of interest	n/a
Outcome data	15	Report numbers of outcome events or summary measures	2.3.1
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (e.g. 95% confidence interval). Make clear which confounders were adjusted for and why they were included	n/a
		(*b*) Report category boundaries when continuous variables were categorised	2.3.2
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful period	n/a
Other analyses	17	Report other analyses done—e.g. analyses of subgroups and interactions, and sensitivity analyses	n/a
Discussion			
Key results	18	Summarise key results with reference to study objectives	2.4.1
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	2.4.6
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies and other relevant evidence	2.4.6
Generalisability	21	Discuss the generalisability (external validity) of the study results	2.4.6
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	n/a

Table A3-2: Completed STROBE checklist for Chapters 3 and 4.

CONSORT checklist of information to include when reporting randomised crossover trials (216)

Section/topic	Item no	Description	Reported in thesis section
Title	1a	Identification as a randomised crossover trial in the title	n/a
Abstract	1b	Specify a crossover design and report all information	n/a
Introduction			
Background	2a	Scientific background and explanation of rationale	1.4.2, 4.1
Objectives	2b	Specific objectives or hypotheses	1.8, 4.1.1
Methods			
Trial design	3a	Rationale for a crossover design. Description of the design features including allocation ratio, especially the number and duration of periods, duration of washout period and consideration of carryover effect	3.2, 3.3.1, 3.3.3
Change from protocol	3b	Important changes to methods after trial commencement (e.g. eligibility criteria), with reasons	n/a
Participants	4a	Eligibility criteria for participants	3.2.2
Settings and location	4b	Settings and locations where the data were collected	3.2.2.2
Interventions	5	The interventions with sufficient details to allow replication, including how and when they were actually administered	3.3.3
Outcomes	6a	Completely defined prespecified primary and secondary outcome measures, including how and when they were assessed	3.3.4.1
Changes to outcomes	6b	Any changes to trial outcomes after the trial commenced, with reasons	
Sample size	7a	How sample size was determined, accounting for within-participant variability	3.2.5.1
Interim analyses and stopping guidelines	7b	When applicable, explanation of any interim analyses and stopping guidelines	
Randomisation			
Sequence generation	8a	Method used to generate the random allocation sequence	3.2, 3.3.3.1, 3.3.3.2
Sequence generation	8b	Type of randomisation; details of any restriction (e.g. blocking and block size)	3.3.3.2
Allocation concealment mechanism	9	Mechanism used to implement the random allocation sequence (e.g. sequentially numbered containers), describing any steps taken to conceal the sequence until interventions were assigned	3.3.3.2
Implementation	10	Who generated the random allocation sequence, who enrolled participants and who assigned participants to the sequence of interventions	3.3.3.2
Blinding	11a	If done, who was blinded after assignment to interventions (e.g. participants, care providers, those assessing outcomes) and how	
Similarity of interventions	11b	If relevant, description of the similarity of interventions	
Statistical methods	12a	Statistical methods used to compare groups for primary and secondary outcomes, which are appropriate for crossover design (i.e. based on within-participant comparison)	3.3.6

Section/topic	Item no	Description	Reported in thesis section
Additional analyses	12b	Methods for additional analyses, such as subgroup analyses and adjusted analyses	3.3.6
Results			
Participant flow (a diagram is strongly recommended)	13a	The numbers of participants who were randomly assigned, received intended treatment and were analysed for the primary outcome, separately for each sequence and period	4.2.1
Losses and exclusions	13b	Number of participants excluded at each stage, with reasons, separately for each sequence and period	4.2.1
Recruitment	14a	Dates defining the periods of recruitment and follow-up	3.2.3
Trial end	14b	Why the trial ended or was stopped	3.2.3
Baseline data	15	A table showing baseline demographic and clinical characteristics by sequence and period	4.2.2
Numbers analysed	16	Number of participants (denominator) included in each analysis and whether the analysis was by original assigned groups	4.2.2
Outcomes and estimation	17a	For each primary and secondary outcome, results including estimated effect size and its precision (e.g. 95% confidence interval) should be based on within-participant comparisons. In addition, results for each intervention in each period are recommended	4.2.3, 4.2.4, 4.2.5
Ancillary analyses	18	Results of any other analyses performed, including subgroup analyses and adjusted analyses, distinguishing prespecified from exploratory	n/a
Harms	19	Describe all important harms or untended effects in a way that accounts for the design	n/a
Discussion			
Limitations	20	Trial limitations, addressing sources of potential bias, imprecision and, if relevant, multiplicity of analyses. Consider potential carryover effects	4.3.5
Generalisability	21	Generalisability (external validity, applicability) of the trial findings	4.3.5
Interpretation	22	Interpretation consistent with results, balancing benefits and harms, and considering other relevant evidence	4.3
Other information			
Registration	23	Registration number and name of trial registry	3.2.1
Protocol	24	Where the full trial protocol can be accessed, if available	3.2.1
Funding	25	Sources of funding and other support (e.g. supply of drugs), role of funders	n/a

Table A3-3: Completed CONSORT checklist for Chapters 3 and 5.

CONSORT 2010 checklist of information to include when reporting a randomised trial (231)

Section/Topic	Item no	Checklist item	Reported in thesis section
Title and abstract			
	1	(*a*) Identification as a randomised trial in the title	n/a
		(*b*) Structured summary of trial design, methods, results and conclusions	n/a
Introduction			
Background and objectives	2	(*a*) Scientific background and explanation of rationale	1.4.3, 1.5, 6.1
		(*b*) Specific objectives or hypotheses	1.8, 6.1.1
Methods			
Trial design	3	(*a*) Description of trial design (e.g. parallel, factorial) including allocation ratio	3.2, 3.4
		(*b*) Important changes to methods after trial commencement (e.g. eligibility criteria), with reasons	n/a
Participants	4	(*a*) Eligibility criteria for participants	3.2.2
		(*b*) Settings and locations where the data were collected	3.2.2
Interventions	5	The interventions for each group with sufficient details to allow replication, including how and when they were actually administered	3.4.3
Outcomes	6	(*a*) Completely defined prespecified primary and secondary outcome measures, including how and when they were assessed	3.4.4
		(*b*) Any changes to trial outcomes after the trial commenced, with reasons	n/a
Sample size	7	(*a*) How sample size was determined	3.2.5
		(*b*) When applicable, explanation of any interim analyses and stopping guidelines	n/a
Randomisation			
Sequence generation	8	(*a*) Method used to generate the random allocation sequence	3.2, 3.4.2
		(*b*) Type of randomisation; details of any restriction (e.g. blocking and block size)	3.3.3
Allocation concealment mechanism	9	Mechanism used to implement the random allocation sequence (e.g. sequentially numbered containers), describing any steps taken to conceal the sequence until interventions were assigned	3.3.3
Implementation	10	Who generated the random allocation sequence, who enrolled participants, and who assigned participants to interventions	3.3.3
Blinding	11	(*a*) If done, who was blinded after assignment to interventions (e.g. participants, care providers, those assessing outcomes) and how	n/a
		(*b*) If relevant, description of the similarity of interventions	3.4.3
Statistical methods	12	(*a*) Statistical methods used to compare groups for primary and secondary outcomes	3.4.8
		(*b*) Methods for additional analyses, such as subgroup analyses and adjusted analyses	3.4.8

Section/Topic	Item no	Checklist item	Reported in thesis section
Results			
Participant flow (a diagram is strongly recommended)	13	(*a*) For each group, the numbers of participants who were randomly assigned, received intended treatment and were analysed for the primary outcome	5.2.1
		(*b*) For each group, losses and exclusions after randomisation, together with reasons	5.2.1
Recruitment	14	(*a*) Dates defining the periods of recruitment and follow-up	3.2.3
		(*b*) Why the trial ended or was stopped	n/a
Baseline data	15	A table showing baseline demographic and clinical characteristics for each group	5.2.2, 5.2.3
Numbers analysed	16	For each group, number of participants (denominator) included in each analysis and whether the analysis was by original assigned groups	5.2.2
Outcomes and estimation	17	(*a*) For each primary and secondary outcome, results for each group, and the estimated effect size and its precision (e.g. 95% confidence interval)	5.2.5
		(*b*) For binary outcomes, presentation of both absolute and relative effect sizes is recommended	n/a
Ancillary analyses	18	Results of any other analyses performed, including subgroup analyses and adjusted analyses, distinguishing prespecified from exploratory	n/a
Harms	19	All important harms or unintended effects in each group	n/a
Discussion			
Limitations	20	Trial limitations, addressing sources of potential bias, imprecision, and, if relevant, multiplicity of analyses	5.3.6
Generalisability	21	Generalisability (external validity, applicability) of the trial findings	5.3.6
Interpretation	22	Interpretation consistent with results, balancing benefits and harms, and considering other relevant evidence	5.3
Other information			
Registration	23	Registration number and name of trial registry	3.2.1
Protocol	24	Where the full trial protocol can be accessed, if available	3.2.1
Funding	25	Sources of funding and other support (e.g. supply of drugs), role of funders	n/a

Table A3-4: Completed Checklist for Reporting Results of Internet E-Surveys (CHERRIES) for Chapter 3 and 5.

CHERRIES checklist of information to include when reporting online surveys (232)

Item category	Checklist item	Explanation	Reported in thesis section
Design	Describe survey design	Describe target population and sample frame. Is the sample a convenience sample? (In 'open' surveys, this is most likely.)	3.2.2
IRB (Institutional Review Board) approval and informed consent process	IRB approval	Mention whether the study has been approved by an IRB.	3.2.1
	Informed consent	Describe the informed consent process. Were the participants told the length of time of the survey, which data were stored, where and for how long, who the investigator was and the purpose of the study?	3.2.3
	Data protection	If any personal information was collected or stored, describe what mechanisms were used to protect unauthorised access.	3.2.5
Development and pre-testing	Development and testing	State how the survey was developed, including whether the usability and technical functionality of the electronic questionnaire had been tested before fielding the questionnaire.	3.2.3
Recruitment process and description of the sample having access to the questionnaire	Open survey versus closed survey	An 'open survey' is a survey open for each visitor of a site, whereas a closed survey is only open to a sample that the investigator knows (password-protected survey).	3.2.3
	Contact mode	Indicate whether or not the initial contact with the potential participants was made on the internet. (Investigators may also send out questionnaires by mail and allow for web-based data entry.)	3.2.3
	Advertising the survey	How/where was the survey announced or advertised? Some examples are offline media (newspapers), or online (mailing lists – If yes, which ones?) or banner ads. (Where were these banner ads posted and what did they look like?) It is important to know the wording of the announcement as it will heavily influence who chooses to participate. Ideally, the survey announcement should be published as an appendix.	3.2.3
Survey administration	Web/Email	State the type of e-survey (e.g. one posted on a website, or one sent out through email). If it is an email survey, were the responses entered manually into a database,	3.2.2

Item category	Checklist item	Explanation	Reported in thesis section
		or was there an automatic method for capturing responses?	
	Context	Describe the website (for mailing list/newsgroup) in which the survey was posted. What is the website about, who is visiting it and what are visitors normally looking for? Discuss to what degree the content of the website could pre-select the sample or influence the results. For example, a survey about vaccination on an anti-immunisation website will have different results from a web survey conducted on a government website.	3.2.2
	Mandatory/voluntary	Was it a mandatory survey to be filled in by every visitor who wanted to enter the website, or was it a voluntary survey?	3.2.3
	Incentives	Were any incentives offered (e.g., monetary, prizes or non-monetary incentives such as an offer to provide the survey results)?	3.2.1
	Time/Date	In what timeframe were the data collected?	3.2.3
	Randomisation of items or questionnaires	To prevent biases, items can be randomised or alternated.	3.2.3
	Adaptive questioning	Use adaptive questioning (certain items, or only conditionally displayed based on responses to other items) to reduce number and complexity of the questions.	n/a
	Number of Items	What was the number of questionnaire items per page? The number of items is an important factor for the completion rate.	3.3.2, 3.4.2
	Number of screens (pages)	Over how many pages was the questionnaire distributed? The number of pages is an important factor for the completion rate.	3.3.2, 3.4.2
	Completeness check	It is technically possible to do consistency or completeness checks before the questionnaire is submitted. Was this done, and if 'yes', how (usually JAVAScript)? An alternative is to check for completeness after the questionnaire has been submitted (and highlight mandatory items). If this has been done, it should be reported. All items should provide a non-response option such as 'not applicable' or 'rather not say', and selection of one response option should be enforced.	3.2.5

Item category	Checklist item	Explanation	Reported in thesis section
	Review step	State whether respondents were able to review and change their answers (e.g., through a Back button or a Review step, which displays a summary of the responses and asks the respondents if they are correct).	3.2.5
Preventing multiple entries from the same individual	Cookies used	Indicate whether cookies were used to assign a unique user identifier to each client computer. If so, mention the page on which the cookie was set and read, and how long the cookie was valid. Were duplicate entries avoided by preventing users access to the survey twice; or were duplicate database entries having the same user ID eliminated before analysis? In the latter case, which entries were kept for analysis (e.g., the first entry or the most recent)?	n/a
	IP check	Indicate whether the IP address of the client computer was used to identify potential duplicate entries from the same user. If so, mention the period for which no two entries from the same IP address were allowed (e.g., 24 hours). Were duplicate entries avoided by preventing users with the same IP address access to the survey twice; or were duplicate database entries having the same IP address within a given period eliminated before analysis? If the latter, which entries were kept for analysis (e.g., the first entry or the most recent)?	3.2.5
	Log file analysis	Indicate whether other techniques to analyse the log file for identification of multiple entries were used. If so, please describe.	n/a
	Registration	In ‘closed’ (non-open) surveys, users need to log in first and it is easier to prevent duplicate entries from the same user. Describe how this was done. For example, was the survey never displayed a second time once the user had filled it in, or was the username stored together with the survey results and later eliminated? If the latter, which entries were kept for analysis (e.g., the first entry or the most recent)?	n/a

Item category	Checklist item	Explanation	Reported in thesis section
Analysis	Handling of incomplete questionnaires	Were only completed questionnaires analysed? Were questionnaires which terminated early (e.g. where users did not go through all questionnaire pages) also analysed?	3.2.5
	Questionnaires submitted with an atypical timestamp	Some investigators may measure the time people needed to fill in a questionnaire and exclude questionnaires that were submitted too soon. Specify the timeframe that was used as a cut-off point, and describe how this point was determined.	n/a
	Statistical correction	Indicate whether any methods such as weighting of items or propensity scores have been used to adjust for the non-representative sample; if so, please describe the methods.	n/a

Table A3-5: Completed STROBE checklist for Chapters 3 and 6.

STROBE Statement—Checklist of items that should be included in reports of cross-sectional studies (189)

	Item no	Recommendation	Reported in thesis section
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	n/a
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	n/a
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	1.5.4.5, 6.1
Objectives	3	State specific objectives, including any prespecified hypotheses	1.8, 6.1.1
Methods			
Study design	4	Present key elements of study design early in the paper	3.2, 3.4.6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up and data collection	3.2.2
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	3.2.2.1
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders and effect modifiers. Give diagnostic criteria, if applicable	3.4.6.3
Data sources/ measurement	8	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	3.4.6.3
Bias	9	Describe any efforts to address potential sources of bias	3.4.9
Study size	10	Explain how the study size was arrived at	3.2.5.1
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	3.4.6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	3.4.9
		(*b*) Describe any methods used to examine subgroups and interactions	3.4.9
		(*c*) Explain how missing data were addressed	3.4.7
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	3.4.9
		(*e*) Describe any sensitivity analyses	3.4.9
Results			
Participants	13	(a) Report numbers of individuals at each stage of study—e.g. numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up and analysed	5.2.1
		(b) Give reasons for non-participation at each stage	5.2.1
		(c) Consider use of a flow diagram	5.2.1
Descriptive data	14	(a) Give characteristics of study participants (e.g. demographic, clinical, social) and information on exposures and potential confounders	5.2.2
		(b) Indicate number of participants with missing data for each variable of interest	n/a

	Item no	Recommendation	Reported in thesis section
Outcome data	15	Report numbers of outcome events or summary measures	6.2.2
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (e.g., 95% confidence interval). Make clear which confounders were adjusted for and why they were included	6.2.3
		(*b*) Report category boundaries when continuous variables were categorised	3.4.6
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful period	n/a
Other analyses	17	Report other analyses done—e.g. analyses of subgroups and interactions, and sensitivity analyses	6.2.5
Discussion			
Key results	18	Summarise key results with reference to study objectives	6.3
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	6.3.6
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies and other relevant evidence	6.3.6
Generalisability	21	Discuss the generalisability (external validity) of the study results	6.3.6
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	n/a

APPENDIX 4 DIET QUALITY SCORES WITHIN N-TILES

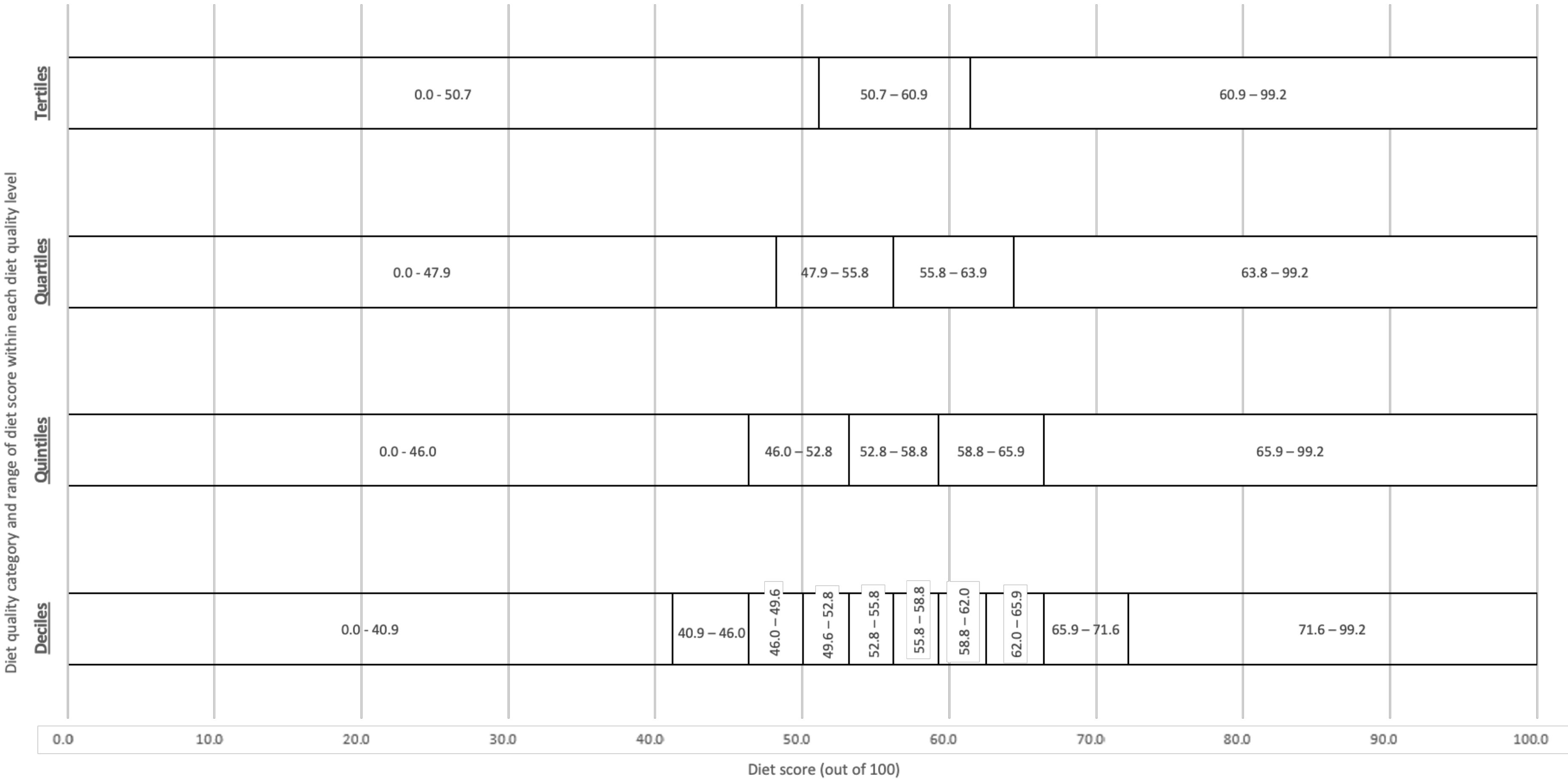


Figure A4-1: Mean diet score ranges for each level of overall diet quality.

Table A4-1: Mean components scores (out of 100) by tertiles of diet quality (N = 216, 045)

Diet quality level	Tertile 1	Tertile 2	Tertile 3
Component scores (/100)	Mean component score		
Discretionary	5.5	14.5	44.2
Dairy	30.7	39.5	46.5
Healthy fats	39.5	51.0	65.3
Vegetables	41.6	59.4	73.8
Fruit	33.8	65.1	84.2
Variety	56.6	67.0	72.1
Grains	60.1	73.5	79.4
Meat	69.4	79.2	84.6
Fluid	87.4	94.2	96.8

Table A4-2: Mean components scores (out of 100) by quartiles of diet quality (N = 216, 045)

Diet quality level	Quartile 1	Quartile 2	Quartile 3	Quartile 4
Component scores (/100)	Mean component score			
Discretionary	4.6	10.5	19.7	47.5
Dairy	29.2	36.9	42.0	50.8
Healthy fats	37.7	47.3	55.0	67.7
Vegetables	38.5	54.2	64.7	75.7
Fruit	29.2	55.2	73.6	86.2
Variety	54.7	64.4	69.2	72.6
Grains	57.5	70.3	76.1	80.1
Meat	67.4	76.9	81.4	85.3
Fluid	85.7	93.2	95.2	97.2

Table A4-3: Mean components scores (out of 100) by quintiles of diet quality (N = 216, 045)

Diet quality level	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5
Component scores (/100)	Mean component score				
Discretionary	4.0	8.7	14.1	24.4	55.7
Dairy	28.1	35.3	39.6	43.3	48.2
Healthy fats	36.4	45.1	50.9	57.9	69.3
Vegetables	36.3	50.9	59.5	67.8	76.9
Fruit	26.2	48.4	65.4	77.8	87.4
Variety	53.2	62.6	67	70.3	72.9
Grains	55.4	68	73.5	77.4	80.6
Meat	65.9	75.2	79.3	82.4	85.7
Fluid	84.3	92.4	94.3	95.7	97.4

Table A4-4: Mean components scores (out of 100) by deciles of diet quality (N = 216, 045)

Diet quality level	1	2	3	4	5	6	7	8	9	10
Component scores (/100)	Mean component score									
Discretionary	2.8	5.2	7.3	10.0	12.4	15.9	20.5	28.3	42.5	50.4
Dairy	24.9	31.2	34.4	36.3	38.5	40.7	42.3	44.4	45.9	68.9
Healthy fats	32.9	40.0	43.5	46.7	49.6	52.3	55.8	60.0	64.6	74.1
Vegetables	30.6	42.0	48.7	53.1	57.2	61.7	65.6	69.9	73.2	80.6
Fruit	18.9	33.5	43.6	53.1	61.8	69.0	75.4	80.1	84.4	90.5
Variety	48.8	57.7	61.3	63.9	66.0	68.0	69.7	71.0	71.9	74.0
Grains	49.4	61.4	66.6	69.5	72.7	74.4	76.9	77.9	78.6	82.6
Meat	61.5	70.4	74.1	76.4	78.3	80.2	81.8	83.1	84.1	87.4
Fluid	79.0	89.5	91.6	93.1	94.0	94.6	95.3	96.0	97.0	97.9

APPENDIX 5 ETHICS APPROVAL LETTERS

SCIENCE IMPACT & POLICY
www.csiro.au

Ecosciences Precinct, Dutton Park QLD 4102
GPO BOX 2583, Brisbane QLD 4001, Australia
T (07) 3833 5615 • ABN 41 687 119 230

Gilly Hendrie
CSIRO Health & Biosecurity
SAHMRI, North Terrace
Adelaide SA 5000

22nd July 2019

Dear Gilly,

Re: CSIRO Health and Medical Human Research Ethics Committee (CHMHREC) – Proposal 2019_051_LR
"Improving My Nutrition Score via an online, tailored, nutrition feedback intervention: A Randomised Controlled with a nested Cross-Over Trial study design"

Thank you for the above submission which was considered by the low risk review panel of the CSIRO Health and Medical Human Research Ethics Committee (CHMHREC), and your subsequent amendments addressing the committee's comments. I am pleased to grant approval for the project to proceed.

Please note that this approval expires 30th June 2021, the completion date nominated by you. The CHMHREC must be informed of any significant alterations to the protocol, changes to the project team or to the completion date. All serious adverse events must also be reported to the CHMHREC coordinator as soon as possible.

At the completion of the project it is a requirement that a Final Report be completed by you and submitted to CHMHREC. Where a project exceeds 12 months duration, a report must be submitted annually on the anniversary of this approval. A copy of the report form can be obtained from the MyCSIRO Human Research Ethics webpage or by contacting the CHMHREC coordinator.

I wish you success with your project and thank you for your application.

Yours sincerely,

For **Assoc Professor Brian Stoffell**
Chair, CSIRO Health and Medical Human Research Ethics Committee

NHMRC Registered Committee Number and Name:
EC00187 CSIRO Health and Medical Human Research Ethics Committee

Dear Joyce,

Your request for ethics approval from the Social and Behavioural Research Ethics Committee (SBREC) at Flinders University based on the ethics approval already granted by the CSIRO Health and Medical Human Research Ethics Committee (CHM HREC) has been received.

As outlined on the Social and Behavioural Research Ethics Committee (SBREC) website ethics approvals conducted by Flinders University staff and students (including those with adjunct status), for social and behavioural research, granted by another Australian NHMRC Human Research Ethics Committee (HREC) will be accepted by the SBREC without further review or scrutiny. This approach is in line with Chapter 5.3 of the *National Statement on Ethical Conduct in Human Research,* which encourages the minimizing of research ethics review duplication. On that basis, the research project listed below has been accepted by the SBREC on the proviso that the following conditions are met:

STRICT Conditions of Clearance	
1.	The research is not clinical in nature (as per the guidelines on the SBREC website)
2.	SA Health Requirements No participants will be recruited from any organisations under the banner of SA Health; **or** be recruited via a third party medical professional association (e.g, doctor or nurses association). Please refer to the SA Health website for specific information about what organisations / hospitals / health services that fall under the banner of SA Health (e.g., Flinders Medical Centre, Noarlunga Hospital, GP Plus Clinics etc – fall under the banner of the Southern Adelaide Local Health Network (SALHN) of SA Health).

ACCEPTANCE OF EXTERNAL APPROVAL

Granted by external NHMRC Certified HREC

SBREC Project Number:	**OH-00224**	SBREC Expiry Date:	**30 June 2021**
Other HREC approval number:	2019_051_LR		
Ethics approval granted by:	CSIRO Health and Medical Human Research Ethics Committee (CHM HREC)		
Project Title:	Improving my Nutrition Score via an online, tailored, nutrition feedback		

	intervention: A Randomised Controleed with a Nested Cross-Over Trial Study Design

Flinders University Researcher:	Ms Joyce Haddad	Please note that the Flinders University researcher has been listed as principal researcher (even if they are not on the application) for the purposes of this SBREC approval.
School / Dept	Student Administration Services	
Email:	joyce.haddad@flinders.edu.au	

Date approval accepted: 5 August 2019

Please note the researcher responsibilities below that need to be adhere to meet the requirements of this Acceptance Notice:

Researcher Responsibilities	
1.	Flinders University Letterhead If the principal researcher is a Flinders University staff or student researcher, it is a requirement that all documentation to be distributed to potential participants is placed on Flinders University letterhead. Please submit a copy of all participant documentation on the Flinders University letterhead if you have not already done so. If a Flinders University researcher is not listed as the principal researcher than documentation does not need to be placed on Flinders University letterhead.
2.	Modifications / Amendments Modification requests approved by the CSIRO Health and Medical Human Research Ethics Committee (CHM HREC) do not also need to be approved by the SBREC; however copies of any modification approvals that involve (a) an extension to the expiry approval expiry date; and/or (b) changes in participant populations to be recruited do need to be submitted to the SBREC to be placed on file and checked to ensure that no participants will be recruited from any organisations / association under the banner of the Southern Adelaide Local Health Network (SALHN).
3.	Final Reports On submission of a final report to the other HREC, please email a copy of the report to the SBREC so it can be saved onto the electronic project file for this project. It does not need to be reviewed and approved by the SBREC; just placed on file and the date of completion noted in the committee database.

For Future Reference

If you need to contact the SBREC in relation to this email in the future please ensure that you quote the project number allocated by the SBREC (OH-00224).

Kind regards

Andrea

APPENDIX 6 BASELINE QUESTIONNAIRE

Shifting My Nutrition Score in 28 days: Day 1

LOGIC Show/hide trigger exists.
Action: Percent Branch
New Percent Branch

ID 454

Hi!

Thank you for taking the time to join CSIRO's new study:

Shifting *My Nutrition Score* in 28 days
#28dayshift

This study is about understanding how we can better motivate and support people to eat healthier.

Some things to consider before we start:

1. **Survey works best** if accessed in a Google Chrome, Firefox, or Safari browser. If you wish to switch browsers at this point, copy and paste this link: https://www.surveygizmo.com/s3/4951354/Shifting-MyNutrition-Score-in-28-days into a new browser.

2. **Don't lose your responses**! Please do not hit your browser's "back" button at any time.

3. **Need to come back to the survey later**? Click on the "Save and continue" button in the top right hand corner of this page and enter your email address. A unique survey link will be emailed to you, giving you access to pick up where you left from.

Alright... let's begin! Please press next.

Page exit logic: Skip / Disqualify Logic
IF: #2 Question "Are you currently living in Australia?" is one of the following answers ("No") **THEN:** Disqualify and display:
Unfortunately, you do not meet the eligibility criteria for the study. If you have any questions regarding your eligibility please contact the study: 28dayshift@csiro.au If you are interested in finding out how healthy your eating habits are, visit this website (copy & paste into your browser): https://my.totalwellbeingdiet.com/healthy-diet-score

Page exit logic: Skip / Disqualify Logic
IF: #3 Question "Are you willing to participate in a brief email study that will run for the next 4 weeks?" is one of the following answers ("No") **THEN:** Disqualify and display:
Unfortunately, you do not meet the eligibility criteria for the study. If you have any questions regarding your eligibility please contact the study: 28dayshift@csiro.au If you are interested in finding out how healthy your eating habits are, visit this website (copy & paste into your browser): https://my.totalwellbeingdiet.com/healthy-diet-score

Page exit logic: Skip / Disqualify Logic
IF: #1 Question "Are you 18 years old or over?" is one of the following answers ("No") **THEN:** Disqualify and display:
Unfortunately, you do not meet the eligibility criteria for the study. If you have any questions regarding your eligibility please contact the study: 28dayshift@csiro.au If you are interested in finding out how healthy your eating habits are, visit this website (copy & paste into your browser): https://my.totalwellbeingdiet.com/healthy-diet-score

ID 215

Please answer the following questions.

DATA Variable name: **criteria_age**
ID 10

Are you 18 years old or over? *

- Yes
- No

DATA Variable name: **criteria_country**

ID 106

Are you currently living in Australia? *

- Yes
- No

DATA Variable name: **criteria_willing**
ID 11

Are you willing to participate in a brief email study that will run for the next 4 weeks? *

- Yes
- No

LOGIC Show/hide trigger exists.
DATA Variable name: **criteria_foodintake**
ID 6

Are you currently eating foods from ***every*** major food group below?
Please read the following carefully:

- *You can still tick "Yes" if you are avoiding meats/dairy ***BUT*** *still eating tofu, beans/legumes, plant-based milks and cheeses, etc.*
- ***You can still tick "Yes" if you are avoiding wheat/gluten* ***BUT*** *still eating alternative grain foods (gluten-free/wheat-free foods)*
- *Please tick "Yes" if you are NOT avoiding any food groups*

Major food groups include:

1. Vegetables and legumes
2. Fruit
3. Wholegrains**
4. Meats, poultry, fish, eggs, tofu, nuts, seeds, legumes/beans, and/or their alternatives*
5. Milk, yoghurt, cheese, and/or their alternatives (ie. plant-based using soy/almond/rice)*

*

- Yes
- No

LOGIC Hidden unless: #4 Question "Are you currently eating foods from ***every*** major food group below?
Please read the following carefully:

- *You can still tick "Yes" if you are avoiding meats/dairy ***BUT*** *still eating tofu, beans/legumes, plant-based milks and cheeses, etc.*
- ***You can still tick "Yes" if you are avoiding wheat/gluten* ***BUT*** *still eating alternative grain foods (gluten-free/wheat-free foods)*
- *Please tick "Yes" if you are NOT avoiding any food groups*

Major food groups include:

1. Vegetables and legumes
2. Fruit
3. Wholegrains**
4. Meats, poultry, fish, eggs, tofu, nuts, seeds, legumes/beans, and/or their alternatives*
5. Milk, yoghurt, cheese, and/or their alternatives (ie. plant-based using soy/almond/rice)*

" is one of the following answers ("No")
DATA Variable name: **criteria_foodintake1**
ID 448

Which food group are you avoiding?
If you are <u>not purposefully</u> avoiding any food groups, please go back to the previous question and check that you ticked 'Yes' *

ID 138

INFORMATION SHEET

Shifting *My Nutrition Score* in 28 days
#28dayshift

INTRODUCTION

CSIRO's Nutrition and Health program conducts research to understand how we can do better to motivate and support people to improve their eating habits. Advances in technology means we are starting to move towards delivering online interventions which can reach more people and be tailored more easily for different people.
For this project, we are testing nutrition messages delivered online, in a short 4-week intervention. The findings will help to guide the development of larger, digital programs which aim to improve the health and wellbeing of Australians.

WHAT IS THE AIM OF THIS STUDY?

The aim of this study is to understand the impact of a brief, online nutrition intervention on adults' eating habits.

HOW WILL THE STUDY BE CARRIED OUT?

This is a brief online study, without face-to-face contact.
You will be randomised into one of two intervention groups – both groups will receive nutrition messages via email from CSIRO staff via the SurveyGizmo platform.
You will be required to complete 2 online surveys, each taking approximately 20 minutes. These surveys will ask a series of questions about your eating habits and factors that may influence what you eat.

As an appreciation of your time, you will be given the opportunity to go in the draw to win one of 30 gift vouchers to the value of $100 at the end of the study.

You are eligible to participate if you meet the following criteria:

- Adults (aged 18 years or over) currently living in Australia with fluency in reading and writing in the English language;
- Willing to participate in a brief online nutrition intervention over 4 weeks (and complete 2 surveys during this time);
- Have access to an internet enabled computer, phone or tablet to receive 3 emails overall;
- Not purposefully avoiding any major food groups (wholegrains, fruit, vegetables, dairy and/or alternatives, meat and/or alternatives) or following a special diet for medical reasons.

WHAT ARE THE BENEFITS OF PARTICIPATING IN THE STUDY?

You may not benefit directly from participation in this study, but you will be providing a valuable contribution to the scientific knowledge in the field. A summary of the study findings will be emailed to you at the completion of the study.

ARE THERE ANY RISKS INVOLVED?

There are no foreseeable risks associated with being involved in this study. All human research undertaken by the CSIRO must comply with the values, principles, governance and review process specified in the NHMRC National Statement on Ethical Conduct in Human Research (2007). A copy of the National Statement can be found at www.nhmrc.gov.au/guidelines/ethics/human_research/index.htm

HOW WILL MY PRIVACY BE PROTECTED?

CSIRO is governed under the Privacy Act 1988 (Cth). CSIRO is collecting your personal information for the purposes of conducting the study and related scientific research. CSIRO will only use and disclose your personal information in accordance with the Privacy Act 1988 and the NHMRC National Statement on Ethical Conduct in Human Research (2007) as amended from time to time, and as otherwise required by law.
In relation to studies conducted by CSIRO, it is customary for all personal information to be identified by a code and stored at CSIRO under lock and key for a period of 7 years. Except where otherwise required by law or a government body, at the end of this period your records will be destroyed or permanently de-identified.
Where third parties are assisting CSIRO in relation to the conduct of this study (such as university staff, students and other health professionals), we may disclose your personal information to those third parties for this purpose on a confidential basis. CSIRO will require such third parties to keep this information confidential and to only use your personal information for the purposes of the study and otherwise in accordance with the Privacy Act 1988. CSIRO may publish study results and data in research publications and press releases,

however, CSIRO will de-identify any personal information contained in the data and results so that you cannot be identified.

WHAT IF I WISH TO WITHDRAW?

You are free to withdraw at any time during the study. However, you will note in the consent form (on the next screen) a request to maintain any data collected prior to your withdrawal from the study. Your data up until your withdrawal are an important part of the data set for analytical purposes. Your personal information will be kept (confidential) with those of continuing participants until the end of the study.
It is also important to understand that we can choose to end your participation, too. That decision would be made if we decided that the study is not in your best interest, if you are unable to follow the protocol of the study, or if the study is discontinued. If we ever have to end your participation, we will make sure you understand the reasons why.

YOUR OBLIGATIONS AS A PARTICIPANT
You will need to inform a study staff member of any changes in your health as some changes could have an effect on your participation in the study and the study findings.

IF YOU HAVE FURTHER QUESTIONS
Please contact:

PhD Candidate:
Joyce Haddad on 08 8305 0668 or via email: *joyce.haddad@csiro.au* ; or

Principal Researchers:
Dr Gilly Hendrie on 08 8305 0662 or via email: *gilly.hendrie@csiro.au*
A/Prof Rebecca Golley on 08 8201 5596 or via email: *rebecca.golley@flinders.edu.au*

This study has been approved by the CSIRO Low Risk Review Panel (*study approval number: 2019_051_LR)*. If you would like to speak with someone with respect to ethical matters or wish to register a formal complaint about the conduct of this research, please contact the Secretary of the Committee via email at chmhrec@csiro.au

---

DATA Variable name: **signature**
ID 143

Signature: *

Clear

Sign name using mouse or touch pad

Signature of

VALIDATION %s format expected
DATA Variable name: **signature_date**
ID 144

Today's date *

�

---

1. I hereby voluntarily consent to take part in the research project entitled: “Shifting My Nutrition Score in 28 days”
   Low Risk Review Panel Number: *2019_051_LR*
2. I acknowledge that I have read and understand the attached Information Sheet entitled: “Shifting My Nutrition Score in 28 days”.
3. I understand that while information gained during this study may be published, I will not be identified and my personal results will not be divulged.
4. I understand that I will be receiving emails from CSIRO staff, through the SurveyGizmo platform for the duration of this study.
5. I understand that I am free to withdraw from the project at any stage.
6. I understand that data collected up to the point of my withdrawal will be included in the analysis of the study, unless I formally request that they be withdrawn.
7. I recognise that my participation in this study will assist with the advancement of science and that I may not benefit personally from the research.
8. I understand that any data obtained from me will be used for the purposes of research related to this study, as specified in the information sheet. I also understand that my data may be stored by CSIRO as stated in the information sheet, before being discarded.
9. I make a donation of these data to the CSIRO for this project and for general research purposes, provided that all research is approved by an ethics committee. I understand that any information gained will not be released in identifiable form, nor will the data be transferred to non-CSIRO personnel or organisations without approval from the ethics committee.

*

☐ By checking this box, I understand the conditions of participating in this study, and I voluntarily consent to taking part in the “Shifting My Nutrition Score in 28 days” research project. I also agree and allow CSIRO to collect, store and reuse the information I am providing as part of the “Shifting My Nutrition Score in 28 days” research project. I declare the information I am providing as part of this form is correct to the best of my knowledge. I understand that all information collected from me during this study will be strictly confidential and handled as per CSIRO privacy policy. For more information about CSIRO’s privacy policy, I can visit the website: https://www.csiro.au/en/About/Access-to-information/Privacy anytime.

First, we would like to tell you about the term: 'discretionary choices'.

'Discretionary choices' is a term used in the Australian Dietary Guidelines to describe certain foods and drinks, including:

- take away foods like burgers and pizza
- hot chips
- pies, sausage rolls
- all types of chocolate
- cakes, biscuits
- processed meats
- crisps, savoury crackers
- lollies
- sugary drinks like soft drinks & energy drinks
- alcohol
- or any foods in the image shown

Now, thinking about how much you intend to change your eating habits each day, in the next month:

VALIDATION Min = 1 Max = 100
DATA Shortname / Alias: **IntentionQ1** Variable name: **INT_1**
ID 2

I expect to eat less discretionary choices at meal and snack times *

Strongly disagree ——— Strongly agree

VALIDATION Min = 1 Max = 100

DATA Shortname / Alias: **IntentionQ2** Variable name: **INT_2**
ID 3

I want to eat less discretionary choices at meal and snack times *

Strongly disagree ——— Strongly agree

VALIDATION Min = 1 Max = 100
DATA Shortname / Alias: **IntentionQ3** Variable name: **INT_3**
ID 4

I intend to eat less discretionary choices at meal and snack times *

Strongly disagree ——— Strongly agree

DATA Shortname / Alias: **COMB_Q** Variable name: **C_Ps1 ,C_Ps2 ,C_Ph1 ,C_Ph2 ,C_Ps3 ,C_Ps4 ,C_Ph3 ,C_Ps5 ,O_Ph1 ,O_Ph2 ,O_Ph3 ,O_Ph4 ,O_Ph5 ,O_So1 ,O_So2 ,O_Ph6 ,M_R1 ,M_R2 ,M_R3 ,M_R4 ,M_Au1 ,M_Au2 ,M_Au3 ,M_Au4**
ID 97

What will help you change your eating habits so you eat less discretionary choices, at meal and snack times, every day?
Select all the statements that apply (select as many or as little as you find apply to you)

I would need to: *

- ☐ Care more about the health consequences associated with it
- ☐ Overcome physical limitations like injuries or disabilities
- ☐ Feel that I want to do it enough
- ☐ Know more about why it is important
- ☐ Develop a habit of planning to eat less discretionary choices
- ☐ Feel that it would be a good thing to do

- ☐ Develop a habit of not buying discretionary choices
- ☐ Have better cooking skills
- ☐ Know what to do
- ☐ Have more money
- ☐ Develop a habit for eating healthier food
- ☐ Have more time to cook or prepare
- ☐ Have less access to discretionary choices
- ☐ Feel that I need to do it enough
- ☐ Have better access to kitchen and/or cooking facilities
- ☐ Overcome mental limitations like stress associated with time constraints or pressure
- ☐ Have more reminders to plan, shop, cook and stick at it
- ☐ Have more people around me eating healthier
- ☐ Know how to enjoy the taste of other, healthier food
- ☐ Have greater willpower
- ☐ Have more triggers to prompt me
- ☐ Have better food planning skills
- ☐ Have more time to meal plan
- ☐ Develop a habit of preparing healthier food

Is there something else holding you back from eating healthier? Tell us in the box below

---

ID 371

Over the next few pages, we'll ask questions about **what you eat and drink** and **how often**.

There are no right or wrong answers so just respond as best as you can!

ID 364

First up, fruit! The following questions help us understand if you eat fruit, how much you eat and how often.

EXAMPLE: HOW TO ANSWER

For example, when we ask "**How often do you usually eat fruit?"** you can answer:

- each day
- each week
- each month
- I don't eat fruit

If you don't eat fruit each day but usually have some fruit in a week, **choose "each week".**
Then, we'll ask **how many serves of fruit you usually have in the selected time frame**. If you usually have 1 apple, 2 bananas and 1 orange during the week, that would be 4 serves. So, slide the bar (shown below) until it says "4".

LOGIC Show/hide trigger exists.
DATA Variable name: **Often_fruit_first**
ID 365

How often do you usually eat fruit? *

Include fresh fruit, dried fruit and canned fruit. **DO NOT include fruit juice.**

- each day
- each week
- each month
- I don't eat fruit

VALIDATION Min = 0.5 Max = 14

LOGIC Hidden unless: #14 Question "How often do you usually eat fruit?" is one of the following answers ("each day","each week","each month")

DATA Variable name: **var126**

ID 366

In total, how many serves of fruit do you usually eat in the timeframe selected above? *

1 serve of fruit =

- 1 medium piece (e.g. apple, banana, orange, pear)
- 2 small pieces (e.g. apricots, plums, kiwi fruit)
- 1 cup diced pieces (e.g. grapes) or canned fruit
- 30g of dried fruit (e.g. 4 apricot halves, 1½ tbsp sultanas)

DO NOT include fruit juice.

Your answer can be in whole or half serves (e.g. 1, 1.5, 2, etc)

0.5 serves | 14 serves or more

Serves of fruit

How often do you usually drink 100% fruit juice? *

- each day
- each week
- each month
- don't drink 100% fruit juice

VALIDATION Min = 0.5 Max = 14

LOGIC Hidden unless: #16 Question "How often do you usually drink 100% fruit juice?" is one of the following answers ("each day","each week","each month")

DATA Variable name: **var130**

ID 368

In total, how many serves of 100% fruit juice do you usually drink in the timeframe selected above? *

1 serve of fruit juice = ½ cup 100% fruit juice or 100% fruit juice concentrate.

Your answer can be in whole or half serves (e.g. 1, 1.5, 2, etc)

0 serves | 14 serves or more

Serves of fruit juice

DATA Variable name: **var13**
ID 357

How often do you usually eat salad vegetables? *
Salad vegetables include lettuce, cucumber, tomato etc.

- each day
- each week
- each month
- don't eat salad vegetables

VALIDATION Min = 0.5 Max = 14
LOGIC Hidden unless: #20 Question "How often do you usually eat salad vegetables?" is one of the following answers ("each day","each week","each month")
DATA Variable name: **var15**
ID 358

In total, how many serves of salad vegetables do you usually eat in the timeframe selected above? *
1 serve of salad vegetables =

- 1 cup green leafy or raw salad vegetables
- 1 medium tomato

Your answer can be in whole or half serves (e.g. 1, 1.5, 2, etc)

0.5 serves — 14 serves or more
Serves of salad vegetables

LOGIC Show/hide trigger exists.
DATA Variable name: **var10**
ID 354

How often do you usually eat starchy vegetables? *
Starchy vegetables include potatoes, corn, sweet potato, taro, cassava and legumes (e.g. baked beans, chickpeas and lentils). **DO NOT include hot chips.**

- each day
- each week
- each month
- I don't eat starchy vegetables

VALIDATION Min = 0.5 Max = 14
LOGIC Hidden unless: #18 Question "How often do you usually eat starchy vegetables?" is one of the following answers ("each day","each week","each month")
DATA Variable name: **var12**
ID 355

In total, how many serves of starchy vegetables (NOT including hot chips) do you usually eat in the timeframe selected above? *
1 serve of starchy vegetables =

- ½ medium potato/sweet potato/cassava/taro
- ½ cup mashed potato (hot chips NOT included)
- ½ cup baked beans, cooked dried or canned beans, peas or lentils
- ½ cup or ½ cob of sweet corn

Your answer can be in whole or half serves (e.g. 1, 1.5, 2, etc)

0.5 serves — 14 serves or more
Serves of starchy vegetables

LOGIC Show/hide trigger exists.

How often do you usually eat cooked vegetables? *

Include baked, roasted, steamed, fried, grilled and boiled green or orange vegetables (e.g. broccoli, spinach, carrots, pumpkin). **DO NOT include starchy vegetables.**

- each day
- each week
- each month
- don't eat cooked vegetables

VALIDATION Min = 0.5 Max = 14

LOGIC Hidden unless: #22 Question "How often do you usually eat cooked vegetables?" is one of the following answers ("each day","each week","each month")

DATA Variable name: **var21**

ID 360

In total, how many serves of cooked vegetables do you usually eat in the timeframe selected above? *

1 serve of cooked vegetables =

- ½ cup cooked fresh or frozen green or orange vegetables
- ½ cup tinned vegetables
- 1 cup vegetable soup (e.g. vegetable or pumpkin soup)

Your answer can be in whole or half serves (e.g. 1, 1.5, 2, etc)

0.5 serves | 14 serves or more

Serves of cooked vegetables

How often do you usually drink vegetable juice?

Include fresh juice, canned or bottled vegetable juice.

- each day
- each week
- each month
- don't drink vegetable juice

VALIDATION Min = 0.5 Max = 14

LOGIC Hidden unless: #24 Question "How often do you usually drink vegetable juice?" is one of the following answers ("each day","each week","each month")

DATA Variable name: **var362**

ID 362

In total, how many serves of vegetable juice do you usually drink in the timeframe selected above? *

1 serve = ½ cup of vegetable juice

Your answer can be in whole or half serves (e.g. 1, 1.5, 2, etc)

0.5 serves | 14 serves or more

Serves of vegetable juice

How often would your evening or main meal include three or more different vegetables?
Include cooked, raw and salad vegetables. *

- always (all the time)
- usually (two thirds of the time)
- sometimes (half the time)
- never
- I don't eat vegetables with my main meal

Page description:
These next questions help us understand how much of your diet comes from the breads and cereals food group which includes pasta, rice, noodles and grains. You can report on your consumption of gluten-free or wheat-free varieties in this section.

LOGIC Show/hide trigger exists.
DATA Variable name: **var23**
ID 346

How often do you usually eat bread? *
Include any type of bread, bread rolls, flat bread, tortillas, crumpets, bagels or english muffins.

- each day
- each week
- each month
- don't eat bread

DATA Variable name: **var25**
ID 347

In total, how many serves of bread do you usually eat in the timeframe selected above? *
1 serve of bread =

- 1 slice of bread
- ½ medium roll or flat bread
- 1 crumpet
- 1 english muffin

Your answer can be in whole or half serves (e.g. 1, 1.5, 2, etc)

0.5 serves | 14 serves or more
Serves of bread

LOGIC Show/hide trigger exists.
DATA Variable name: **var27**
ID 348

How often do you usually eat pasta, rice, noodles or other cooked cereals or grains? *
Include rice, pasta, noodles, couscous, taco shells, polenta, barley, buckwheat, semolina, quinoa or other grains.

- each day
- each week
- each month
- don't eat any of the foods listed above

In total, how many serves of cooked cereals or grains do you usually eat in the timeframe selected above? *

1 serve of cooked cereals or grains =

- ½ cup of cooked rice, pasta or noodles
- ½ cup of cooked couscous, barley, polenta, buckwheat, semolina, quinoa or other grains

Your answer can be in whole or half serves (e.g. 1, 1.5, 2, etc)

0.5 serves — 14 serves or more

Serves of cooked cereals or grains

LOGIC Show/hide trigger exists.

DATA Variable name: **var30**

ID 351

How often do you usually eat breakfast cereal? *

Include breakfast cereal flakes, oats, muesli or porridge.

- each day
- each week
- each month
- don't eat breakfast cereals

In total, how many serves of breakfast cereal do you usually eat in the timeframe selected above? *

1 serve of breakfast cereals =

- ½ cup (120g) porridge
- ⅔ cup (30g) cereal flakes
- ¼ cup (30g) muesli

Your answer can be in whole or half serves (e.g. 1, 1.5, 2, etc)

0.5 serves — 14 serves or more

Serves of breakfast cereal

LOGIC Hidden unless: #27 Question "How often do you usually eat bread?" is one of the following answers ("each day","each week","each month")

DATA Variable name: **var34**

ID 353

How often is the bread you eat wholegrain/wholemeal? *

Include high fibre white bread, wholegrain made from white flour with added seeds/grains, wholemeal bread, wholemeal/wholegrain made from wholemeal flour with added seeds/grains.

- always (all the time)
- usually (two thirds of the time)
- sometimes (half the time)
- never
- I don't eat bread

LOGIC Show/hide trigger exists.
DATA Variable name: **var37**
ID 334

How often do you usually eat red meats? *

Red meats include beef, lamb, veal, offal (e.g. liver, kidney), or game meats such as kangaroo. Include all steaks, chops, roasts, mince, stir-fries and casseroles. **DO NOT include chicken, fish or processed meats such as sausages.**

- each day
- each week
- each month
- don't eat red meat

VALIDATION Min = 0.5 Max = 14
LOGIC Hidden unless: #34 Question "How often do you usually eat red meats?" is one of the following answers ("each day","each week","each month")
DATA Variable name: **var39**
ID 335

In total, how many serves of red meat do you usally eat in the timeframe selected above? *

1 serve of red meat =

- 65g cooked lean meat such as beef, lamb, veal, pork, goat or kangaroo
- include all steaks, chops, roasts, mince, stir-fries and casseroles
- 65g cooked meat = 100g raw meat

DO NOT include chicken, fish or processed meats such as sausages.
Your answer can be in whole or half serves (e.g. 1, 1.5, 2, etc)

0.5 serves — 14 serves or more
Serves of red meat

DATA Variable name: **var40**
ID 336

How often do you usually eat poultry? *

Poultry includes chicken or turkey. Include all steaks, chops, roasts, mince, stir-fries and casseroles. **DO NOT include processed meats such as nuggets or sausages.**

- each day
- each week
- each month
- don't eat poultry

VALIDATION Min = 0.5 Max = 14
LOGIC Hidden unless: #36 Question "How often do you usually eat poultry?" is one of the following answers ("each day","each week","each month")
DATA Variable name: **var42**
ID 337

In total, how many serves of poultry do you usually eat in the timeframe selected above? *

1 serve of poultry =

- 80g cooked chicken or turkey
- include all steaks, chops, roasts, mince, stir-fries and casseroles
- 80g cooked meat = about 100g raw meat

DO NOT include processed meats such as chicken nuggets or sausages.
Your answer can be in whole or half serves (e.g. 1, 1.5, 2, etc)

0.5 serves — 14 serves
Serves of poultry

ID 338

How often do you usually eat fish? *

Include fresh fish fillets and canned fish.

- each day
- each week
- each month
- don't eat fish

VALIDATION Min = 0.5 Max = 14

LOGIC Hidden unless: #38 Question "How often do you usually eat fish?" is one of the following answers ("each day","each week","each month")

DATA Variable name: **var45**

ID 339

In total, how many serves of fresh or canned fish do you usually eat in the timeframe selected above? *

1 serve of fish =

- 100g cooked fish fillet (100g cooked fish = about 115g raw meat)
- 1 small can of fish

DO NOT include processed fish such as fish fingers.

Your answer can be in whole or half serves (e.g. 1, 1.5, 2, etc)

0.5 serves | 14 serves or more

Serves of fish

How often do you usually eat meat products? *

Include sausages, frankfurters, devon, fritz, ham, salami, hot dogs, hamburgers and chicken nuggets.

- each day
- each week
- each month
- don't eat meat products

VALIDATION Min = 0.5 Max = 14

LOGIC Hidden unless: #40 Question "How often do you usually eat meat products?" is one of the following answers ("each day","each week","each month")

DATA Variable name: **var48**

ID 341

In total, how many serves of processed meat products do you usually eat in the timeframe selected above? *

1 serve =

- 2 slices (55g) processed meat such as ham, salami, devon or fritz
- 2 thin or 1½ thick (60g) sausages, frankfurters or hot dogs
- 1 hamburger pattie
- 3 (60g) chicken nuggets

Your answer can be in whole or half serves (e.g. 1, 1.5, 2, etc)

0.5 serves | 14 serves or more

Serves of processed meat

How often do you usually eat legumes, nuts or other meat alternatives? *
Include baked beans, three bean mix, lentils, split peas, dried beans or other meat alternatives such as tofu.

- each day
- each week
- each month
- don't eat legumes, nuts or meat alternatives

VALIDATION Min = 0.5 Max = 14
LOGIC Hidden unless: #42 Question "How often do you usually eat legumes, nuts or other meat alternatives?" is one of the following answers ("each day","each week","each month")
DATA Variable name: **var51**
ID 343

In total, how many serves of legumes, tofu, nuts, seeds or other meat alternatives do you usually eat in the timeframe selected above? *
1 serve =

- 1 cup (150g) cooked or canned beans/legumes such as chickpeas and lentils
- 170g tofu
- 30g nuts, seeds or peanut butter

Your answer can be in whole or half serves (e.g. 1, 1.5, 2, etc)

0.5 serves | 14 serves or more
Serves of legumes, tofu, nuts, seeds

How often do you eat eggs? *
Include boiled, poached and fried eggs as well as omelettes, quiche or egg based frittata.

- each day
- each week
- each month
- don't eat eggs

VALIDATION Min = 0.5 Max = 14
LOGIC Hidden unless: #44 Question "How often do you eat eggs?" is one of the following answers ("each day","each week","each month")
DATA Variable name: **var54**
ID 345

In total, how many serves of eggs do you usually eat in the timeframe selected above? *
1 serve =

- 2 large eggs
- 120g quiche or egg based frittata

Your answer can be in whole or half serves (e.g. 1, 1.5, 2, etc)

0.5 serves | 14 serves or more
Serves of eggs

Page description:
Now let's move on to dairy. These questions help us understand if you consume dairy foods or dairy alternatives, and how often you enjoy them. You can report on your consumption of dairy alternatives such as plant-based milk, plant-based yoghurt and/or plant-based cheese in this section.

How often do you usually drink milk? *
Include cow's milk, soy milk, rice milk, milk on cereal and flavoured milk.

- each day
- each week
- each month
- don't have any milk

VALIDATION Min = 0.5 Max = 14
LOGIC Hidden unless: #46 Question "How often do you usually drink milk?" is one of the following answers ("each day","each week","each month")
DATA Variable name: **var59**
ID 328

In total, how many serves of milk do you usually have in the timeframe selected above? *
1 serve = 250ml of milk or a household tea cup.
Your answer can be in whole or half serves (e.g. 1, 1.5, 2, etc)

0.5 serves — 14 serves or more
Serves of milk

What type of milk do you usually have? *

- whole (4%)
- reduced fat (1-2%)
- skim (less than 1%)
- regular soy
- reduced fat soy
- other
- don't have any milk

LOGIC Show/hide trigger exists.
DATA Variable name: **var62**
ID 330

How often do you usually eat cheese? *
Include processed (such as Kraft Singles, Bega slices) and hard cheese (such as cheddar or parmesan) and ricotta cheese.

- each day
- each week
- each month
- don't eat cheese

In total, how many serves of cheese do you usually eat in the timeframe selected above? *
1 serve =

- 2 slices or 40g cheese
- ½ cup (120g) ricotta cheese

Your answer can be in whole or half serves (e.g. 1, 1.5, 2, etc)

0.5 serves — 14 serves or more
Serves of cheese

LOGIC Show/hide trigger exists.
DATA Variable name: **var65**
ID 332

How often do you usually eat yoghurt? *
Include yoghurt in a tub, bowl or package, bought or home-made.

- each day
- each week
- each month
- don't eat yoghurt

In total, how many serves of yoghurt do you usually eat in the timeframe selected above? *
1 serve = 3/4 cup or 200g (small tub) yoghurt
Your answer can be in whole or half serves (e.g. 1, 1.5, 2, etc)

0.5 serves | Serves of yoghurt | 14 serves or more

Page description:
The questions get quicker from here! These next ones help us understand the different types of beverages you drink, and how often.

LOGIC Show/hide trigger exists.
DATA Variable name: **var69**
ID 323

How often do you usually have soft drink, cordial or sports drinks? *
Include all drinks with **added sugar** such as soft drinks, cordials, fruit drinks, vitamin waters, energy and sports drinks.

- each day
- each week
- each month
- don't drink sweetened soft drink, cordial or sports drinks

In total, how much soft drink, cordial or sports drinks do you usually drink in the timeframe selected above? *
1 serve =
- 1 can (375ml) of soft drink
- 1 bottle of sports drink
- 375ml of cordial or fruit drink

Your answer can be in whole or half serves (e.g. 1, 1.5, 2, etc)

0.5 serves | Serves of soft drink, cordial or sports drink | 14 serves or more

LOGIC Show/hide trigger exists.
DATA Variable name: **var72**
ID 325

How often do you usually drink water? *
Include tap, bottled or rain water and **water in tea/coffee**.

- each day
- each week
- each month
- don't drink water

In total, how many cups of water do you usually drink in the timeframe selected above? *
1 cup = 250ml, a household tea cup
Your answer can be in whole or half cups (e.g. 1, 1.5, 2, etc)

0.5 cups — Cups of water — 14 cups or more

Page description:
These next questions explore the different types of fats and oils in your diet, and how often you enjoy them.

DATA Variable name: **var77**
ID 321

What type of spread do you usually have? *
For example on bread, biscuits or crackers.

- butter
- table margarine (e.g. Country Gold Dairy Blend, Devondale spread)
- unsaturated margarine (e.g. Flora, MeadowLea, Olive Grove, Bertolli, Gold N Canola, Logical)
- don't have spread
- other

How often do you have meat that was trimmed before cooking? *
For example, removing the chicken skin or all visible fat removed from beef, lamb and pork before cooking.

- always (all of the time)
- usually (two thirds of the time)
- sometimes (half the time)
- rarely/never
- don't eat meat

Page description:
Now we would like to understand how often you eat take away foods, and foods such as pies, chips, cakes and lollies.

LOGIC Show/hide trigger exists.
DATA Variable name: **var81**
ID 305

How often do you usually have meals or snacks from take away food stores? *
This includes places like McDonalds, Hungry Jacks, Pizza Hut, KFC, Red Rooster, Fish/Chicken Shop or local take away food places and foods such as burgers, pizza, hot dogs, battered chicken or fish and chips.

- each day
- each week
- each month
- never

ID 306

In total, how many times do you usually have meals or snacks from these take away food stores in the timeframe selected above? *
This includes places like McDonalds, Hungry Jacks, Pizza Hut, KFC, Red Rooster, Fish/Chicken Shop or local take away food places and foods such as burgers, pizza, hot dogs, battered chicken or fish and chips.

0.5 times — 14 times or more
Meals/snacks from fast foods places

LOGIC Show/hide trigger exists.
DATA Variable name: **var83**
ID 307

How often do you usually eat oven baked potato gems/chips/hashbrowns, hot chips/French fries, wedges or fried potatoes? *

- each day
- each week
- each month
- don't eat any of the foods listed above

In total, how many serves of potato gems/chips/hashbrowns, hot chips/French fries, wedges or fried potatoes do you usually eat in the timeframe selected above? *
1 serve =

- 12 fried hot chips
- 60g potato gems/hashbrowns, or wedges

Your answer can be in whole or half serves (e.g. 1, 1.5, 2, etc)

0.5 serves — 14 serves or more
Serves of fried potato products

LOGIC Show/hide trigger exists.
DATA Variable name: **var86**
ID 309

How often do you usually eat savoury snacks such as crisps, pretzels or plain/flavoured crackers? *

- each day
- each week
- each month
- don't eat any of the foods listed above

In total, how many serves of savoury snacks such as crisps, pretzels or plain/flavoured crackers do you usually eat in the timeframe selected above? *

1 serve =

- ½ snack size packet of crisps
- 30g of salty crackers or pretzels

Your answer can be in whole or half serves (e.g. 1, 1.5, 2, etc)

0.5 serves — 14 serves or more

Serves of savoury snacks

LOGIC Show/hide trigger exists.

DATA Variable name: **var89**

ID 311

How often do you usually have sweet biscuits/cakes/buns/muffins/doughnuts? *

Include both home-made and bought.

- each day
- each week
- each month
- don't eat any of the foods listed above

In total, how many serves of sweet biscuits/cakes/buns/muffins/doughnuts do you usually eat in the timeframe selected above? *

1 serve =

- 2-3 (35g) sweet biscuits
- 1 doughnut
- 1 slice (40g) of plain cake or sweet bun
- 1 small muffin

Your answer can be in whole or half serves (e.g. 1, 1.5, 2, etc)

0.5 serves — 14 serves or more

Serves of sweet biscuits/cakes

LOGIC Show/hide trigger exists.

DATA Variable name: **var93**

ID 313

How often do you usually eat savoury pastries? *

This includes pies, pasties, sausage rolls, Kransky Dogs and frankfurters wrapped in pastry.

- each day
- each week
- each month
- don't eat savoury pastries

In total, how many serves of pies or savoury pastries do you usually eat in the timeframe selected above? *

1 serve =

- 1/4 (60g) commerical meat pies or pastie
- 1 party size pie or sausage roll

Your answer can be in whole or half serves (e.g. 1, 1.5, 2, etc)

0.5 serves — Serves of savoury pastries — 14 serves or more

LOGIC Show/hide trigger exists.

DATA Variable name: **var96**

ID 315

How often do you usually eat snack type bars? *

This includes muesli bars, fruit bars and breakfast cereal bars.

- each day
- each week
- each month
- don't eat snack type bars

In total, how many snack type bars do you usually eat in the timeframe selected above? *

This includes muesli bars, fruit bars and breakfast cereal bars.

Your answer can be in whole or half serves (e.g. 1, 1.5, 2, etc)

0.5 snack type bars — Number of snack type bars — 14 snack type bars or more

LOGIC Show/hide trigger exists.

DATA Variable name: **var98**

ID 317

How often do you usually have chocolate or lollies? *

Include all types of chocolate and both hard and soft lollies.

- each day
- each week
- each month
- don't eat chocolate or lollies

In total, how many serves of chocolate or lollies do you usually eat in the timeframe selected above? *

1 serve =

- ½ chocolate bar
- 4 pieces of chocolate (25g)
- 5-6 (40g) lollies

Your answer can be in whole or half serves (e.g. 1, 1.5, 2, etc)

0.5 serves | 14 serves or more

Serves of chocolate or lollies

LOGIC Show/hide trigger exists.

DATA Variable name: **var101**

ID 319

How often do you usually have ice-cream or ice-blocks? *

This includes ice-blocks, ice-cream in a bowl or ice-creams on a stick.

- each day
- each week
- each month
- don't eat ice-cream or ice-blocks

In total, how many serves of ice-cream or ice-blocks do you usually eat in the timeframe selected above? *

1 serve =

- 2 scoops (60g) ice-cream
- 1 stick ice-cream or ice-block

Your answer can be in whole or half serves (e.g. 1, 1.5, 2, etc)

0.5 serves | 14 serves or more

Serves of ice-cream or ice-blocks

Page description:
Next up... a quick question about alcohol. Stick with it, you're not far from going onto the next phase of the study!

LOGIC Show/hide trigger exists.

DATA Variable name: **var104**

ID 379

How often do you usually drink alcohol? *

Include beer, wine, spirits and ciders.

- each day
- each week
- each month
- don't drink alcohol

In total, how many alcoholic drinks do you usually have in the timeframe selected above? *

1 serve =

- 200ml of wine,
- a stubbie or can of beer (400ml)
- 60ml spirits

Your answer can be in whole or half serves (e.g. 1, 1.5, 2, etc)

0.5 serves — 14 serves or more

Serves of alcohol

Page description:
These questions give us a sense of how much variety you get in your diet.

DATA Variable name: **var106**
ID 372

How many different types of fruit have you eaten in the past 48 hours (2 days)? *
e.g. one banana + one apple = 2 types

- nil
- 1
- 2
- 3
- 4
- 5+

How many different types of vegetables have you eaten in the past 48 hours (2 days)? *
e.g. lettuce in a sandwich + peas, carrots and corn at dinner = 4 different types of vegetables

- nil
- 1
- 2
- 3
- 4
- 5+

DATA Variable name: **var108**
ID 374

How many different red or orange vegetables have you eaten in the past 48 hours (2 days)? *
Red or orange vegetables include tomatoes, carrots, pumpkin, red capsicum and sweet potato.

- nil
- 1
- 2
- 3
- 4
- 5+

How many different green vegetables have you eaten in the past 48 hours (2 days)? *
Green vegetables include, beans, broccoli, asparagus, bok choy, spinach and lettuce.

- ○ nil
- ○ 1
- ○ 2
- ○ 3
- ○ 4
- ○ 5+

DATA Variable name: **var110**
ID 376

How many different types of dairy foods have you eaten in the past 48 hours (2 days)? *
Include only milk, cheese and yoghurt. DO NOT include ice-cream.

- ○ nil
- ○ 1
- ○ 2
- ○ 3
- ○ 4
- ○ 5+

Which of the following foods have you eaten over the past 7 days: *
Choose as many answers as applicable.

- ☐ baked beans
- ☐ beef
- ☐ chicken
- ☐ eggs
- ☐ fish
- ☐ lamb
- ☐ lentils
- ☐ nuts
- ☐ pork
- ☐ processed meat (e.g. bacon, devon, fritz, ham, salami)
- ☐ tofu
- ☐ turkey
- ☐ veal
- ☐ none of the above

Which of the foods have you eaten over the past 24 hours: *

Choose as many answers as applicable.

- ☐ bread (brown, flat bread, mixed grain, pita bread, rolls, rye, white, wholegrain)
- ☐ breakfast cereal other than muesli/porridge
- ☐ oats/muesli/porridge
- ☐ pasta, noodles or couscous
- ☐ pearl barley or other grains
- ☐ polenta, taco shells, tortilla
- ☐ rice (brown or white)
- ☐ quinoa
- ☐ none of the above

ID 137

You will now be shown some fun brain-teasers and a series of messages about discretionary choices.

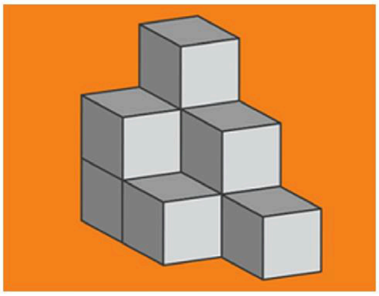
After each message, you will be asked a series of questions.

Press next to continue.

Have a look at the picture below. How many blocks can you point out? Can you get all 9 blocks?

Spend at least 30 seconds on this brain teaser *(the countdown timer is shown at the bottom of the page)*. When the 30 seconds are up, you can press next to continue.

Don't worry too much about getting the answer or not, the important thing is you have a go!



Action: Page Timer
Brain teaser #1 Timer

LOGIC Hidden unless: XO_Group_Number is less than or equal to "6"

ID 151

Please read the following message carefully.

If you start eating less discretionary choices, you'll improve your chances of:

- ⊘ **Better heart health**
- ⊘ **Better mental health**
- ⊘ **Lower blood sugar levels**
- ⊘ **Lower cholesterol levels**
- ⊘ **Lower blood pressure**

In turn, you'll be much more likely to live a longer, healthier life! 😮

Is your health worth a shot?

After reading this message, think about how much you intend to change your eating habits each day, in the next month:

LOGIC Hidden unless: (XO_Group_Number is greater than or equal to "7" AND XO_Group_Number is less than or equal to "12")
ID 148

Please read the following message carefully.

If you keep eating too many discretionary choices, you'll increase your risk of:

- ✖ **Poor heart health**
- ✖ **Poor mental health**
- ✖ **Higher blood sugar**
- ✖ **Higher cholesterol levels**
- ✖ **Higher blood pressure**

In turn, you'll be much more likely to develop heart disease, stroke and even some types of cancer! 😮

Is your health worth the risk?

After reading this message, think about how much you intend to change your eating habits each day, in the next month:

LOGIC Hidden unless: (XO_Group_Number is greater than or equal to "13" AND XO_Group_Number is less than or equal to "18")
ID 149

Please read the following message carefully.

We know eating too many discretionary choices every day is not recommended. 👎✖

Yet, recent data shows that 97% of Australian adults eat discretionary choices every day!! 😮

Do you want to be a part of this statistic?

After reading this message, think about how much you intend to change your eating habits each day, in the next month:

LOGIC Hidden unless: XO_Group_Number is greater than or equal to "19"
ID 150

Please read the following message carefully.

We know eating too many discretionary choices every day is not recommended.👎✖

Yet, recent data shows that only 3% of Australian adults limit their intake of discretionary choices every day!!😨

Do you want to be a part of this statistic?

After reading this message, think about how much you intend to change your eating habits each day, in the next month:

VALIDATION Min = 1 Max = 100
DATA Shortname / Alias: **IntentionQ1_1** Variable name: **INT_1_1**
ID 152

I expect to eat less discretionary choices at meal and snack times *

Strongly disagree Strongly agree

VALIDATION Min = 1 Max = 100
DATA Shortname / Alias: **IntentionQ2_1** Variable name: **INT_2_1**
ID 153

I want to eat less discretionary choices at meal and snack times *

Strongly disagree Strongly agree

VALIDATION Min = 1 Max = 100
DATA Shortname / Alias: **IntentionQ3_1** Variable name: **INT_3_1**
ID 154

I intend to eat less discretionary choices at meal and snack times *

Strongly disagree Strongly agree

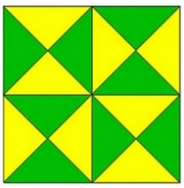
ID 119

Have a look at the picture below.

How many triangles do you see? Can you count all 44 triangles?

Remember, just have a go! It really doesn't matter if you get the right answer or not.

Please spend at least 30 seconds on this brain teaser *(the countdown timer is shown at the bottom of the page)*. When the 30 seconds are up, you can press next to continue.



Action: Page Timer
Brain teaser #2 Timer

LOGIC Hidden unless: (((((XO_Group_Number is exactly equal to "7" OR XO_Group_Number is exactly equal to "8") OR XO_Group_Number is exactly equal to "13") OR XO_Group_Number is exactly equal to "14") OR XO_Group_Number is exactly equal to "19") OR XO_Group_Number is exactly equal to "20")
ID 155

I intend to eat less discretionary choices at meal and snack times *

Strongly disagree | Strongly agree

122

Can you find the dog amongst the pandas?

Don't worry too much if you can't find the dog, the important thing is you have a go!

Please spend at least 30 seconds on this brain teaser *(the countdown timer is shown at the bottom of the page)*. When the 30 seconds are up, you can press next to continue.

Action: Page Timer
Brain teaser #3 Timer

Hidden unless: (((((XO_Group_Number is exactly equal to "9" OR XO_Group_Number is exactly equal to "11") OR XO_Group_Number is exactly equal to "15") OR XO_Group_Number is exactly equal to "17") OR XO_Group_Number is exactly equal to "21") OR XO_Group_Number is exactly equal to "23")

162

Please read the following message carefully.

If you start eating less discretionary choices, you'll improve your chances of:

- **Better heart health**
- **Better mental health**
- **Lower blood sugar levels**
- **Lower cholesterol levels**
- **Lower blood pressure**

In turn, you'll be much more likely to live a longer, healthier life!

Is your health worth a shot?

After reading this message, think about how much you intend to change your eating habits each day, in the next month:

Hidden unless: (((((XO_Group_Number is exactly equal to "3" OR XO_Group_Number is exactly equal to "5") OR XO_Group_Number is exactly equal to "13") OR XO_Group_Number is exactly equal to "18") OR XO_Group_Number is exactly equal to "19") OR XO_Group_Number is exactly equal to "24")

163

Please read the following message carefully.

If you keep eating too many discretionary choices, you'll increase your risk of:

- ✖ **Poor heart health**
- ✖ **Poor mental health**
- ✖ **Higher blood sugar**
- ✖ **Higher cholesterol levels**
- ✖ **Higher blood pressure**

In turn, you'll be much more likely to develop heart disease, stroke and even some types of cancer! 😲

Is your health worth the risk?

After reading this message, think about how much you intend to change your eating habits each day, in the next month:

LOGIC Hidden unless: (((((XO_Group_Number is exactly equal to "1" OR XO_Group_Number is exactly equal to "6") OR XO_Group_Number is exactly equal to "7") OR XO_Group_Number is exactly equal to "12") OR XO_Group_Number is exactly equal to "20") OR XO_Group_Number is exactly equal to "22")
ID 164

Please read the following message carefully.

We know eating too many discretionary choices every day is not recommended.👎✖

Yet, recent data shows that 97% of Australian adults eat discretionary choices every day!! 😲

Do you want to be a part of this statistic?

After reading this message, think about how much you intend to change your eating habits each day, in the next month:

LOGIC Hidden unless: (((((XO_Group_Number is exactly equal to "2" OR XO_Group_Number is exactly equal to "4") OR XO_Group_Number is exactly equal to "8") OR XO_Group_Number is exactly equal to "10") OR XO_Group_Number is exactly equal to "14") OR XO_Group_Number is exactly equal to "16")

ID 165

Please read the following message carefully.

We know eating too many discretionary choices every day is not recommended.👎✖

Yet, recent data shows that only 3% of Australian adults limit their intake of discretionary choices every day!!😲

Do you want to be a part of this statistic?

After reading this message, think about how much you intend to change your eating habits each day, in the next month:

VALIDATION Min = 1 Max = 100
DATA Shortname / Alias: **IntentionQ1_3** Variable name: **INT_1_3**
ID 166

I expect to eat less discretionary choices at meal and snack times *

Strongly disagree Strongly agree

VALIDATION Min = 1 Max = 100
DATA Shortname / Alias: **IntentionQ2_3** Variable name: **INT_2_3**
ID 167

I want to eat less discretionary choices at meal and snack times *

Strongly disagree Strongly agree

VALIDATION Min = 1 Max = 100
DATA Shortname / Alias: **IntentionQ3_3** Variable name: **INT_3_3**

I intend to eat less discretionary choices at meal and snack times *

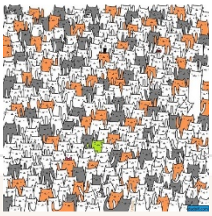
Strongly disagree Strongly agree

ID 124

Can you spot the bunny amongst the cats?

Remember, the important thing is that you just have a go!

Please spend at least 30 seconds on this brain teaser *(the countdown timer is shown at the bottom of the page)*. When the 30 seconds are up, you can press next to continue.



Action: Page Timer

Brain teaser #4 Timer

LOGIC Hidden unless: (((((XO_Group_Number is exactly equal to "10" OR XO_Group_Number is exactly equal to "12") OR XO_Group_Number is exactly equal to "16") OR XO_Group_Number is exactly equal to "18") OR XO_Group_Number is exactly equal to "22") OR XO_Group_Number is exactly equal to "24")

ID 169

Please read the following message carefully.

If you keep eating too many discretionary choices, you'll increase your risk of:

- **✖Poor heart health**
- **✖Poor mental health**
- **✖Higher blood sugar**
- **✖Higher cholesterol levels**
- **✖Higher blood pressure**

In turn, you'll be much more likely to develop heart disease, stroke and even some types of cancer! 😮

Is your health worth the risk?

After reading this message, think about how much you intend to change your eating habits each day, in the next month:

LOGIC Hidden unless: (((((XO_Group_Number is exactly equal to "2" OR XO_Group_Number is exactly equal to "5") OR XO_Group_Number is exactly equal to "8") OR XO_Group_Number is exactly equal to "11") OR XO_Group_Number is exactly equal to "19") OR XO_Group_Number is exactly equal to "21")

ID 171

Please read the following message carefully.

We know eating too many discretionary choices every day is not recommended.👎✖

Yet, recent data shows that 97% of Australian adults eat discretionary choices every day!! 😮

Do you want to be a part of this statistic?

After reading this message, think about how much you intend to change your eating habits each day, in the next month:

LOGIC Hidden unless: (((((XO_Group_Number is exactly equal to "1" OR XO_Group_Number is exactly equal to "3") OR XO_Group_Number is exactly equal to "7") OR XO_Group_Number is exactly equal to "9") OR XO_Group_Number is exactly equal to "13") OR XO_Group_Number is exactly equal to "15")

ID 172

Please read the following message carefully.

We know eating too many discretionary choices every day is not recommended.👎✖

Yet, recent data shows that only 3% of Australian adults limit their intake of discretionary choices every day!!😲

Do you want to be a part of this statistic?

After reading this message, think about how much you intend to change your eating habits each day, in the next month:

VALIDATION Min = 1 Max = 100
DATA Shortname / Alias: **IntentionQ1_4** Variable name: **INT_1_4**
ID 173

I expect to eat less discretionary choices at meal and snack times *

Strongly disagree | Strongly agree

VALIDATION Min = 1 Max = 100
DATA Shortname / Alias: **IntentionQ2_4** Variable name: **INT_2_4**
ID 174

I want to eat less discretionary choices at meal and snack times *

Strongly disagree | Strongly agree

VALIDATION Min = 1 Max = 100
DATA Shortname / Alias: **IntentionQ3_4** Variable name: **INT_3_4**

I intend to eat less discretionary choices at meal and snack times *

Strongly disagree | Strongly agree

Debug logging enabled - set to 0 to turn off debug messages in script! **Action: Hidden Value**
Value: 0

LOGIC Hidden unless: Question "New Percent Branch" is exactly equal to "1"
ID 126

.

Action: Custom Script
Calculate averages, differences, etc.

IntentionM_1 **Action: Hidden Value**
Value:

IntentionM_2 **Action: Hidden Value**
Value:

IntentionM_3 **Action: Hidden Value**
Value:

IntentionM_4 **Action: Hidden Value**
Value:

Custom8 **Action: Hidden Value**
Value: all

Custom9 **Action: Hidden Value**
Value: all

Page description:
Now, we would like to know a little more about you. You will remain anonymous and all your responses will be confidential.

DATA Variable name: **gender**
ID 99

What is your gender? *

- Male
- Female

VALIDATION Min = 1919 Max = 2002 Max character count = 4 Min character count = 4
DATA Variable name: **birthyear**
ID 100

What is your year of birth? (YYYY) *

VALIDATION Min = 13 Max = 250 Must be numeric Max character count = 3 Min character count = 2
DATA Variable name: **weight_raw**
What is your weight in kilograms (kg)? Please provide a figure that has been measured in the last two weeks, and write it as a whole number. E.g. 89 *

VALIDATION Min = 100 Max = 200 Max character count = 3 Min character count = 3
DATA Variable name: **height_raw**
ID 104

What is your height in centimetres (cm)? Please provide a figure that has been measured in the last two weeks, and write is a whole number. E.g. 164 *

VALIDATION Must be numeric Max character count = 4 Min character count = 4
DATA Shortname / Alias: **PostCode** Variable name: **postcode**
ID 102

What is your post code? *

VALIDATION %s format expected
DATA Shortname / Alias: **Email** Variable name: **email_raw**
ID 103

Please provide your email address to receive the intervention emails. We will only use this information for sending you emails associated with the study.

Please enter the email address you check most frequently:
*

VALIDATION %s format expected

DATA Shortname / Alias: **EmailConfirm** Variable name: **email_conf**
ID 110

Please confirm your email address *

DATA Shortname / Alias: **Name** Variable name: **firstname**
ID 139

Finally, what is your first name? (Please click next after completing this question) *

LOGIC Hidden unless: Best_Message is exactly equal to "1"
Group 1 Email 1 Pos
To: [question("value"), id="110"]
From: My Nutrition Score (noreply@surveygizmo.com)
Subject: Day 1 of Shifting My Nutrition Score in 28 Days!

LOGIC Hidden unless: Best_Message is exactly equal to "2"
Group 1 Email 1 Neg
To: [question("value"), id="110"]
From: My Nutrition Score (noreply@surveygizmo.com)
Subject: Day 1 of Shifting My Nutrition Score in 28 Days!

LOGIC Hidden unless: Best_Message is exactly equal to "3"
Group 1 Email 1 Maj
To: [question("value"), id="110"]
From: My Nutrition Score (noreply@surveygizmo.com)
Subject: Day 1 of Shifting My Nutrition Score in 28 Days!

LOGIC Hidden unless: Best_Message is exactly equal to "4"
Group 1 Email 1 Min
To: [question("value"), id="110"]
From: My Nutrition Score (noreply@surveygizmo.com)
Subject: Day 1 of Shifting My Nutrition Score in 28 Days!

LOGIC Hidden unless: Best_Message
Group 2 Email 1 Cont
To: [question("value"), id="110"]
From: My Nutrition Score (noreply@surveygizmo.com)
Subject: Day 1 of Shifting My Nutrition Score in 28 Days!

Yay! You have completed the first phase of the study and are now up to the second phase!

Are you ready for the 28 day challenge?

What now?
You will soon be sent your first email from *My Nutrition Score*, with the subject heading "Day 1 of Shifting My Nutrition Score in 28 Days!" *Please* make sure you check your Inbox or Junk Mail regularly in the next 12 hours so you don't miss the email.

If you don't see an email in your Inbox folder, it would have likely landed in your junk folder. Please take the time to move the email into your Inbox. Most email accounts will allow you to do this by simply selecting "It's not spam" or by right clicking on the email and selecting "Move to Inbox".

If you still can't find the email, please flag this with the My Nutrition Score team by emailing *28dayshift@csiro.au* as soon as possible.

Then what?
You will be sent another reminder email **two weeks (14 days)** after the first email with the subject heading "You're half-way though Shifting My Nutrition Score". Again, please ensure you check your Inbox / Junk Mail regularly during this time so you do not miss the email.

Then, **four weeks from now** (the 28 day mark)**,** you will be sent your third and final email. This email will contain the link to the final survey which you will need to complete to be eligible to go in the draw to win a "*Prezzee*" gift card worth $100 to spend at a retailer of your choice.

Go ahead and find your first email. Thank you for being a part of this study and good luck for the next 28 days!

APPENDIX 7 CROSSOVER TRIAL RANDOMISATION PROTOCOL

Table A7-1: Crossover trial randomisation protocol. Each number represents the group each participant was randomised to, which instructed the survey logic system on the message to display on each survey page.

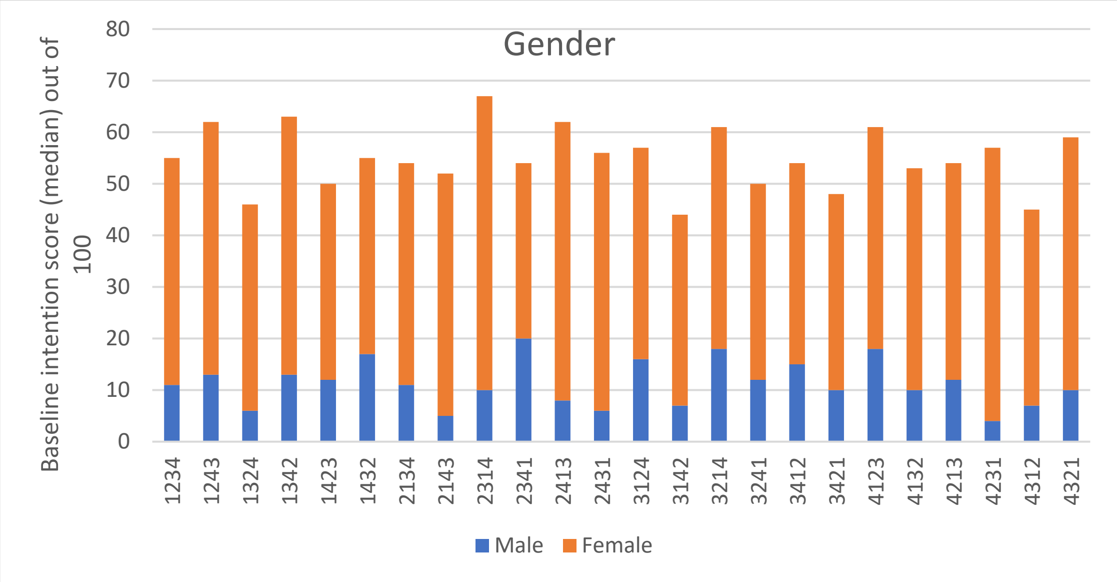
Page	**1**	**2**	**3**	**4**
Only show Positive: Message 1 if Group Number is	Logic per message per page: ≤ 6	= 7 8 13 14 19 20	= 9 11 15 17 21 23	= 10 12 16 18 22 24
Only show Negative: Message 2 if Group Number is	≥ 7 AND ≤ 12	= 1 2 15 16 21 22	= 3 5 13 18 19 24	= 4 6 14 17 20 23
Only show Majority: Message 3 if Group Number is	≥ 13 AND ≤ 18	= 3 4 9 10 23 24	= 1 6 7 12 20 22	= 2 5 8 11 19 21
Only show Minority: Message 4 if Group Number is	≥ 19	= 5 6 11 12 17 18	= 2 4 8 10 14 16	= 1 3 7 9 13 15
Group Number = Participant's random sequence group number (1 – 24)				

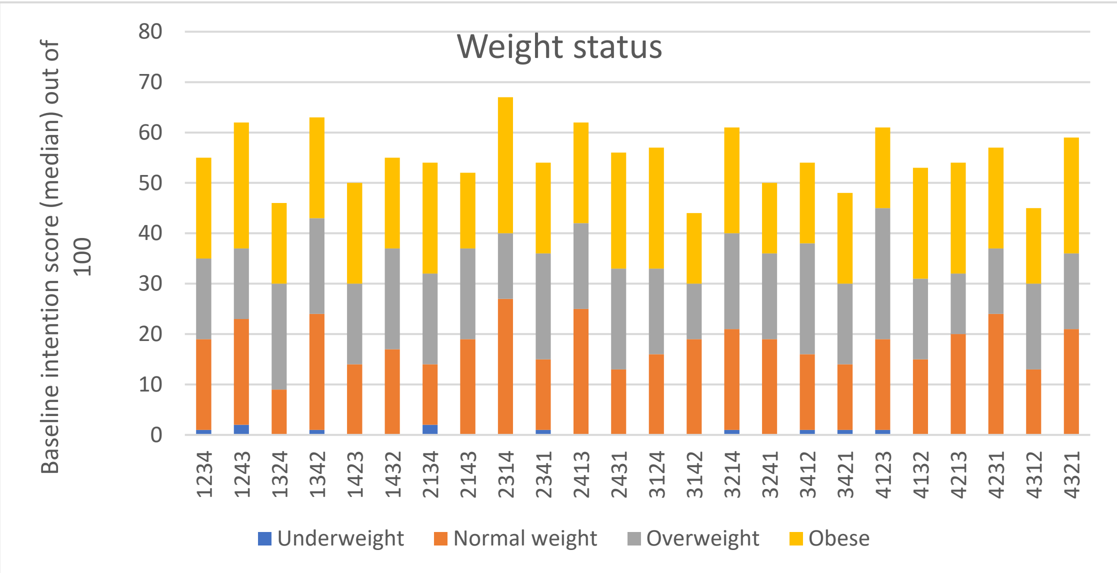
APPENDIX 8 CROSSOVER TRIAL SEQUENCE DIFFERENCES

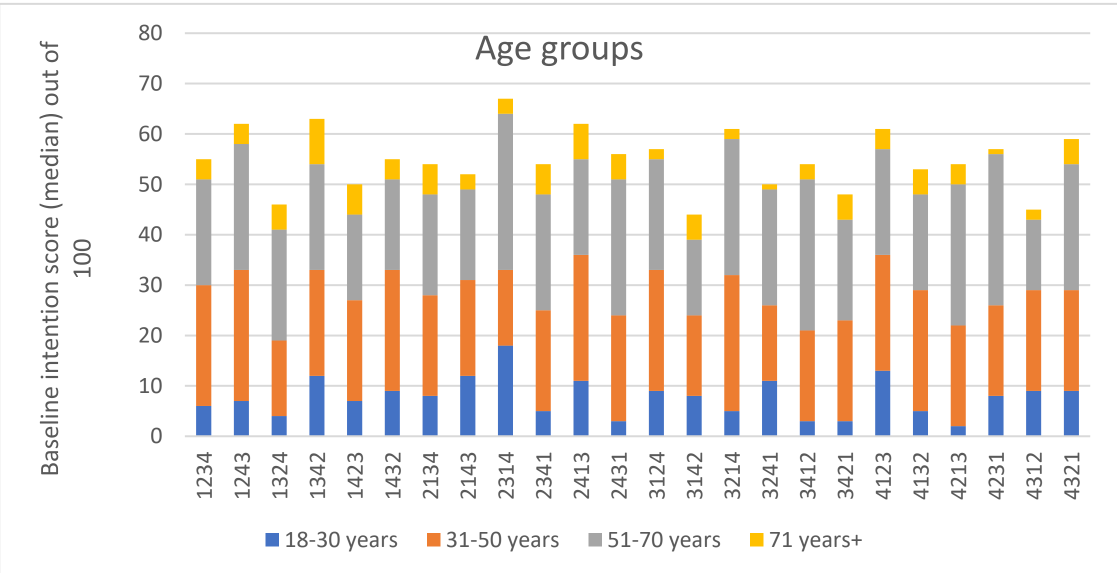
Table A8-1: Median intention scores by message exposure sequence

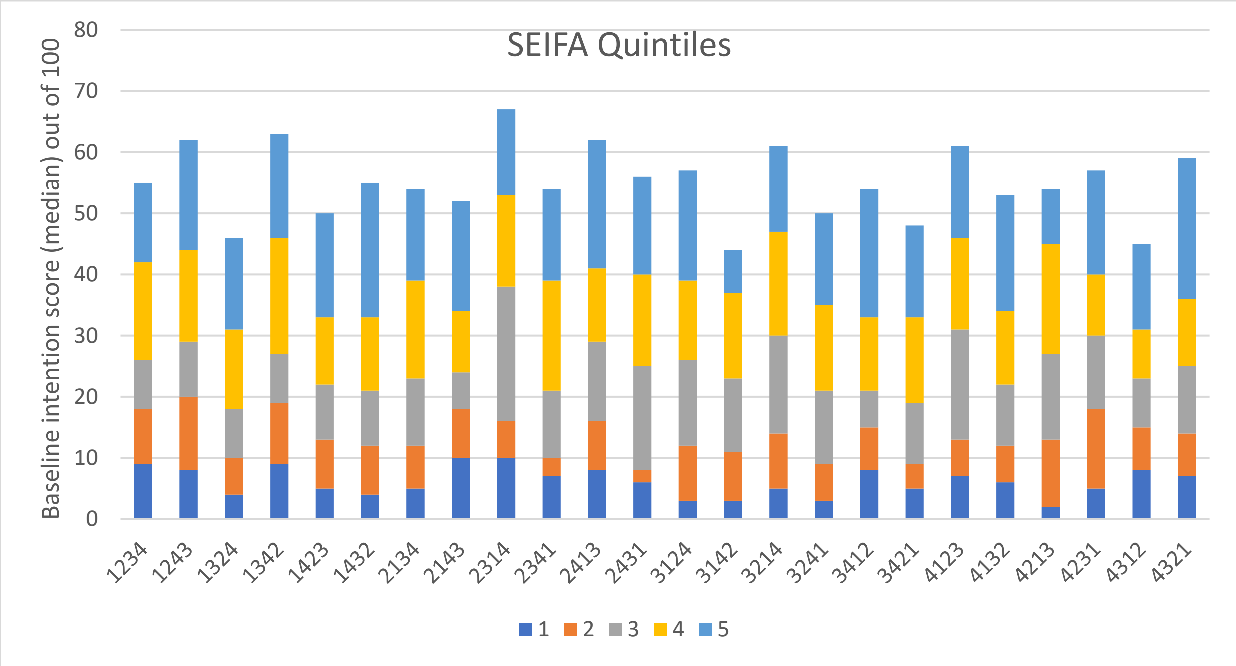
		Median intention scores at baseline and by treatment				
Order of message (1 = positive, 2 = negative, 3 = majority, 4 = minority)	**Sequence number**	**Baseline**	**Positive**	**Negative**	**Majority**	**Minority**
1234	1	79	83	84	81	85
1243	2	81	87	88	90	90
1324	3	91	93	97	94	98
1342	4	81	84	89	84	83
1423	5	77	85	83	81	83
1432	6	83	85	92	90	90
2134	7	82	93	87	88	88
2143	8	83	90	88	90	90
2314	9	78	90	83	84	88
2341	10	77	86	83	80	85
2413	11	77	90	81	87	81
2431	12	86	90	85	88	83
3124	13	83	88	85	80	86
3142	14	84	85	91	85	89
3214	15	84	88	86	84	86
3241	16	82	92	89	86	89
3412	17	77	86	85	77	85
3421	18	79	87	88	83	87
4123	19	80	85	90	88	83
4132	20	83	90	90	90	86
4213	21	84	96	93	95	91
4231	22	83	92	90	89	84
4312	23	87	94	91	88	89
4321	24	84	93	93	90	85
Range of median intention scores		77-91	83-96	81-97	77-95	81-98

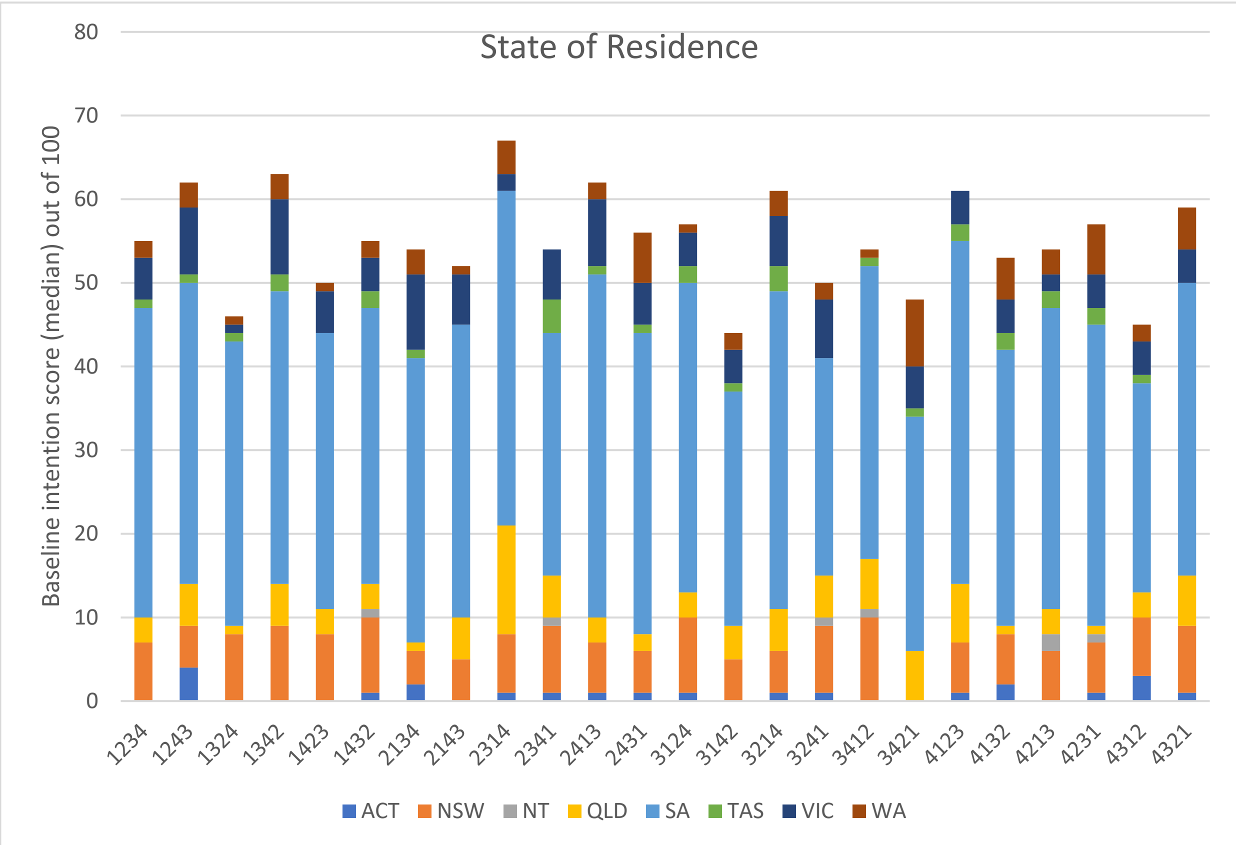
Figures A6.1 to A6.5: Baseline intention scores by demographic, anthropometric and geographic characteristics








SEIFA Quintiles
Baseline intention score (median) out of 100
0
10
20
30
40
50
60
70
80
1234
1243
1324
1342
1423
1432
2134
2143
2314
2341
2413
2431
3124
3142
3214
3241
3412
3421
4123
4132
4213
4231
4312
4321
1
2
3
4
5


State of Residence
Baseline intention score (median) out of 100
0
10
20
30
40
50
60
70
80
1234
1243
1324
1342
1423
1432
2134
2143
2314
2341
2413
2431
3124
3142
3214
3241
3412
3421
4123
4132
4213
4231
4312
4321
ACT
NSW
NT
QLD
SA
TAS
VIC
WA

APPENDIX 9 EXAMPLE INTERVENTION EMAILS

Tailored message email 1:

Subject: Day 1 of 28 of Shifting My Nutrition Score!

Hi [participant name]!

Thank you for joining ***Shifting My Nutrition Score in 28 Days***

You can improve your nutrition score by eating less discretionary choices. For the next month, please keep the following message in mind:

[Tailored message: positively framed]

Doing the following tips for the next 14 days will help you cut down on eating discretionary choices AND you'll improve your health:

1. Remind yourself how positive you are going to feel
2. Be proactive! Seek fresh meal and snack ideas
3. Be organised! Plan your snacks
4. Act smart! Think before you drink
5. Bring your social network on board

Let's expand on these…

Remind yourself how positive you are going to feel when you avoid discretionary choices
Remember how great you felt when you've previously eaten healthier. Now, write down how you're going to feel every time you eat a healthier alternative to discretionary choices (i.e. "I know eating a healthier option will make me feel much more energetic")

Seek healthy meal and snack ideas
If you have meal ideas, you'll find it easier to avoid take-away food! Click here (https://my.totalwellbeingdiet.com/resources/recipes.aspx?id=recipes_index_dinner) for quick & easy meals and snack ideas. You can also search for meal, cooking and recipe inspiration from Dietitians on any social media forum by searching the term or hashtag #Dietitian. Accounts run by dietitians are trustworthy and a great way to develop and practice your skillset in the kitchen!

Plan your snacks
Make sure you keep a piece of fruit, yoghurt, nuts (or roasted beans or chickpeas), or whole-grain crackers and cheese in your bag or the fridge (at home or work), and you will be less likely to grab something less healthy on the run. These snacks are higher in fibre and protein, and lower in sugar and salt.

Think before you drink
Keep a filled water bottle in front of you! This will help you drink fewer soft drinks, fruit juice, sports drinks or energy drinks. If you don't like water from the tap, then try it sparkling, with fruit

slices, or fruit-flavoured tea-bags. Try having 1 or 2 glasses of water before each meal or snack. If you plan on drinking alcohol, make sure you break up each drink with a glass of water.

Bring your friends, colleagues and family on board
Everything is more fun when done with others. Extend this 28 day challenge onto your family, friends, colleagues and/or house-mates. Do the activity (below) with them and discuss your progress frequently so you can keep each other on track.

Stay motivated and on track by printing off or taking a screen shot of the table and tips below. For the next 14 days, see how many of the above tips you can do and cross off each day that you were able to eat less discretionary choices by doing one or more of the tips.

Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Day 8	Day 9	Day 10	Day 11	Day 12	Day 13	Day 14

Your tips:
Remind yourself how positive you are going to feel
Be proactive! Seek fresh meal and snack ideas
Be organised! Plan your snacks
Act smart! Think before you drink
Bring your social network on board

You can also write the tips down on post-it notes to stick on your computer screen, or you can even save them as the screen-lock image on your phone! The more you read the information in this email, the more likely you'll stay motivated and on track.

Let's see what you can achieve in the next 14 days! You've got this!

We will be in touch soon, please remember to check your emails in 14 days' time. This will keep you in the running to win one of $100 gift vouchers.

Generic message (control group) email 1:

Hi [participant name]!

Thank you for joining ***Shifting My Nutrition Score in 28 Days***

For the next month, please keep the following message in mind:

Eat fewer discretionary choices

Your diet could be improved if you ate fewer discretionary choices also known as "extra foods".
Extra foods include cakes, biscuits, pastry, chips, lollies, ice-cream, processed meats, regular sausages, sugar sweetened beverages, alcohol and similar foods.
It is recommended that you eat these foods only sometimes and in small amounts.

We will be in touch in 14 days to see how you're going, please remember to check your email then!

Don't forget, by completing the final survey (which you will receive access to in 28 days), you'll be in the running to win a $100 gift card to use at a retailer of your choice! 🛍 You'll also be helping us find ways to improve Australia's eating habits.

Follow-up email to both groups:

Subject: The last step to Shifting My Nutrition Score in 28 Days!

Hi [participant name]!

You've made it to the 28 day mark of Shifting My Nutrition Score in 28 Days! 🎉

But before we let you go… We would like some extra information from you.

Remember, if you complete this final survey, you will go in the draw to win a $100 gift card to use at a retailer of your choice! 🛍 You'll also be helping us find ways to improve the population's eating habits.

The following survey will only take 10-15 minutes of your time. Click on the following link and you will be directed to the last survey.

[invite(survey_link)]http://www.surveygizmo.com/s3/5084399/followup?Grp=1&sessid=[invite("custom 1")]

Thank you so much for participating in this study.

APPENDIX 10 FOLLOW-UP QUESTIONNAIRE

Shifting My Nutrition Score in 28 days: Last step

ID 27

Welcome back!

This is the final phase of
Shifting *My Nutrition Score* in 28 days
#28dayshift

Finishing this survey will put you in the draw to win a $100 "*Prezzee*" gift card to use at a retailer of your choice!

Some things to consider before we continue:

1. **Survey works best** if accessed in a Google Chrome, Firefox, or Safari browser.
2. **Don't lose your responses**! Please do not hit your browser's "back" button at any time.
3. **Your responses will be saved.** The link that sent you to this page will save all your responses, meaning you can come back to the survey via this link and pick up where you left from. We do ask you to please do the best you can and try to complete all your responses today. The responses you provide today are a crucial part of the study.

Alright... let's begin! Please press next.

ID 26

Thinking about how much you intend to change your eating habits each day, in the next month:

VALIDATION Min = 1 Max = 100
I expect to eat less discretionary choices at meal and snack times, each day for the next month *

Strongly disagree ——— Strongly agree

VALIDATION Min = 1 Max = 100
DATA Shortname / Alias: **IntentionQ2_1** Variable name: **INT_2_F**
ID 195

I want to eat less discretionary choices at meal and snack times, each day for the next month *

Strongly disagree ——— Strongly agree

VALIDATION Min = 1 Max = 100
DATA Shortname / Alias: **IntentionQ3_1** Variable name: **INT_3_F**
ID 196

I intend to eat less discretionary choices at meal and snack times, each day for the next month *

Strongly disagree ——— Strongly agree

ID 278

Over the next few pages, we'll ask questions about **what you eat and drink** and **how often**.

There are no right or wrong answers so just respond as best as you can!

SHORT FOOD SURVEY IS COMPLETED AGAIN, AS PER APPENDIX 4

ID 279

The next part of the survey will ask about what you thought of the overall study, to help us understand how we can improve future studies of this kind.
Only 5 short questions to go - nearly there!

DATA Shortname / Alias: **Recruitment** Variable name: **Recruit_LinkedIn ,Recruit_Facebook ,Recruit_Twitter ,Recruit_Flyer ,Recruit_CSIROWeb ,Recruit_FUWeb ,Recruit_WOM ,Recruit_Instagram ,Recruit_Other ,Recruit_Other1**
ID 2

How did you hear about this study? (select as little or as many as are applicable) *

- ☐ Email invitation
- ☐ Facebook
- ☐ Instagram
- ☐ Twitter
- ☐ Flyers
- ☐ CSIRO website
- ☐ Flinders University website
- ☐ Word of mouth
- ☐ Other

LOGIC Show/hide trigger exists.
DATA Shortname / Alias: **Open_Email** Variable name: **Email_open**
ID 31

Did you open the email(s) sent to you?
*

- ○ Yes
- ○ No

LOGIC Hidden unless: #75 Question "Did you open the email(s) sent to you?
" is one of the following answers ("Yes")
DATA Shortname / Alias: **OftenOpen_email** Variable name: **Email_often**
ID 32

How often did you open the email(s)?

- At least once a day
- At least once a week
- At least once a fortnight
- At least once a month

LOGIC Show/hide trigger exists.
DATA Shortname / Alias: **Read_email** Variable name: **Email_read**
ID 33

Did you read the email(s) sent to you? *

- Yes
- No

LOGIC Hidden unless: #77 Question "Did you read the email(s) sent to you?" is one of the following answers ("Yes")
DATA Shortname / Alias: **OftenRead_email** Variable name: **Email_read_often**
ID 34

How often did you read the email(s)? *

- At least once a day
- At least once a week
- At least once a fortnight
- At least once a month

LOGIC Hidden unless: #77 Question "Did you read the email(s) sent to you?" is one of the following answers ("Yes")
DATA Shortname / Alias: **TimeRead_email** Variable name: **Email_read_time**
ID 35

How long do you think you spent reading each email? *

- Less than 5 minutes
- Between 5 - 15 minutes
- 15 minutes or more

ID 8

On a scale of 1 to 5, where strongly disagree (= 1) and strongly agree (= 5), please rate the following statements:

DATA Shortname / Alias: **Applicable_content** Variable name: **Applicable**
ID 3

The content provided in the email(s) was applicable and/or relevant to me *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	**Strongly Agree**

DATA Shortname / Alias: **Motivating_content** Variable name: **Motivating**
ID 5

The content provided in the email(s) motivated me to change my eating *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	**Strongly Agree**

DATA Shortname / Alias: **Worthwhile_content** Variable name: **Worthwhile**

The content provided in the email(s) was worthwhile to me *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	**Strongly Agree**

DATA Shortname / Alias: **Received_byemail** Variable name: **Content**
ID 38

I liked receiving the content by email *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	**Strongly Agree**

DATA Shortname / Alias: **All_online** Variable name: **Online**
ID 37

I liked that the study was completely online *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	**Strongly Agree**

DATA Shortname / Alias: **Amount_emails** Variable name: **Amount**
ID 39

I am satisfied with the amount of emails I recieved *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	**Strongly Agree**

DATA Shortname / Alias: **Frequency_email** Variable name: **Frequency**
ID 281

I am satisfied with the frequency of emails I received *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	**Strongly Agree**

DATA Shortname / Alias: **Expectations_met** Variable name: **Expectations**
ID 7

The *"Shifting My Nutrition Score in 28 days"* study met my expectations *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	**Strongly Agree**

DATA Shortname / Alias: **Change_anything** Variable name: **Change**
ID 41

There is nothing I would change about the *"Shifting My Nutrition Score in 28 days"* study *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	**Strongly Agree**

DATA Shortname / Alias: **Overall_satisfaction** Variable name: **OverallSatisfaction**

Overall, I am satisfied with the *"Shifting My Nutrition Score in 28 days"* study (ie. emails as a mode of communication, how frequently I was contacted, the information I received) *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	**Strongly Agree**

DATA Shortname / Alias: **Time_taken** Variable name: **Timetaken**
ID 9

The time this study took from me over the last 28 days: *

- ○ Too much time
- ○ The right amount of time
- ○ Too little time

DATA Shortname / Alias: **Interaction_open** Variable name: **NoInteraction**
ID 13

If relevant, what are the reasons you did not interact with *"Shifting My Nutrition Score in 28 days"*? (i.e. opening the emails frequently, use the information provided to you)

DATA Shortname / Alias: **Other_open** Variable name: **Somethingelse**
ID 282

Is there something else you would like to say about the study?

LOGIC Hidden unless: URL Variable "Grp" is exactly equal to "1"
DATA Shortname / Alias: **Message_pref** Variable name: **Msg1_Pref ,Msg2_Pref ,Msg3_Pref ,Msg4_Pref**
ID 280

If you were to do this intervention again...

Which of the following messages would you have preferred to receive?

If you are on a desktop computer or laptop: please drag and drop the messages in your preferred order, where the top message (=1) is your most favourite and the bottom message (=4) is your least favourite

If you are on a smartphone or tablet: please select the messages in your order of preference: 1=most favourite; 4=least favourite.
*

Message 1

If you start eating less discretionary choices, you'll improve your chances of:
Better heart health
Better mental health
Lower blood sugar levels
Lower cholesterol levels
Lower blood pressure
In turn, you'll be much more likely to live a longer, healthier life! 😮

Is your health worth a shot?

Message 2

If you keep eating too many discretionary choices, you'll increase your risk of:
Poor heart health
Poor mental health
Higher blood sugar
Higher cholesterol levels
Higher blood pressure

In turn, you'll be much more likely to develop heart disease, stroke and even some types of cancer! 😮

Is your health worth the risk?

Message 3

We know eating too many discretionary choices every day is not recommended.

Yet, recent data shows that 97% of Australian adults eat discretionary choices every day!! 😮

Do you want to be a part of this statistic?

Message 4

We know eating too many discretionary choices every day is not recommended.

Yet, recent data shows that only 3% of Australian adults limit their intake of discretionary choices every day!!😮

Do you want to be a part of this statistic?

Drag items from the left-hand list into the right-hand list to order them.

- Message 1
- Message 2
- Message 3
- Message 4

ID 199

If you were to do this intervention again…

DATA Shortname / Alias: **Platform_pref** Variable name: **Email_DeliveryPref ,SMS_DeliveryPref ,Combo_DeliveryPref ,Social_DeliveryPref**

Which platform would you prefer to be contacted through?

If you are on a desktop computer or laptop: please drag and drop the options in your preferred order, where the top option (=1) is your most preferred and the bottom message (=4) is your least preferred

If you are on a smartphone or tablet: please select the messages in your order of preference: 1=most preferred; 4=least preferred.
*

Drag items from the left-hand list into the right-hand list to order them.

- Email
- Text message
- A combination of email and text messages
- Social media platform

Page exit logic: Skip / Disqualify Logic
IF: #95 Question "Did you seek any ***extra*** help (other than the study content) to change your eating habits in the last 28 days?" is one of the following answers ("No") **THEN:** Jump to page 21 - Prize draw email

Page exit logic: Skip / Disqualify Logic
IF: #95 Question "Did you seek any ***extra*** help (other than the study content) to change your eating habits in the last 28 days?" is one of the following answers ("Yes") **THEN:** Jump to page 20 - Contamination2

DATA Shortname / Alias: **Contamination_1** Variable name: **Contamination1**

Did you seek any ***extra*** help (other than the study content) to change your eating habits in the last 28 days? *

- Yes
- No

DATA Shortname / Alias: **Contamination_2** Variable name: **Contamination_other1 ,Contamination_dietit ,Contamination_wshop ,Contamination_program ,Contamination_online ,Contamination_other**
ID 19

What did you use to help change your eating habits? (Select as little or as many as are applicable): *

- A consultation with a nutrition professional
- Healthy eating workshops
- Other healthy eating program: lite n easy or similar; ready-made meal delivery program; meal-kit delivery program; gym challenge
- Online sources of information relating to nutrition: social media, website, smartphone app
- Other

VALIDATION %s format expected
DATA Shortname / Alias: **Prezzee** Variable name: **Prize_email**
ID 197

If you would like to go in the draw to win a gift card worth $100, which you can use at a retailer of your choice, please enter your email address below.

That's it!

Thank you again for taking the time to be a part of ***Shifting My Nutrition Score in 28 Days***.

A summary of the study findings will be emailed to you at the completion of the study.

APPENDIX 11 PROCESS EVALUATION COMPONENTS

Table A11-1: Components of a Process-Evaluation with application to the *Shifting My Nutrition Score in 28 Days* intervention

Component	**Purpose**	**Application for Shifting My Nutrition Score in 28 Days**
Fidelity (quality)	Extent to which the intervention was implemented as planned.	Consistency in timing of receiving the e-mails. Consistency between intervention and control in receiving first e-mail.
Dose delivered (completeness)	Amount or number of intended units of each intervention or component delivered or provided by interventionists.	Satisfaction or dose of intervention delivered – number of e-mails, number of time points.
Dose received (exposure)	Extents to which participants actively engage with, interact with, are receptive to, and/or use materials or recommended resources: can include “initial use” and “continued use”.	The frequency of opening and reading the e-mails and the length of time taken to read the e-mails.
Dose received (satisfaction)	Participant (primary and secondary audiences) satisfaction with program, interactions with staff and/or investigators.	Acceptability/Usability/Appropriateness/ Usefulness/Relevance questionnaire, i.e. ranking agreement of intervention being worthwhile, motivating, and meeting expectations.
Reach (participation rate)	Proportion of the intended priority audience that participates in the intervention: often measured by attendance; includes documentation of barriers to participation.	Retention was assessed as the number of participants completing the process evaluation.
Recruitment	Procedures used to approach and attract participants at individual or organizational levels: includes maintenance of participant involvement in intervention and measurement components of the study.	Recruitment question on how participant heard about the study.
Context/Contamination	Aspects of the environment that may influence intervention implementation or study outcomes; includes contamination or the extent to which the control group was exposed to the program.	Contamination questions for both intervention and control groups.

Note:
Adapted from Saunders et al. (234) with components added as per previously published recommendations (165, 235).
The **shaded** boxes represent the components that were assessed during this process-evaluation. The **non-shaded** boxes were applied when designing the intervention or discussed in another section of this thesis.

APPENDIX 12 COLLINEARITY RESULTS FOR EXPLORATORY ANALYSIS

Table A12-1: Pearson's correlations between logistic regression variables for the primary outcome: reduction of discretionary choice (DC) intake by one serve or more

	Reducing by one serve or more	**Intervention group**	**Baseline DC serve intake**	**Gender**	**BMI (weight status)**	**Age**	**SEIFA Quintiles**	**Capability**	**Opportunity**	**Motivation**	**Intention**	**Diet Score**
Reducing by one serve or more	1											
Intervention group	0.001	1										
Baseline DC	.432**	.064*	1									
Gender	-0.008	0.017	-.108**	1								
BMI	.120**	-.052*	.211**	-.055*	1							
Age	-0.030	-.054*	-0.037	-.132**	.166**	1						
SEIFA Quintiles	-.052*	0.027	-0.045	-0.012	-.168**	-0.011	1					
Capability	.123**	-0.033	.180**	0.015	.156**	-.091**	-0.050	1				
Opportunity	.093**	0.015	.098**	.106**	.079**	-.258**	-.054*	.496**	1			
Motivation	.118**	-0.020	.169**	0.014	.195**	.116**	-.056*	.457**	.364**	1		
Intention	.062*	0.004	-0.015	.106**	.101**	-0.026	-0.046	.174**	.151**	.165**	1	
Diet Score	-.234**	-0.012	-.290**	0.011	-.160**	.246**	.100**	-.135**	-.163**	-.140**	-0.015	1

**Correlation is significant at the 0.01 level (2-tailed) * Correlation is significant at the 0.05 level (2-tailed).

Table A12-2: Pearson's correlations between logistic regression variables for the secondary outcome: complying with the discretionary choice (DC) guideline

	Complying with guideline	**Intervention group**	**Baseline DC serve intake**	**Gender**	**BMI (weight status)**	**Age**	**SEIFA Quintiles**	**Capability**	**Opportunity**	**Motivation**	**Intention**	**Diet Score**
Complying with guideline	1											
Intervention group	$-.070^{**}$	1										
Baseline DC	$-.413^{**}$	$.064^{*}$	1									
Gender	0.037	0.017	$-.108^{**}$	1								
BMI	$-.099^{**}$	$-.052^{*}$	$.211^{**}$	$-.055^{*}$	1							
Age	$.077^{**}$	$-.054^{*}$	-0.037	$-.132^{**}$	$.166^{**}$	1						
SEIFA	-0.031	0.027	-0.045	-0.012	$-.168^{**}$	-0.011	1					
Capability	$-.109^{**}$	-0.033	$.180^{**}$	0.015	$.156^{**}$	$-.091^{**}$	-0.050	1				
Opportunity	$-.071^{**}$	0.015	$.098^{**}$	$.106^{**}$	$.079^{**}$	$-.258^{**}$	$-.054^{*}$	$.496^{**}$	1			
Motivation	$-.126^{**}$	-0.020	$.169^{**}$	0.014	$.195^{**}$	$.116^{**}$	$-.056^{*}$	$.457^{**}$	$.364^{**}$	1		
Intention	$.063^{*}$	0.004	-0.015	$.106^{**}$	$.101^{**}$	-0.026	-0.046	$.174^{**}$	$.151^{**}$	$.165^{**}$	1	
Diet Score	$.265^{**}$	-0.012	$-.290^{**}$	0.011	$-.160^{**}$	$.246^{**}$	$.100^{**}$	$-.135^{**}$	$-.163^{**}$	$-.140^{**}$	-0.015	1

**Correlation is significant at the 0.01 level (2-tailed) * Correlation is significant at the 0.05 level (2-tailed).