Promoting uptake of the MIND diet to prevent cognitive decline in adults at midlife: Employing the Behaviour Change Wheel and COM-B model.

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I confirm that the word count of this thesis is less than 100,000 words excluding the title page, content, acknowledgements, abstract, abbreviations, footnotes, diagrams, illustrations, tables, appendances, and references.

Dedication

I would like to dedicate this thesis to two amazing people in my life.

Firstly, I dedicate this thesis to my mother, who held the space for me while I did my PhD. Not only did my mother support me in all areas of my life throughout my PhD, she did so with kindness, compassion and understanding. She also spent many hours listening to me practice for conferences, lectures, and proofread many papers for peer review and chapters for this PhD. I am truly grateful for her support.

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Table of contents

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Abstract

Background: The incidence of dementia is predicted to double every 20 years, with prevalence in the UK to reach 2.1 million by 2050. Modifiable risk factors such as diet in midlife have been shown to be associated with a reduced risk of dementia in later life. The aim of the research was to use the Behaviour Change Wheel and COM-B model to explore barriers and facilitators to the uptake of the MIND diet (Mediterranean-DASH Intervention for Neurodegenerative Delay) which was designed to promote brain health, and examine the effects of a dietary intervention on the cognitive function, mood and quality of life of Northern Ireland adults in midlife.

Design: The Behaviour Change Wheel (BCW) was used to guide and inform intervention development which involved the use of several methodological approaches. A systematic review was conducted to assess the effectiveness and use of psychological theory in dietary interventions that promote a whole diet. Content of the interventions were coded according to the Theory Coding Scheme. Focus groups and interviews based on the COM-B model and Theoretical Domains Framework (TDF) explored barriers and facilitators to the uptake of the MIND diet (n=25). The BCW guided the systematic selection of intervention function, behaviour change techniques and mode of delivery in designing a 12-week randomised controlled feasibility dietary intervention (n=41). Outcome measures for COM-B, cognitive function, mood, and quality of life was recorded for both the intervention and control groups. Participants were healthy males and females aged between 40-55 years old, living in Northern Ireland

Results: Nine intervention studies were included in the systematic review. Results found that dietary scores improved for at least one food group. Overall, studies reported a moderate application of the theory coding scheme, with poor reporting on fidelity. Content analysis revealed that the main perceived barriers and facilitators to the uptake of the MIND diet were; time, work environment, taste preference and convenience, improved health, planning and organisation, and access to good quality food. A repeated measures ANOVA showed that in comparison to the control group, the 12-week dietary intervention improved mood, quality of life, MIND diet score and capability, opportunity, and motivation towards MIND diet consumption.

Conclusion: Findings from this research provide insight into the personal, social, and environmental factors that participants report as barriers and facilitators to the uptake of the MIND diet. To our knowledge, this is the first study to use a theoretical framework to explore people's attitudes towards consuming the MIND diet, and the first RCT examining the effectiveness of the MIND diet on health outcomes. The results add to the dietary and cognitive function literature and to the behaviour change literature by describing and specifying the design, content, proposed mechanism of action and implementation for a theoretically informed dietary intervention. Recommendations for enhancing the role of health professionals in promoting cognitive function at midlife in an attempt to promote functional independence and better cognitive function in later life.

List of Abbreviations

Abbreviation	Description
AD	Alzheimer's Disease
ACE-R	Addenbrooke's Cognitive Examination Revised
ALA	A-linoleic Acid
ANOVA	Analysis of variance
BCAT	Basic Cognitive Aptitude test
BCW	Behaviour Change Wheel
BCT	Behaviour Change Techniques
BDNF	Brain Derived Neurotrophic Factor
BNT	Boston Naming Test
CANTAB	Cambridge Neuropsychological Test Automated Battery
CDT	Clock Drawing Test
CDR	Clinical Dementia Rating Scale
COM-B	Capability, opportunity, motivation, and behaviour
DASH	Dietary Approaches to Stop Hypertension
DGI	Diet Guidelines Index
DHA	Docosahexaenoic Acid
DRS	Dementia Rating Scale
EFML	Executive Function Memory Learning
EPA	Eicosapentaenoic Acid
EVO	Extra Virgin Oil
FFQ	Food Frequency Questionnaire
MCI	Mild Cognitive Impairment
MEDAS	Mediterranean Diet Adherence Screener
Med Diet	Mediterranean Diet

MIND	Mediterranean-DASH Intervention for Neurodegenerative Delay
MMSE	Mini Mental State Examination
MO	Mechanism of Action
MRC	Medical Research Council
NCD	Non-Communicable Disease
NI	Northern Ireland
NTI	Non-Tailored Intervention`
PAL	Paired Associates Learning
PANAS	Positive and Negative Affect Scale
PBC	Perceived Behavioural Control
PICOS	Population, Intervention, Comparison, Outcome, Study Design
POMS	Profile of Mood States
PRISMA	Preferred Reporting Items for Systematic Reviews
PUFA	Polyunsaturated Fatty Acid
RCT	Randomised Controlled Trial
SCM	Social Cognition Models
SCT	Social Cognitive Theory
SDT	Self-Determination Theory
SES	Socio-Economic Status
SF-12	Short Form Health Survey
SN	Subjective Norm
TBI	Tailored Behavioural Intervention
TCS	Theory Coding Scheme
TDF	Theoretical Domains Framework
TMT	Trial Making Test
UC	Usual Care
UK	United Kingdom
USA	United States of America
WAIS	Wechsler Adult Intelligence Test

WHO	World Health Organisation
WHOQOL	Who health Organization Quality of Life

Conference Presentations and Publications arising from the Research in this Thesis

Publications and preprints

Timlin, D., McCormack, J. M., & Simpson, E. E. (2020). Using the COM-B model to identify barriers and facilitators towards adoption of a diet associated with cognitive function (MIND diet). *Public Health Nutrition*, 1-14.

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Conference presentations:

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Declaration

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List of Tables

List of Figures

Chapter 1: Introduction to thesis

1.1 Introduction

The current chapter sets the context for the thesis with a background overview of the area and a summary for each of the seven chapters (Chapter 2 to 8) that follows. The current thesis focused on establishing facilitators and barriers to adoption of the MIND diet and to determine predictors of the MIND diet uptake, which informed the design of an intervention to promote the MIND diet and monitor cognition in its users. The studies within this thesis are interlinked. That is, the findings of one study informed the aims or study design of the next study.

1.1.1 Background Overview. In 2018, the leading cause of death in the UK was Dementia and Alzheimer's disease (AD), accounting for 12.7% of all deaths registered (Office for National Statistics, 2020). There are over 850,000 people in the UK currently living with Dementia and is predicted to rise to 1.5 million by 2040 (Alzheimer's Society, 2019). There is currently no cure or treatment to slow the progression of Dementia, however, modifiable improvements on dietary intake seem to hold a crucial role in preventing cognitive impairment in recent literature. There is a need to develop strategies to promote healthy ageing to reduce the burden of disease later in life. With no pharmacological treatments effective to treat or prevent age related cognitive decline, recent opinion is emerging, that for an intervention to be beneficial, it would need to start in the preclinical stage (Flanagan et al., 2020). The brain develops neurologically until approximately 30 years (lebel and Beaulieu et al., 2011), before it starts to decline slowly, with signs of neurodegeneration generally not occurring until older age. This slow process gives an opportunity for preventative measures or intervention strategies to take place (Flanagan et al., 2020). Furthermore, mid-life appears to be a vulnerable window for onset of functional limitations and the transition to disability. Declines in functioning during midlife may be related to the acceleration of other adverse changes the midlife including the onset of metabolic syndrome and diabetes, adverse changes in lipid profiles, obesity, cardiovascular issues and menopause. However, research indicates that lifestyle and biological risk factors in midlife are associated with longevity and various aspects of healthy life in old age (Lafortune et al., 2016).

With ageing, the ability to think slows down and people may experience difficulty in memory recall, such as retrieving a name. While this is all part of normal cognitive ageing, it is a very different scenario when the capacity to remember places and names diminish. Those are the experiences of people with dementia and why it is a feared consequence of ageing (Langa, 2018). To grow older with a healthy brain, to make independent decisions, connect with people and relationships, is what people hope for, for their future (Morris, 2018). However, debilitating cognitive decline does not have to be the future. Following a healthy diet is one of the most assured ways to keep your brain functioning at its best (Spencer et al., 2017). While exercising, learning new tasks, and keeping socially active are helpful in brain functioning, these activities would not be possible without the right nutrition to fuel the brain (Morris, 2018). It has been shown that many of the factors that reduce the risk of developing dementia and cognitive decline are also important for a healthy heart. In fact, many of the major cardiovascular risk factors that lead to heart disease and stroke, such as high blood pressure and obesity, have also been linked to an increasing decline in cognitive abilities as we age. While there are medications that can control these conditions, they can be largely controlled through diet. Two established healthy dietary patterns, Mediterranean diet (Med diet) (Panagiotakos et al., 2007), and Dietary Approach to Stop Hypertension (DASH) diets (Sacks et al., 1999) have been shown to improve heart health, and heart health lends to a healthy mind (Morris, 2018), these diets are not specific to the literature on nutrition and the brain. Therefore, a new diet called the MIND diet was designed that incorporated many of the basic components of Mediterranean and DASH diet, but with modifications that reflect the best scientific evidence on nutrition and prevention of dementia (Morris, 2018). These modifications include, specifying berries and leafy greens, which have been shown to improve cognitive function (Morris et al., 2018; Whyte et al., 2018). Research conducted by Dr Martha Morris, who designed the MIND diet, found that those with high MIND diet scores had a 53% lower risk of developing AD, and those with an intermediate MIND diet score had a 35% lower risk of developing AD in older adults over 5 years (Morris, 2015). Interestingly, Morris (2015) also found that the MIND diet was more protective than either the Mediterranean or DASH diet, and that the protective association of the MIND diet score with cognitive decline was almost twice as strong as either the Mediterranean or DASH diet. However, research testing the effectiveness of the MIND diet on cognitive function is needed. The thesis presents the first research to understand MIND diet behaviour and test the effectiveness of the MIND diet on cognitive function on healthy adults at midlife.

1.2 Chapter 2

Chapter 2 presents relevant literature related to the work of this thesis. Given that cognitive function is an important part of this thesis, an overview of cognitive function, ageing and diet is presented first. This is followed by a section on research looking at specific single nutrients and food groups associated with cognitive function, with a focus on experimental studies. This leads on to a section discussing whole dietary patterns and the impact on cognitive function, which was a main focus in the current thesis. The chapter then discusses the uses and limitations of commonly used Social Cognition Models (SCMs), followed by presenting new approaches to intervention design. This chapter provides an informative review on past research on diet and cognitive function, and the use of theory in designing behaviour change interventions, identifying a gap in the literature, paving the way for the aims of this thesis. From this, it was found that theory is not applied extensively to behaviour change interventions and discusses the most commonly used SCMs. Furthermore, this chapter discusses some of the advances in methods for understanding behaviour and designing interventions, such as the Behaviour Change Wheel (BCW), Capability, Opportunity, Motivation and Behaviour (COM-B) model and the Theoretical Domains Framework (TDF). Moreover, how work is advancing in establishing systematic methods for linking theory and Behaviour Change Techniques (BCTs), providing a rationale for the use of the BCW in this thesis. Chapter 2 concludes by outlining the main aims and objectives to be addressed in the following chapters.

1.3 Chapter 3: Systematic Review

Chapter 3 presents a systematic review providing a comprehensive and systematic assessment of the effectiveness and use of social cognition models in dietary interventions that promote “whole dietary patterns”. This review used the Theory Coding Scheme (TCS) to highlight the extent to which theory was used in dietary interventions. A fidelity framework was also used to assess the quality of reported fidelity in each included study. This chapter further helps identify specific gaps in the literature, providing further justification and rationale for the research in this thesis.

1.4 Chapter 4: Behavioural Diagnosis

Chapter 4 outlines the application of the COM-B model to understand MIND diet behaviour in the context in which it occurs and identified barriers and facilitators towards adoption of the MIND diet. The COM-B model is at the core of the Behaviour Change Wheel (BCW)(Michie et al., 2014), an 8 step/3 stage systematic approach in designing an intervention. This chapter uses step 1 of the BCW to understand what needs to change in order for MIND diet behaviour to occur. Findings from this study provide insight into the personal, social, and environmental factors that influence adoption of the MIND diet. The results from this chapter informed the design of the behaviour change intervention in Chapter 6.

1.5 Chapter 5: Rome study

Chapter 5 was an international collaboration, extending the research in chapter 4, to compare barriers and facilitators towards adoption of the MIND diet across two cultures. This research was conducted in in a sample of participants in Italy and compared data to Northern Ireland (Chapter 4). The same methodology was used as that in chapter 4, using the COM-B model to understand MIND diet behaviour. The difference and similarities in barriers and facilitators towards adoption of the MIND diet were presented, highlighting the cultural differences in terms of important factors that need addressed in intervention design. This is important, as an intervention to change MIND diet behaviour in Northern Ireland (NI), may not address the needs of those living in Italy.

1.6 Chapter 6: Methodology: Behaviour Change Wheel

Chapter 6 systematically describes the theoretical framework adopted in the current thesis. It provides a rationale for the decisions to undertake a mixed-method research approach that involved qualitative methods involving individual interviews and focus groups, and a feasibility randomised controlled trial (RCT). This chapter describes the process of designing a behaviour change intervention using the BCW 8 step approach. This included a very brief overview of the findings in chapter 4, followed by the subsequent steps of the BCW process. This approach linked theoretical constructs from the COM-B model to BCTs, drawing on the guidance of the BCW framework (Michie et al., 2014), and relevant literature to support decisions. The next step is to test the feasibility and acceptability of the MIND diet intervention.

1.7 Chapter 7: Randomised Control Feasibility Trial and Evaluation

This chapter implements and evaluates the intervention that was designed in Chapter 6. Firstly, this chapter aimed to assess the usefulness of the intervention to increase capability, opportunity, and motivation in adhering to the MIND diet in 40-55-year olds. Results found that MIND diet adherence was increased over the intervention period, and that the BCW framework was acceptable to design and deliver effective interventions to increase capability, opportunity and motivation to adhere to the MIND diet. Secondly, the intervention aimed to assess the effectiveness of the MIND diet on cognitive function, mood, and quality of life, showing a significant improvement in positive affect and physical quality of life. Thirdly, an evaluation of the intervention was conducted using interviews to assess the acceptability of the intervention.

1.8 Chapter 8: Discussion

This is the concluding chapter of the thesis. In this chapter, a summary of the findings for each chapter is presented, and how each chapter adds to the literature. A reflection on how the aims of this thesis were addressed. The strengths and limitations of this thesis along with recommendations for future research are discussed. Implications for future practice are also addressed.

1.9 References

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Chapter 2

Literature review

2.1 Introduction

In 2020, a demographic milestone has been reached, with the number of people aged over 60 years predicted to outnumber children younger than 5 years old for the first time in recorded history (He et al., 2015; WHO, 2017). Currently, there are 703 million people in the world over the age of 65, and this is predicted to rise to 1.5 billion people by 2050. In 2019, 1 in 11 people were aged over 65 years and this is predicted to rise to 1 in 6 by 2050 (United Nations, 2019). This ageing trend is predicted to continue, with people aged 65 years expected to live on average an extra 17 years, increasing to 19 years by 2050 (United Nations, 2019). The speculated increase in life expectancy results partly due to improvements in socio-economic status, technology, and access to healthcare. However, an increased life expectancy also comes with social and economic challenges. One particular concern is cognitive decline and Dementia. For this reason, emphasis is placed on strategies to promote healthy ageing to reduce the burden of disease later in life.

Current evidence suggests that a healthy lifestyle throughout the lifespan, may reduce the risk or delay onset of cognitive decline (Power et al., 2019). Specifically, evidence continues to grow suggesting that diet and nutrition is important for cognitive function (Valls-Pedret et al., 2015), and maintenance of cognition (Pelletier et al., 2015). There are two basic categories of nutrients. Firstly, the macronutrients (proteins, carbohydrates, and fats), provide energy and the structural components required for cell function (Morris, 2017). Secondly, micronutrients (vitamins and minerals), help protect the cells from damage caused as the brain uses energy to function (Morris, 2017). Many of these nutrients are important for optimal brain functioning including cellular energy production, myelin generation, cell maintenance and repair, and neurotransmitter synthesis (Harms et al., 2011).

It has been suggested that an integral whole dietary pattern such as the MIND diet (Morris et al., 2015), Med diet(Panagiotakos et al., 2007) and DASH diet (Sacks et al., 1999) are particularly beneficial to brain health (Milte et al., 2016; Radd-Vagenas et al., 2017), due to the synergism between nutrients and food groups (Mumme et al., 2019). This literature review will give an overview of some of the single nutrients (B-vitamins, omega-3), food groups (fruit and vegetables) and “whole” dietary patterns (Med, DASH and MIND diet) associated with heathy ageing and cognitive function. This review focused on RCTs exploring the effectiveness of interventions at improving cognition and/or preventing dementia in adults. Secondly, this review will give an overview of the most commonly used psychological theories used to understand, predict, and change dietary behaviour.

2.2 What happens to cognitive function with age?

As we age, our brains are subject to cognitive changes. Cognition is a mental process, acquiring information and understanding through several pathways, such as the senses, our thoughts, and experiences. Two broad groups of cognitive abilities have been proposed by Cattell (1963), which are crystallized and fluid abilities. Crystallised cognitive ability refers to cognitive skills, accumulated knowledge and memories acquired over a lifetime, and these remain preserved or even improve throughout life until a person reaches approximately 60 years old, when they plateau (Harada et al., 2013). Fluid cognitive ability refers to a person’s capability to process novel information and the ability to transform information to complete a task (e.g. reasoning, problem solving, working memory). A general finding is that fluid cognitive abilities may start to deteriorate by the mid-twenties (Thompson et al., 2014). There are several domains that cognition can be divided into, such as, language, memory, perception, planning, decision making and reasoning, with some of these domains remaining relatively stable as we age, such as procedural memory (e.g. remembering how to play an instrument), language and speech (Murman et al., 2015). However, other domains decline with age, such as executive function (e.g. planning), and prospective memory (e.g. remembering to do something in the future) (Murman et al., 2015). When changes start to occur in the brain with ageing the brain can compensate for these initial changes (e.g. using additional brain regions and neural circuity for computational support), allowing individuals to continue functioning normally. Reuter-Lorenz & Park. (2014), showed that older adults required more prefrontal circuitry than younger adults when completing the same working memory task. However, due to both internal and external factors, neural damage increases, and the individual starts to show cognitive decline as the brain no longer can compensate for the changes (Raz, 2009). Further signs of cognitive decline emerge as the effectiveness of neurons ability to communicate with one another decline (Raz, 2009), leading to forgetfulness or poor retrieval of information.

2.2.1 What aspects of cognitive function are affected by neurodegeneration and dementia?

Dementia is an umbrella term used to describe any disease that cause a deterioration or change in memory, thinking skills and ability to perform everyday tasks, that go beyond normal ageing (Power et al., 2019). Dementia is the one of the fastest growing age-related diseases (Power et al.,2019), with 5-8% of the global population over 60 years old living with dementia at any given time (WHO, 2017).

Globally, it is estimated that nearly 50 million people currently have dementia, and this is projected to increase to 152 million by 2050 (WHO, 2017). This has both significant social and economic implications in terms of medical and social care costs to society.

Alzheimer’s Disease (AD) is an irreversible neurodegenerative disease and is the most common form of dementia (60-70% of cases) (Alzheimer’s Association, 2016). In AD, nerve cells eventually die, and brain tissue is lost, due to a loss of connection between cells from a build-up of abnormal structures called plaques and tangles (Alzheimer’s society, 2020). AD is a progressive disease, therefore, more gradual damage of the brain occurs overtime. This leads to the development and worsening of symptoms (Alzheimer’s Society, 2020). Typically, those with AD will have progressive episodic memory loss and cognitive impairment (Dubois et al., 2014). In the early stages of AD, damage is done to the hippocampus in the brain, which affects day to day memory and affects people’s ability to recall recent events and learn new information (Alzheimer’s Society, 2020). As the disease progresses, symptoms may worsen to include problems with reasoning, language, perception and thinking abilities (Alzheimer’s Society, 2020), impacting on the physical, emotional, and financial pressures to families and carers.

Mild Cognitive Impairment (MCI) is an intermediate stage of cognitive decline that can be seen between the normal cognitive changes associated with ageing and early dementia (Power et al., 2019). Those with MCI present with cognitive problems such as language, planning, memory, and attention which tend to decline more rapidly than those with normal ageing cognitive decline. However, these changes do not impact their ability to function normally in their everyday lives (Ray & Davidson, 2014). MCI is common in those over 65 years old, and it has been shown that the prevalence rates of MCI increase with age and lower educational level (Peterson et al., 2018).

People with MCI are more likely to develop dementia, with a rate of transition of 10-15% annually and 50% in 5 years (Farias et al., 2009). MCI and dementia have similar risk factors. Some of which are non-modifiable such as age and genetics, with research showing that those with the APOEε4 allele were twice as likely to progress from MCI to AD compared to non APOEε4 carriers (Fei et al., 2013). However, others can be modified through preventative measures such as diet and exercise (Zhao et al., 2018). Furthermore, MCI can be further differentiated between amnestic MCI (aMCI) and non-amnestic MCI (naMCI). The difference depends on whether memory is impaired and how many domains are impaired (Hughes et al., 2011), with aMCI being highly associated with progression to AD (Albert et al., 2011).

2.2.2 Screening tests for cognitive impairment

The very early stages of cognitive decline may show subtle changes in cognition, with less neuronal damage and more functional reservation (Pan et al., 2020). Detecting individuals with these subtle changes is imperative for dementia prevention and treatment. With a rapid rise in those suffering with dementia, it is important to screen for MCI quickly and accurately, as these individuals are at a higher risk of developing dementia than the normal population (Livingston et al., 2017). There are a range of cognitive tests to measure different aspects of cognition. The Mini Mental State Examination (MMSE)(Folstein et al., 1975), is a widely used cognitive screening test used to map out levels of cognitive functions (Ismail et al.,2010), and assess cognitive domains such as memory, attention, and language. However, while the MMSE has been shown to have good inter-rater reliability and to be a relatively sensitive marker of dementia (Baek et al., 2016), it has been shown to be less useful in detecting MCI (Delavaran et al.,2017). Furthermore, in those with high premorbid intelligence, there is a risk of ceiling effects leading to false positives (Palsetia, Rao,Tiwari, Lodha, & De Sousa,2018). One systematic review found that the MMSE was insufficient for registering subtle changes in cognitive function in those with MCI, especially for detecting dementia in those with a decline in memory such as frontotemporal dementia and primary progressive apraxia (Arevalo-Rodriguez et al., 2015). Similar results were found for the Dementia Rating Scale (DRS) (Mattis, 1988), where specificity was high, but sensitivity was very low in the diagnosis of MCI. This review found that despite lower scores on both the MMSE and the DRS-Memory tests relative to healthy controls, both measures failed to differentiate declining versus stable patients and therefore were not helpful in distinguishing those at risk for conversion to AD (Ivanoiu et al., 2005).

There are also a range of cognitive tests to assess an individual's level of cognitive functioning within different cognitive domains. The Boston Naming Test (BNT) (Kaplan et al., 2001), is a commonly used measure to assess language abilities (Bortnik et al., 2013). Research shows that while the BNT has utility in normal ageing and can distinguish between normal ageing and AD, it is less sensitive in identifying MCI (Balthazar et al., 2008; Brouillette et al., 2011).

Verbal episodic memory was generally considered the best predictor of cognitive decline in MCI (Arnáiz, E., & Almkvist, 2003), and list learning tasks are perhaps the most sensitive measure of episodic memory to assess change in MCI (Rabin et al., 2009). However, cognitive tests across studies differ in sensitivity (Silva et al., 2012). Kave and Heinik (2004) found that the criteria was met for MCI on delayed recall using Rey-Auditory Verbal learning Rest (RAVLT;Schmidt, 1996), however, on the Rey- Osterrieth Complex Figure Test; Spreen & Strauss, 1988) and story recall (Logical Memory I and II from the Wechsler Memory Scale-Third Edition, WMS-III; Wechsler, 1997 tests), participants demonstrated normal performance.

Computerised neuropsychological testing could overcome some of the limitations of paper and pen assessments, such as minimising the floor/ceiling effects, proving a standardised measure of subjective performance which is crucial for an accurate detection of neurodegeneration (Sternin et al., 2019). Also, computerised tests can measure accurately in milliseconds participants response latencies, and report on various aspects of performance simultaneously. Computerised tests may also be shorter in duration and report scores more accurately leading to a greater test sensitivity (Wild et al., 2008). This makes these tests more appropriate for assessing subtle cognitive changes in ageing and detecting mild cognitive impairments as early as possible (Sternin et al., 2019).

The Cambridge Neuropsychological Test Automated Battery (CANTAB) (Cognition, 2017) consists of a range of computerised tests, measuring attention and psychomotor speed, executive function, memory, and social and emotional cognition, and potentially, are more beneficial over conventional pen and paper cognitive test (Barnett et al., 2015). The tests have brain-to-behaviour reliability (Luciana & Nelson, 2002). Recent research has applied CANTAB tests to older adults and found adequate test-retest reliability (Goncalves et al., 2016a; Goncalves et al., 2016b). Construct validity has been obtained from studies with both AD and without neuropsychiatric diagnosis (Goncalves et al., 2018). CANTAB tests have demonstrated sensitivity to detecting changes in neuropsychological performance and have been proven to be a valid tool for the assessment of cognitive function of healthy adults (Pettersen, 2017; Savulich et al., 2019). Furthermore, CANTAB tests also allows for early detection of cognitive impairment (Juncos-Rabadán et al., 2014), and have shown to be sensitive towards cognitive function across a range of clinical groups, such as MCI and dementia (Goldberg et al., 2019; Knight et al., 2018), depression and other mood disorders (Lim et al., 2020; Tickell et al., 2019), and nutrition related disorders (Lelijveld et al., 2019).

Normative cognitive data can help to distinguish pathological decline from normal ageing. Abbott et al. (2019), presented normative data from CANTAB in mid to late life which showed age related cognitive decline across all tests, and that CANTAB measures are sensitive to cognitive change in healthy ageing. Paired Associate Learning (PAL) is a test of episodic memory within CANTAB. Performance in this test is sensitive to AD progression (Nathan et al., 2017). Deterioration in PAL performance has been linked to biomarkers sensitive to disease progression in AD, such as the presence of apolipo-protein E (APOE)ε4 allele (Abbott et al., 2016).

2.3 Single nutrients/food groups

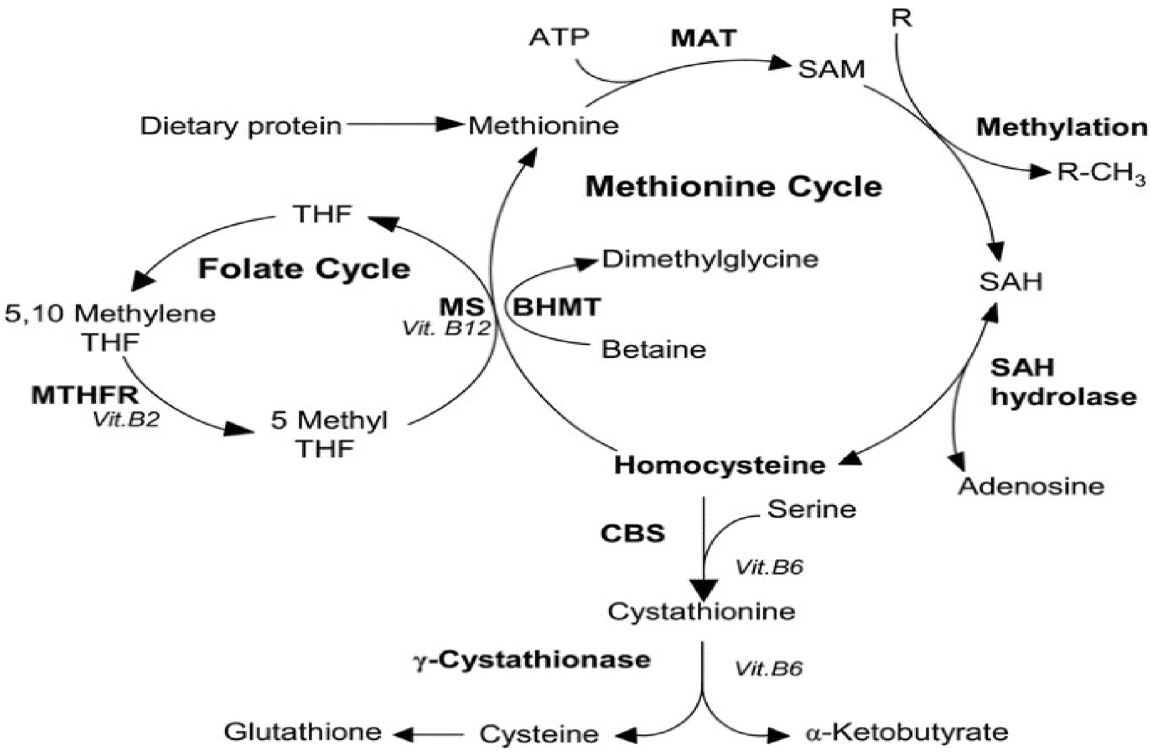
There has been an array of research examining the impact of single nutrients and food groups on cognitive function. The following section examines the role of some of the main nutrients and food groups covered in research on cognitive function.

2.3.1 B-Vitamins and Folate

Folate and the metabolically related B-vitamins, namely vitamins B_{12}, B_6 and B_2, are important for brain function as they can cross the blood brain barrier and are regulated by homeostatic mechanisms in the brain (Spector 2014), which guarantees high concentration levels. Vitamin B_{12} is crucial for normal brain functioning, and one of the symptoms of B_{12} deficiency is memory complaints, such as difficulty thinking, reasoning and memory loss (Tu et al., 2016). Vitamin B_6 has a direct effect on immune function and gene expression (Dakshinamurti et al., 2013), and has a role to play in brain glucose regulation (Anitha et al., 2012). Levels of vitamin B_6 are associated with biomarkers of inflammation, possibly due to its role in the metabolism of tryptophan (Sakakeeny, 2012), which is important as inflammatory processes contribute to the aetiology of dementia and cognitive decline (Ferreira, 2014). Deficiency in any of the B-vitamins is associated with neurological symptoms, including cognitive decline and dementia (Dakshinamurti, 2013). Folate and the related B-vitamins are thought to exert a beneficial effect on cognition through metabolism of homocysteine (an amino acid in the blood), with a deficiency of these vitamins resulting in an increase in homocysteine levels (see Figure 2.1). High levels of homocysteine are negative for brain health due to the inhibition of methylation and the increase of oxidative stress leading to DNA damage and neurotoxicity (Kennedy et al., 2016). As methylation is a key mechanism by which the body deals with toxins, the inhibition of methylation may contribute to disorders such as AD and dementia (An et al., 2019).

Figure 2.1

Homocysteine Metabolism



Homocysteine is methylated to form essential methionine. The reaction of homocysteine re-methylation catalysed by the vitamin B_{12}-dependant methionine synthase captures a methyl group from the folate dependant one carbon pool (5-methltetrahydrofolate). McNulty (2019).

2.3.2 Evidence for effectiveness of B-Vitamins on cognitive function

Cross-sectional and longitudinal studies have shown that high levels of homocysteine increase the risk of cognitive dysfunction (Soni et al., 2018; Smith et al., 2018), and supplementation with B vitamins have been shown to decrease homocysteine levels (Maruyama et al., 2019). RCTs can clarify if the progression of cognitive decline or risk of dementia can be decreased with B-vitamin usage. A recent meta-analysis of RCT's has examined the role of B-vitamin's in improving brain function in those with AD. It was found that while vitamin B_{12} and folate decreased plasma homocysteine levels over a 2 year period, there were no improvements in cognition as measured with the Dementia Rating Scale (DRS) (Mattis, 1988), Neuropsychiatric Inventory and the Cornell Scale for Depression in dementia (Albrahim et al., 2020). This finding supports other reviews reporting reduced homocysteine levels with B-vitamin supplementation but no effect on cognition in adults with AD (Li et al., 2014; Zhang et al., 2017), with or without cognitive impairment (Ford et al., 2019) as measured with MMSE. However, both the MMSE and the DRS have been criticised for having low sensitivity in the diagnosis of MCI (Delavaran et al., 2017), and have been considered unhelpful in distinguishing those at risk for conversion to AD (Ivanoiu et al., 2005).

A recent meta-analysis (Suh et al., 2019) on the efficacy of nutrients on cognitive function in non-demented adults found that B-vitamins (vitamin B6, 12 or folate) consumed over a three-month period was beneficial for global cognition and episodic memory for those with MCI. The latter review only found one study showing an insignificant beneficial effect of B-vitamins for those with normal cognitive functioning making it difficult to draw any meaningful conclusions. However, it was concluded that, identification of protective effects of B-vitamins on cognitively heathy adults is not expected as cognitive decline is not occurring. However, the protective effect may be more noticeable in those with MCI, which is what this review found (Suh et al., 2020).

Kwok et al. (2019) conducted an RCT to assess the effectiveness of vitamin B_{12} and folic acid with adults over 65 years with MCI. In this study, participants were randomised to either the intervention group, where they consumed folic acid and vitamin B12 daily (methyl cobalamin 500 µg and folic acid 400 µg) for 2 years or to a placebo group. While it was shown that B-vitamin supplementation lowered serum homocysteine, no significant reduction in cognitive decline was found over 2 years measured by the Chinese version of MMSE (Chiu et al., 1998), Clinical Dementia Rating Scale (CDR)(Lam et al., 2008). However, it was noted that the small sample size in this study was insufficient to detect a difference in cognitive function. Furthermore, the sensitivity of the MMSE for registering subtle changes in cognitive function in those with MCI has been shown to be insufficient ((Arevalo-Rodriguez et al., 2015). Therefore, it would be more effective and appropriate to use a cognitive test that is more sensitive to cognitive change, such as CANTAB (Abbott et al.,2019).

There are several methodological factors attributable to the null findings of studies examining the effects of B-vitamins on cognitive function. First, as already mentioned, the insensitivity of cognitive tests could affect the outcome of studies. Also, the cognitive status of participants at the start of the study, duration of study and pooling of data obscuring the positive findings from more rigorous studies could all affect the outcome of studies (McCaddon et al., 2015).

2.3.3 Omega-3 fatty acid and fish

Omega 3 polyunsaturated fatty acids are primarily derived from fish and consist of eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), and *a*-linoleic acid (ALA) (Lv et al., 2020). Omega-3 may be associated with better cognitive function through a direct influence on neuronal membrane integrity (Smith et al., 2016). Both the structural integrity and functionality of neurons are supported when the brain is enriched with DHA (Smith et al., 2016). DHA is a long chain fatty acid and is gathering interest, as it has been correlated with protection against oxidative stress (Meital et al., 2019), which is associated with cognitive decline (Baierle et al., 2015). Not only does omega-3 have modulatory effects on the nervous system, higher levels of omega-3 in the diet seems to have a neuroprotective effect (Nobre et al., 2016).

Raji et al. (2014) found that weekly consumption of fish was positively associated with brain structural integrity, specifically in the gray matter of the hippocampus, praecuneus, posterior cingulate, and orbital frontal cortex in cognitively healthy adults over 65 years old. These parts of the brain are responsible for memory and cognition in healthy adults (Raji et al., 2014). This study also found, that while volumes in the brain regions were associated with fish consumption, they were not associated with omega 3 fatty acids, suggesting that it is the consumption of fish and not the biological factors that can affect the structural integrity of the brain. However, the cognitive benefits of fish consumption may be due to various nutrients in fish other than fatty acids, such as vitamin D, B-vitamins, and selenium (Chowdhury et al., 2012). In fact, findings from RCTs on supplementation with omega 3 fatty acid and cognitive change, suggest that the cognitive benefits from the nutrients in fish may not be limited to omega 3 alone (Qin et al., 2014). This study has important implications for clinicians and researchers in the development of preventative strategies in cognitive ageing.

2.3.4 Evidence for effectiveness of omega-3 fatty acid/fish on cognitive function

Multiple prospective studies have reported that greater fat intake is associated with cognitive decline (Cao et al., 2019; Ding et al., 2018), whereas increased omega-3 (Cook et al., 2019) and fish consumption (Zhang et al., 2015) was associated with less cognitive decline and lower incidence of dementia (Wu et al., 2015). Despite promising results from observational studies, RCT results are less clear, showing mixed results for the benefits of omega 3 and cognitive function (Sydenham et al., 2012).

There are mixed results in the literature on the effects of omega-3 on cognition in healthy adults, with some studies observing improvements in cognition and some studies observing no positive effects (Flodgren & Berg, 2016). One RCT (Wittle et al., 2014) tested the effects of omega 3 supplementation on cognition on healthy adults. Sixty-five participants were randomised to either the omega 3 supplementation group or a placebo group for 20 weeks. Results found that those in the intervention group significantly enhanced executive function measured by the Stroop test ((Stroop, 1936) and Trail Making Test Part A and B (Reitan et al., 1986). Furthermore, it was found that an increase in executive function was correlated with omega 3 index and brain derived neurotrophic factor (BDNF), underlining positive effects of EPA and DHA on neuronal functioning (Wittle et al., 2014). Other research found improvements in a range of cognitive measures, including executive function, episodic memory, reaction time and visual recognition memory in healthy adults aged 50-75 years old (Kulzow et al., 2016; Yurko-Mauro et al., 2010). In contrast, research found no significant benefit of omega-3 on psychomotor speed, executive or episodic memory, and fluid intelligence in healthy adults at mid-late life over 18 weeks. However, participants in this study were well educated and above average IQ. Furthermore, cognitive functioning may be more stable at midlife, resulting in less intervention effects. Moreover, it is unclear in the literature the optimal intake of DHA for brain health, and therefore, 400mg daily, which was provided in this study, may be insufficient. However, Danthiir et al. (2018), 18-month RCT with older adults, found no improvement in cognitive performance with 1720mg of DHA daily.

Clinical trials conducted on those with dementia also observe mixed results. While some experimental studies have shown a positive effect of omega-3 on cognitive performance (Eriksdotter et al., 2015). There is a general consensus that omega-3 supplementation does not improve cognitive function in those with dementia (Power et al. 2019). A recent meta-analysis found no evidence that omega 3 supplementation improved cognitive function in those with AD (Araya-Quintanilla et al., 2020). This finding is supported in other reviews. Burckhardt et al. (2016), found no benefit of omega 3 on cognition over 6 months in the treatment of AD. However, one systematic review found a beneficial effect of omega 3 on cognition in those with MCI but not AD (Marti et al., 2019; Mazereeuw et al., 2012). One possible explanation for this is found in Quinn et al. (2010) RCT of DHA supplementation in individuals with mild to moderate AD. This study found no benefit of DHA to slow cognitive decline compared to a control group. However, in an exploratory analysis, it was found that those who were negative for APOEε4 showed a benefit on the cognitive tests, and that this protective effect in dementia patients may be confined to APOEε4–negative individuals (Whalley et al., 2008).

In fact, there is stronger evidence for experimental studies examining adults with MCI. A systematic review (Marti et al., 2019), reviewed 4 studies with the effects of omega-3 in participants with MCI. Three of the four studies found an improvement over 12 months in short term and working memory, immediate verbal memory and delayed recall capability (Philips et al.,2015), working memory (Bo et al., 2017; Zhang et al., 2017) and overall score on the Basic Cognitive Aptitude Tests (BCATs), measuring perceptual speed, space imagery efficiency and working memory over a 6 month period (Bo et al., 2017). Stavrinou et al. (2020) found that high doses of omega-3 improved global cognition score measured by MMSE and Addenbrooke's Cognitive Examination -Revised (ACE-R) (Mioshi et al., 2006) over 6 months. However, this study also supplemented with omega-6 and antioxidants, and with the higher dosage of supplementation compared to other studies, this may have added to the beneficial effect.

There are various reasons for discrepancies between studies. These include different doses and quality of omega-3 used and the difference in weight ratio between the individual DHA/EPA. DHA is the most important omega-3 PUFA in the brain, therefore, it has the potential to protect older adults who are at risk of cognitive impairment and dementia (Dyall et al., 2015). Further discrepancies around homogeneity of the populations in terms of cognitive status, cognitive tests employed, diversity of participants and also the limitations of each trials.

2.3.5 Fruit and Vegetables

Fruit and vegetables contain high levels of vitamins, antioxidants, flavonoids, and other bioactive substances. These compounds provide neuroprotective properties by modulating cholesterol synthesis, detoxifying enzymes and stimulate the immune system (Lampe et al., 1999). Previous research shows that higher consumption of vegetables are associated with reduced risk of cognitive impairment (Mottaghi et al., 2018;). However, while improved cognitive function in the elderly (Zielińska et al., 2017) and higher consumption of fruit and vegetables in young adulthood is associated with better cognitive function in midlife (Mao et al., 2019), the strongest association is observed for leafy greens (Kang et al., 2005; Morris et al., 2006; Morris et al., 2018). This association may be due to the neuroprotection actions of nutrients such as lutein and folate found in leafy greens, which previous research has found to improve cognitive function (Morris et al., 2018; Renzi-Hammond et al., 2017). Lutein in particular has strong antioxidant and anti-inflammatory properties which may counter the effects of age-related oxidative stress and neuroinflammation (Heneka et al., 2015), resulting in an increased chance of preserving brain health and supporting successful aging (Rosano et al., 2012). Furthermore, lutein may enhance inter neural signalling at gap junctions (Stahl &Sies, 2001), and improve cellular communication by altering gene expression (e.g., connexin 43; Bertram, 1999)

Previous research on cognitive function or dementia do not observe protective effects for overall fruit consumption (Chen et al., 2012; Nooyens et al., 2011), however, berries were shown to improve memory and learning in animal models (Willis et al., 2009), and improved executive function in young adults (Whyte et al., 2019). Also, findings from the Nurses' Health Study (Devore et al., 2012), demonstrated that berries slowed cognitive decline, particularly in global cognition and verbal memory. This study found that over a 6-year period in adults over 70 years, higher and long-term intake of berries was associated with slower rates of cognitive decline, with delayed cognitive ageing by up to 2.5 years. Support for this claim is found in, Agarwal et al. (2019) which states that berry-derived anthocyanidins, which are a subclass of flavonoids that give berries their red and blue colours and have been shown to exhibit potent anti-inflammatory and antioxidant properties (Alvarez-Suarez et al., 2014), are capable of both crossing the blood–brain barrier and localizing in brain regions involved in learning and memory. The anthocyanins have been shown to reach the central nervous system directly to deliver their antioxidant and anti-inflammatory capabilities, which may reduce age related deficits in brain function, by enhancing the neuro- signalling pathways associated with memory (Ali et al., 2018).

2.3.6 Evidence for effectiveness of fruit and vegetables on cognitive function

There are mixed results for the benefit of fruit and vegetables on cognitive function in the literature**.** Recent research has found that daily consumption of both fruit and vegetables was associated with reduced risk of cognitive impairment (An et al., 2019). However, other research has reported that cognitive disorders were related to vegetables only (Morris et al., 2006; Kang et al., 2005; Vizuete et al., 2010), fruit only (Jiang et al., 2017) or none of them (Mottagi et al., 2018). In terms of experimental designs, there is very little research examining the effects of fruit and vegetable intake on cognitive outcomes.

Neshatdoust et al. (2016) conducted a RCT over an 18-week period with 40 healthy adults with an average age of 68 years old. This study examined the effects of high and low portions of flavonoid rich fruit and vegetables against a control on cognitive function using a battery of tests to measure executive, episodic, working, spatial, implicit memory, attention, information processing speed and psychomotor speed. Results found a significant improvement in global cognitive function in the high flavonoid group compared to the low flavonoid and control group. However, Kwok et al. (2012) examined whether a dietary intervention promoting fruit and vegetables was effective in preventing cognitive decline. This study recruited 429 non-demented adults with an average age of 83 living in old age hostels over a 2-year period. The intervention group received dietary support from dieticians promoting the "brain preservation diet", with a target of 2 portions of fruit and 3 portions of vegetables a day. Cognitive decline was measured by the Clinical Dementia Rating Scale (CDR) (Morris et al., 2001), Chinese Mini Mental State (MMSE) (Chiu et al., 1998) and the Category Fluency Test (CFT)(Strauss et al., 2006). Results found that although fruit intake was maintained over the intervention period, the risk of cognitive decline was not significantly reduced. However, one possible reason for this, is that fruit intake at baseline was high and so the magnitude of change was small.

While there is little evidence for fruit and vegetables relating to cognition, there is recent evidence to show that individual fruits such as berries or berry supplementation have a positive impact on cognitive function (Dodd et al., 2019).

Interventions with healthy older adults found that berry supplementation over 6 weeks (Schrager et al., 2015), 3 months (Miller et al., 2018) and 6 months (Whyte et al., 2018), improved measures of episodic memory and executive function, and improved working memory over a 5 week period with a mixed berry drink (Nilsson et al., 2017). Furthermore, research has found that in those suffering cognitive impairment, interventions have been particularly effective in improving episodic memory following blueberry supplementation (Krikorian et al., 2010; McNamara et al., 2018) or grape supplementation (Krikorian et al., 2012; Krikorian et al., 2010), suggesting that episodic memory is particularly sensitive to berries and in those with cognitive dysfunction, the effects of the berries may be particularly strong. This may be due to elevated or sustained levels of Brain Derived Neurotropic Factor (BDNF) (Neshatdoust et al., 2016) following flavonoid-rich interventions. BDNF is known to be involved in hippocampal function related to episodic memory and may enhance neuronal connections or neuronal growth (Bell et al., 2015) leading to the improved memory performance.

2.4 Dietary Patterns

2.4.1 Neuroprotective properties of the Mediterranean, DASH and MIND Diet

It is thought that the Med, DASH and MIND diet can provide neuroprotection, however, the underlying mechanisms are not fully understood. Despite the array of research investigating single nutrients and food groups with cognitive function, it has been suggested that an integral whole dietary pattern is more beneficial (Milte et al. 2016; Radd-Vagenas et al., 2017.), due to the synergism between nutrients and food groups (Mumme et al., 2019). The Med diet consists of foods abundant in antioxidants, vitamins, phytonutrients such as polyphenols, and carotenoids that are associated with neuroprotective effects (Abbatecola et al., 2018), and reduced systemic inflammation (Galland et al., 2010). The diets high monounsaturated fatty acid (MUFA) content is shown to be attributed to its beneficial effect (Solfrizzi et al., 2006). These diets have been associated with lower plasma levels of inflammatory markers (Bonaccio et al., 2017; Smidowicz et al., 2015; Soltani et al., 2018). As inflammation is a risk factor for cognitive impairment (Engelhart et al., 2004), with high levels of inflammatory markers such as interleukin-6 and C-Reactive protein associated with greater cognitive decline, suggesting that diet has an impact of inflammation and therefore indirectly affecting cognitive health (Ozawa et al., 2017). The neuroprotective effects of these diets may also be mediated by suppressing the effects of oxidative stress (Billingsley & Carbone, 2018) and increase cerebral blood flow, both of which, are key factors in the pathogenesis of normal cognitive ageing and chronic neurodegenerative change (Liguori et al., 2018).

2.4.2 Mediterranean Diet

The Med diet incorporates the traditional healthy food habits of people living in countries bordering the Mediterranean Sea, such as Italy, Spain, Greece, and France. The Med Diet varies by country, but, in essence, it is characterised by a high intake of plant food (fruit, vegetables, cereals and legumes), olive oil as the main source of fat, a moderate intake of fish, a low to moderate intake of dairy products and alcohol, a low intake of saturated fats, meat and poultry. Adherence to the Med Diet is determined by a composite score of foods and nutrients. A higher score generally is indicative of better adherence to the diet.

2.4.3 The evidence for effectiveness of the Mediterranean Diet on cognitive function

The general consensus regarding the Med diet, is that higher adherence is associated with better global cognition (Shannon et al 2019), better cognitive performance at midlife (McEvoy et al.2019), lower dementia rates (Anastasiou et al., 2018), reduced risk of progressing from MCI to AD (Singh et al., 2014), and adherence to the Med diet in midlife was associated with a lower risk of cognitive impairment in later life at a 20 year follow-up (Wu et al., 2019).

To date, there are only a few RCT's investigating the effectiveness of the Med Diet on cognitive outcomes in cognitively healthy older adults (Martinez-Lapiscina et al., 2013; Valls-Pedret et al, 2015; Knight et al., 2016; Marseglia et al., 2018), midlife adults (Wardle et al., 2000; Wade et al.,2018) and young adults (Lee et al., 2015; McMillan et al., 2011), and only one RCT assessed cognitive outcomes in those with neurodegenerative disorders (Paknahad et al., 2020).

Two of these RCT's emerge from the overarching PREDIMED (PREvención con DIeta MEDiterránea) study. Martinez-Lapiscina et al., (2013) conducted a parallel-group RCT to test the effectiveness of two Med diets (one of the diets was supplemented with extra virgin oil (EVO) and the other with mixed nuts) compared to a low fat group, on the cognitive performance among 522 elderly Spanish participants at high cardiovascular risk. Results found that global cognitive performance scores indicated by the MMSE and Clock Drawing Test (CDT) were significantly higher for participants in the Med diet intervention groups (EVO+NUTS), than those in the control group over 6.5 years intervention period. Similarly, Valls Pedret et al., (2015) conducted a parallel-group RCT with 447 older Spanish men and women at high risk of cardiovascular disease over a 5-year period. This study found that those in the Med diet (EVO) group scored significantly higher in episodic memory measured by the RAVLT compared to controls. No other significant differences across cognitive domains were observed between groups. However, this study created three composite scores of: memory, frontal and global cognition. Those in the Med diet supplemented with nuts improved on memory composite score over time than those in the control group. Participants in the Med diet supplemented with EVO improved on frontal and global composite scores overtime than those in the control group. The findings from these two studies have important implications. As there is a lack of effective treatment for cognitive decline, there is a need for preventative measures to delay or minimise the effects of neurodegeneration, and these studies show that consuming a Med diet supplemented with olive oil and nuts in older adults, may counter the effects of cognitive decline.

RCT's examining the effectiveness of the Med diet and cognitive function at midlife have found a significant improvement in processing speed over an 8-week period among those at risk of cardiovascular disease (Wade et al., 2018). However, other research at midlife found no improvements with cognitive function over a 12-week intervention (Wardle et al., 2000), or with healthy participants over a 6-month intervention (Knight et al., 2016). Several factors could contribute to these inconsistent findings between studies. Not only was the study duration short, especially for detecting change in cognition, but the Med diet in Knight et al. (2016) was modified based on participants cultural foods (Australian) rather than the conventional Med diet, which could have impacted the results on cognitive function in the intervention group. Furthermore, it is possible that some associations between diet and cognitive function do not show during midlife (Nooyens et al., 2011).

Two further RCT's were conducted with young adult (19-30 years old) females over a 10-day period and found mixed results for cognitive function. Both studies used a battery of tests to measure attention, working memory, long-term memory, and executive function. Results found an improvement in immediate and delayed memory (Lee et al., 2015), and word recall and numeric working memory (McMillian et al., 2011). However, reaction time improved in the control group and not the intervention group post intervention (McMillian et al., 2011), and reduced accuracy in the 3 back working memory task in the intervention group compared to the control group (Lee et al., 2015). In the latter study (Lee et al. 2015), participants were randomly assigned to either the Med diet group or no diet change group for 10 days before switching to the other condition for a further 10 days. However, with no wash out period between the two conditions, it is possible that some of the effects remained for those who underwent the Med diet first. Nevertheless, evidence suggests that the Med diet is associated with improved cognitive function. However, it is important to consider that the above studies exhibit profound differences in methodology; namely target population (midlife and older adults), study design, duration of follow-up (ranging from 10 days to 6.5 years) and cognitive tests, all of which could affect outcomes on cognition. Taken together, these findings are important for researchers and those in clinical settings in determining preventative strategies for cognitive decline.

2.4.4 Limitations of the Mediterranean Diet

The Med diet is one of the most widely studied dietary patterns. It is important to highlight limitations, in particular, the scoring system used to determine dietary intake are inconsistent across studies. Various ways to determine a dietary pattern include, *a priori* scoring systems, *a posteriori* dietary pattern formation, food diaries, food pyramids, general descriptions (Kafatos et al., 2000) with different scoring criteria across several priori Med diet score (Trichopoulou, et al., 2003; Panagiotakos et al., 2006; Milà-Villarroel et al., 2011). In Sofi et al. (2014) systematic review, collected and compared data from 26 cohort studies utilising one of Med diet scores. Results found a wide range of cut off points for major food groups such as cereals and vegetables, even among cohorts from the same country. Milà-Villarroel et al. (2011) evaluated 10 priori Med diet indices and found a wide adherence range between 22.7-87.7% with poor correlation between most indices, implying the definitions of the components of the Med diet used to calculate scores are different. These scores may not be applicable to people living outside the Mediterranean with different lifestyles, as they have mainly been tested in Mediterranean populations (Trichopoulou, et al., 2003; Panagiotakos et al., 2007). Future research with different cohorts in other countries are needed to strengthen the evidence for these indices. Furthermore, it may be useful to combine both a prior and posterior dietary pattern to better understand the relationship between cognitive decline and eating patterns (Alles et al., 2012). To achieve a higher level of evidence, further internal validation of patterns is needed. For example, describing these dietary patterns in relation to biomarkers would add considerable support to their interpretation (Alles et al., 2012).

2.4.5 Dietary Approaches to Stop Hypertension (DASH) diet

The DASH diet was developed to treat or prevent hypertension and had been shown to effectively lower blood pressure in those with hypertension (Saneei et al., 2014). The DASH diet is characterised by high consumption of fruits, vegetables, wholegrains, fish, poultry, nuts, low fat dairy and low consumption of sweets, fats, and red meat. Compared to the Med diet, the DASH diet requires high intake of low-fat dairy (Berendsen et al., 2017).

2.4.6.Evidence for the Dietary Approaches to Stop Hypertension (DASH) diet on cognitive function

The DASH diet (Dietary Approaches to Stop Hypertension) (Sacks et al., 1998), a less studied dietary pattern in relation to cognitive function, has demonstrated that higher adherence to the diet is associated with less cognitive decline in episodic, semantic and working memory (Tangney et al., 2014), and executive function memory learning and psychomotor speed (Smith et al., 2010). However, in menopausal women aged over 65 years, adherence to the DASH diet was not associated with cognitive decline over 9-year period (Haring et al., 2016). Furthermore, while the DASH diet was associated with better average cognition in older adults, there was no improvement in cognitive decline after 10.6 years follow up (Wengreen et al., 2013).

In terms of experimental evidence, Smith et al. (2010) conducted an RCT to examine the effects of the DASH diet on cognition in cognitively healthy older adults over a 4-month period. Participants were randomised into DASH diet alone, DASH with behavioural weight management program including exercise or usual diet control group. Participants were assessed for executive function-memory-learning (EFML) and psychomotor speed before and after a 4-month intervention. Participants in both DASH groups improved psychomotor speed but only those in the additional behavioural weight management with DASH improved in EFML. Furthermore, it was found that exercise and weight loss mediated neurocognitive improvements.

More recently, Blumenthal et al. (2020) conducted an RCT with 160 older sedentary adults with cognitive impairments with no dementia. Participants were randomised into one of four groups: exercise, DASH diet, combined exercise with DASH diet or control group for 6 months. The cognitive domains measured were; executive function assessed by the Trial-Making Test (TMT) (Reitan et al., 1986), the Stroop Colour and Word Test (Stroop, 1936), Digit Span Forward and Backward subtest from the Wechsler Adult Intelligence Scale (WAIS)(Scale , 1955),the Digit Symbol Substitution Test from the WAIS (Scale, 1955) and the Ruff 2 and 7 Selective Attention Test (Ruff et al., 1992). Memory was assessed by the Hopkins Verbal Learning Test-Revised (Brandt et al.,1991), and the Medical College of Georgia Complex Figure Test (Ingram et al.,1997), and language/verbal fluency was assessed by the Controlled Oral Word Association Test and the Animal Naming Test. It was found that those in the exercise group and to a lesser extent those in the DASH diet group, demonstrated better executive function post intervention compared to the control. Both these RCTs show that exercise has beneficial effects for cognitive function in older adults and that adding a healthy dietary pattern such as the DASH diet could provide added benefits for the cognitive health of older adults.

2.4.7 MIND Diet

Both the Med and DASH diets demonstrated protective effects on cardiovascular conditions that can adversely affect brain health. However, their dietary components may not specifically capture the levels and types of foods to optimise brain health (Morris et al., 2015). Therefore, the MIND diet was designed to emphasize the dietary components and servings linked to neuroprotection and dementia prevention (Morris et al., 2015). The MIND diet consists of 10 healthy foods (leafy greens, other vegetables, nuts, berries, fish, poultry, olive oil, beans, whole grains, red wine) and 5 other foods which are to be limited (red meat, butter, cheese, pastries and sweets, fried foods).

2.4.8 Evidence for the effectiveness of the MIND diet on cognitive function

There has been limited research investigating the MIND diet, as this diet is relatively new. However, recent research with older adults found that the MIND diet can slow cognitive decline over an average of 4.7 years (Morris et al., 2015). This study found that the MIND diet score was more predictive of cognitive decline than either the Med diet or DASH diet. Research found a 53% lower risk for AD with high adherence to the MIND diet (Morris et al., 2015). Furthermore, a 35% lower risk of AD was shown for a moderate adherence to the MIND diet (Morris et al., 2015), whereas no significant association with AD was shown for the Med or DASH diet (Van Den Brink et al., 2019). Further support for a lower risk of cognitive decline with both moderate and high adherence to the MIND diet was shown in Adjibade et al. (2019). This study showed that 72% of the large sample (6011) adhered at least moderately to the MIND diet. Interestingly, recent research found that the MIND diet and not the Med diet, protected against 12-year incidence of MCI and dementia in older adults (Hosking et al., 2019). A longitudinal study with older adults found higher adherence to the MIND diet was associated with less cognitive decline after a 6 year follow up (Shakersain et al., 2018) and that greater long-term adherence to the MIND diet was associated with better verbal memory over 6 years in older adults (Berensden et al., 2018). To date, there is only one RCT that examines the effect of the MIND diet on cognitive performance in obese women (Arjmnd et al., 2020). This study recruited 37 females at midlife and randomised to take part in a calorie restricted modified MIND diet or control group. This study found that adherence to the MIND diet had a significant positive effect on the Forward Digit Span Task and Backward Digit Span Task, which were used to measure verbal short term memory. In addition, this study also found an improvement in Trail making test A, that is considered as executive function, as well as verbal recognition memory concerning better performance on Auditory Verbal Learning Task. The results from this study showed that the effects were specific for those participants with little or marked weight loss. This finding highlighted the impact on dietary patterns and cognitive performance simultaneously.

Nutrition is an important modifiable risk factor of cognitive function. The evidence presented in this literature review suggests that certain individual nutrients and food groups such as B-vitamins, omega-3 fatty acids, and fruit and vegetables potentially benefit cognitive function. However, this review focused mainly on experimental studies, and mixed results were found for the benefit of omega-3 and fruit/vegetables on the cognitive function of healthy adults and those with dementia. However, stronger evidence for experimental studies examining adults with MCI was found for omega-3 and berry consumption. No effect was found for the benefit of B-vitamins on cognitive function in healthy adults or those with AD. Generally, it was found that while vitamin b supplementation decreased plasma homocysteine levels, there were no improvements in cognitive function. However, mixed results found for those with MCI, with improvements found in global cognition and episodic memory. Stronger evidence exists for whole dietary patterns, such as the Med, DASH and MIND diet, than for individual nutrients and food groups. The literature suggests, that from the three whole dietary patterns, the MIND diet slows cognitive decline over and above the effect seen with the other two diets. Overall, while the underlying mechanisms are not fully understood, this review found positive relationships between dietary patterns that are abundant in antioxidants, vitamins, rich in poly/monounsaturated fatty acids, with reduced consumption of saturated fat and process food and cognitive function in adults

2.5 Theoretical models

2.5.1 Use of theory for intervention design

In designing behavioural interventions, it is essential to have adequate knowledge of not only the behavioural factors, but also the environmental, biological, and psychosocial factors influencing healthy behaviours. These predictors are explained in behaviour change theories and aim to both clarify the nature of health behaviours and the motivating factors associated with them. This helps support not only the development of behaviour change interventions but help understand and identify what intervention components work well, providing evidence for improving intervention design in different contexts. The existing body of theory can only advance if the interventions and evaluations are theoretically informed (Michie et al., 2008).

However, research shows that designing, evaluating, and reporting interventions that are not explicitly theoretically informed are widespread (Painter et al, 2008). Davies et al. (2010), conducted a meta-analysis with 235 implementation studies, and found that only 22.5% of the studies explicitly used behaviour change theories. Furthermore, when theory was used, it was rarely rigorously applied to the design and evaluation of an intervention (Prestwich et al., 2014). In Prestwich et al. (2014) review of 190 studies to increase healthy eating and physical activity, 56% of included studies reported using theory, but only 10% reported that theoretical constructs were used to select the most appropriate BCTs.

Moreover, there is some debate whether explicitly theory informed interventions are more likely to be effective than those that are not. Some research has shown a positive association between theory use and effectiveness (Taylor et al., 2012; Webb et al., 2010). However, one meta-analysis found no association between dietary intervention effectiveness and theory use (Prestwich et al., 2014), while another review found a negative association (Gardner et al., 2011). A possible explanation for the mixed results is that intervention designers may have chosen a theory not appropriate to their study. For example, when examining a behaviour that is influenced by habit, then a theory that focusses on beliefs and reflective thought may not be appropriate when designing interventions (Conner & Norman, 2015), as the model may not assess the impact of the determinant unique to that behaviour (Conner & Norman, 2017). A second explanation may be that theory has been poorly applied to the design of the intervention, such as only targeting a few of the theoretical constructs (Prestwich et al.,2014). To address this, the theory coding scheme (TCS) (Michie and Prestwich, 2010), was developed to evaluate the extent theory has been used in the design of interventions and evaluations. The TCS contains 19 items and provides a reliable tool to describe the theoretical base of interventions (Michie & Prestwich, 2010). With specification of theory use, researchers should be able to predict, explain and change behaviour (Conner and Norman, 2015).

2.6 Social cognition approach to health behaviour

Social cognition models are widely used for predicting and changing health behaviour (Conner and Norman, 2015; Rejeski et al., 2019). They guide the identification of key cognitions that distinguish between those who do and do not perform health related behaviours (Abraham et al., 2008). The most commonly used SCMs used to understand and predict behaviour are: Theory of Planned Behaviour/Theory of Reasoned Action (TPB/TRA) (Ajzen et al., 1991; Fishbein and Ajzen et al., 2010), Health Belief Model (HBM) (Becker et al., 1974), Social Cognitive Theory (SCT) (Schwarzer et al., 1992), Health Action Process Approach (HAPA) (Schwarzer et al., 2008) and the Transtheoretical Model (TTM) of behaviour change (Prochaska and DiClemente, 1984). Furthermore, SCMs are made up of behavioural constructs that interventions target in order to change behaviour. These models assume human behaviour to be rational and thus behaviour is the result of rational decision making based upon deliberate, systematic processing of the available information (Conner & Norman, 2015). Most of the SCMs assume that individuals base their decisions on behaviour by weighing up the cost and benefits of differing actions. The general assumption, is that individuals aim to increase utility and therefore, prefer to engage in behaviours that are associated with maximum expected utility (Conner & Norman, 2015). Behaviour has different subjective expected utilities because of the value of the different outcomes associated with different behaviours and probability of each behaviour being associated with each outcome. While models allow for subjective assessments of both utility and probability, it is assumed these assessments are combined in a rational consistent way. Such judgements underlie many of the SCMs, and while they may provide good predictions of health behaviours, it is argued that it does not provide an adequate description of the way in which individuals make decisions (Van der Pligt et al., 2000). The next section will give a brief overview of the main social cognition models used in health psychology to predict and understand behaviour and behaviour change.

2.6.1 Health Belief Model (HBM)

The HBM was developed by Rosenstock (1966) and has been used to predict a variety of health behaviours including dietary behaviour. According to the HBM, behaviour is the result of a set of core beliefs; susceptibility and severity of illness, the costs, and benefits of carrying out the behaviour, cues to action, health motivation and perceived control. Therefore, people will follow dietary advice if they are motivated and believe they are susceptible to disease. That this susceptibility may affect their life; that by following the dietary advice may decrease their vulnerability; the benefits outweigh the harms (Rosenstock, 1966). HBM's determinants predict approximately 20% of variance in healthy behaviour (Cohen, 1992), leaving 80% of the variance unaccounted for. However, more recently, research has extended the HBM to include other determinants of behaviour such as self-identity, perceived importance, consideration of future consequences, and concern for appearance. The extended HBM model led to predict approximately 71% of variance in healthy behaviour (Orji et al., 2012).

2.6.2 Theory of Planned Behaviour/Theory of Reasoned Action (TPB/TRA)

The Theory of Planned Behaviour (Ajzen et al., 1991), which is an extension of the Theory of Reasoned Action (Fishbein and Ajzen, 1975)), is of the most widely used model to predict behaviour. This model states that behaviour can be predicted by two variables: intention and perceived behavioural control (PBC). Intention is viewed as the most important precursor to actual behaviour. PBC represents a person's perception of actual control over their behaviour. PBC has both a direct effect on behaviour and an indirect effect through intention. Intention itself is also determined by three factors: 1) attitudes, which is an evaluation of behaviour and beliefs about the outcome; 2) subjective norm (SN), an evaluation of whether significant others think they should engage with the behaviour, and attitudes; 3) perceived behavioural control, the extent to which an individual perceives a behaviour to be easy or difficult. Therefore, regarding healthy dietary patterns, according to the TPB, if an individual believed that eating a healthy diet would be beneficial to their health and believed significant others wanted them to eat healthy, and they believed they were capable of doing so, this would predict high intentions to eat a healthy diet.

Although the TPB has been found to be useful in predicting dietary behaviour with 21.1% of the variance, that still leaves 79.9% unexplained. It has been suggested by critics that the TPB only reliably measures intentions rather than actual behaviour (Schwarzer, 2014) and whether it should be retired altogether (Sniehotta, Presseau, & Araújo-Soares, 2014).However, in response to criticism, many researchers added variables to the existing model in an effort to improve the predictive ability of the model. One of these variables is “anticipated regret” (e.g., Abraham & Sheeran, 2004; Payne, Jones, & Harris, 2004), and has been found to contribute variance in the prediction of a range of health behaviours (Brewer et al., 2016; Sandberg et al., 2016), including dietary behaviour (Lash et al., 2016), contributing a further 7% of the variance in intention and 1% in behaviour (Sandberg and Conner, 2008).

2.6.3 Social Cognitive Theory (SCT)

SCT was developed by Bandura (1986) and has been used extensively to predict and change health behaviours (Torkan et al., 2018). The model states that 3 interacting elements lead to learning and action, which are (1) the person (cognitive, affective, beliefs, outcome expectations, and self-regulation), (2) the environment (social settings, other individuals, reinforcements), and (3) individuals behaviour (observations, intentions, acquired skills, and directed goals). Self-efficacy, outcome-expectations, goal setting, self-regulation, and social support are constructs of SCT that influence behaviour (Anderson, Winett, Wojcik, & Williams, 2010b; Doerksen & McAuley, 2014). It has been shown that SCT constructs are strong indicators of dietary behaviour change (Doerksen & McAuley, 2014). Research found that SCT constructs accounted for 61% of the variance for fruit and vegetables and 35% of the variance in fat intake in adults (Anderson et al., 2007), and that changes is self-efficacy and self-regulation was associated with changes in diet (fat and fruit/vegetables) (Anderson et al., 2010).

2.6.4 Self-Determination Theory (SDT)

Self-Determination Theory was developed by Deci and Ryan (1985) and proposes that motivation to perform a behaviour is driven by the extent to which the behaviour satisfies three basic psychological needs; the need for autonomy (to feel like we have control over what we do), competence (to feel like we have done a good job) and relatedness (to feel connected to and interact with others). According to SDT, there are three different types of motivation (amotivation, extrinsic and intrinsic) that can be placed along a continuum from non-self-determined regulations (amotivation; lack of intention to act) to self-determined motivation (intrinsic; highly autonomous). At the amotivation side of the continuum, individuals believe that their behaviour is governed by external forces, however, as they move towards intrinsic motivation, behaviour is performed for enjoyment. In between amotivation and intrinsic motivation is extrinsic motivation, which reflects that a behaviour is performed to obtain an outcome other than enjoyment. Once individuals are engaging in behaviours with intrinsic motivation, they experience quality motivation, which leads to positive behavioural and psychological out-comes (Vallerand et al., 2008). Recent research showed that competence and relatedness correlated positively with a healthy diet, while autonomous motivation did not. This study found competence and relatedness explained 11% of the variance in healthy eating (Oumrait et al., 2020).

2.6.5 Health Action Process Approach (HAPA)

The HAPA model is a stage model of health beliefs developed by Schwarzer (1992) and assumes that behaviour change is not only a continuous process but can be described in terms of qualitative stages. The HAPA model includes elements of other SCMs such as the TPB, SCT and TTM. The HAPA distinguishes between three stages; the pre-intenders stage: similar to SCT, this stage has self-efficacy and outcome expectancy as key determinants of intentions. This stage also adds risk perception as a predictor of intentions, which refers to an individual's perception of vulnerability to and severity of illness, leading to the decision of whether to change behaviour; the second stage is intenders, which is composed of factors that determine the extent to which a behaviour is initiated and maintained. These factors are action, coping planning and coping self-efficacy. The final stage is actors, which distinguish between initiating and maintaining behaviour, so to differentiate issues linked to starting a behaviour and those linked to maintaining a behaviour over time. Action control and coping self-efficacy are key to progression, and recovery self-efficacy is seen as key to dealing with relapses in behaviour. Schwarzer (1992) argues that this model helps bridge the gap between intention and behaviour. He argues that self-efficacy is the best predictor of intention and behaviour change and is crucial in initiating and maintaining behaviour. There is support for use of the HAPA in predicting healthy eating. Two studies that used the HAPA to predict dietary intake, found that intention and coping self-efficacy explained 33% to 48% of the variance in nutrition up to 6 months later (Renner et al., 2008; Schwarzer et al., 2000).

2.6.6 Transtheoretical model of change (TTM)

The TTM was developed by Prochaska and di Clemente (1984) to address behaviour change. The TTM has been applied to many health behaviours including diet. This model assumes that an individual moves through stages of change, and that the process involved at each stage are independent and different form each other. Using dietary behaviour as an example, here are 5 stages of readiness proposed by TTM; 1) pre-contemplation stage, an individual is not thinking about changing dietary behaviour with no intention to change behaviour in the next 6 months; 2) contemplation stage, the individual is starting to think about changing dietary behaviour but not committed to just yet; 3) preparation stage, the individual is ready to change behaviour and has intentions to do so by making plans and setting goals; 4) action stage, the individual actively attempts to change dietary behaviour, e.g. eating fruit and vegetables instead of sweets and pastries; 5) maintenance stage, an individual keeps up dietary change. The model also proposes that a person will weigh up the pros and cons of changing behaviour at each stage of the process (decisional balance, Janis and Mann, 1977). A regression analysis in the Van Duyn et al. (1998) study showed that a person's stage of change was a good predictor for F&V consumption such that it was able to explain 17% of the total variation in F&V consumption by participants (Van Duyn et al. 1998). Pros and stages of change explained 44% of the variance in processes of change and 13% of the variance in self-efficacy in physical activity (Liu., et al., 2018).

2.6.7 Criticisms of social cognition models

Despite considerable evidence to support SCMs as a predictive model of behaviour, there are several disadvantages to their application (Odgen et al., 2003). There is debate over the usefulness of SCMs, as they can over-simplify the behaviour change process, and may not provide a complete understanding of behaviour change (Armitage and Conner, 2000). SCMs rarely focus on theories that involve “automatic” processes such as habit and emotions (Michie et al., 2014). Furthermore, SCMs focus less on capability and opportunity, which are important factors of behaviour change. This could be partly responsible for the significant proportion of variance unaccounted for by SCMs in behavioural outcomes (Odgen, 2003). Another limitation is that SCMs were developed to explain differences between groups and not between individuals’ overtime, which limits their usefulness in informing interventions to change (Conner & Norman, 2015). Finally, SCMs focus less on behavioural determinants such as socio-cultural and environmental factors, and instead focus on intra-individual constructs.

However, using theory to develop behaviour change interventions have been criticised. While SCMs specify what theoretical constructs should be changed to change behaviour, they typically do not specify how to change these constructs. This has led research to identify how to change specific theoretical constructs such as self-efficacy (Prestwich et al., 2014) and social influences (Prestwich et al., 2016). This research may help to identify evidence-based techniques to change theoretical constructs and thereby increase the effectiveness of theory-based interventions. It has been suggested, those that target change mechanisms at population, community and individual levels are the most effective (NICE, 2007), suggesting that behaviour change interventions may benefit from drawing on a wider range of theories than SCMs (Conner and Norman, 2015).

Furthermore, Sheeran et al. (2016) conducted a meta-analysis to examine the impact of changing attitudes, norms and self-efficacy on intentions and behaviour. It was found that successfully changing cognitions led to changes in intentions and behaviour. However, intentions to change behaviour was stronger than changing actual behaviour, suggesting the need for further variables or interventions to help bridge the intention-behaviour gap.

2.6.8 A New Approach: Designing behaviour change interventions

A cross disciplinary review of theories of behaviour (Michie et al., 2014) was conducted and led to the identification of 83 theories and 1659 constructs, constructs beyond those most commonly used in SCMs. One of the models identified by this review was the COM-B model (Michie et al., 2011), which stands for capability, opportunity, motivation, and behaviour. Capability can be divided into psychological and physical; motivation can be divided into reflective and automatic, and opportunity can be divided into social and environmental. Together, these components provide a rationale for why behaviour is not engaged in and then identifies which of these components needs to be addressed to bring about behaviour change. The model posits that all 3 components influence behaviour, which accounts for all the factors outside the person that make the behaviour possible. The model also posits that both capability and opportunity influence motivation making it the central mediator of the model, therefore, capability and opportunity affect behaviour both directly and indirectly. According to the COM-B model, in order to change behaviour, one or more of the COM-B components need to change, relating to either the behaviour or behaviours that support or compete with it (Michie et al., 2014). This model seeks to provide a framework, that other theories can be considered. SCMs constructs mainly fall into the reflective motivation component of the COM-B model and either minimally or not at all into the other 5 components (Conner and Norman, 2015).

The COM-B model is at the core of an overarching framework called the Behaviour Change Wheel (BCW)(Michie et al., 2014) which is an eight-step systematic approach to designing a behaviour change intervention using a synthesis of 19 frameworks of behaviour change from the literature. This framework includes 9 intervention functions and 7 policy categories, linked to the COM-B model. SCMs differ from the COM-B/BCW as a method for intervention design for several reasons. SCMs are predictive models used to identify constructs associated with a target behaviour, which are often referred to as “determinants”, and are targeted in interventions to change behaviour. Determinants are a subset of maintaining factors that account for any variance in behaviour between individuals. However, limiting interventions to target these determinants, it is more likely that other potential levers of change are overlooked (Conor and Norman, 2015). For example, other maintaining factors with insufficient or too much variance between individuals and therefore not identified as determinants, or factors that have not influenced behaviour but have potential to (novel incentives). One the other hand, the COM-B model considers where change within the system is most likely to bring about change in behaviour. This is informed by a “behavioural diagnosis”, considering what has influenced past behaviour, current potential and limitations of the individual, and context, leading to the development of effective interventions. This is an holistic approach for changing behaviour, based on a model of an individual, rather than a mechanistic process of identifying determinants of behaviour based on factors accounting for variation in current behaviour between individuals (Conner and Norman, 2015).

The COM-B model can be further elaborated by the Theoretical Domains Framework (TDF) (Cane et al., 2012) (see Figure 1). Although the TDF is descriptive and fails to postulate the link between domains (Francis et al., 2004), it consists of 14 domains covering the spectrum of behavioural determinants and can be mapped directly onto the COM-B components (Cane et al., 2012). This specifies the relationship between domains in regards to a person's capability, motivation and opportunity to enact a behaviour (Michie et al., 2015), and includes constructs aligned with other behaviour change theories such as the Theory of Planned Behaviour (Ajzen et l., 1991). Each domain of the TDF is further elaborated by several core components such as; belief about capabilities which include, self-efficacy, control of behaviour and confidence (Cane et al., 2012). The comprehensive coverage of the TDF allows researchers to analyse the most important domains specific to their target behaviour, allowing a crucial step in predicting, and ultimately changing dietary behaviour. By providing a wider range of behavioural determinants, researchers gain a deeper understanding of factors influencing behaviour which can be addressed fully in intervention design.

Interventions to change behaviour are complex and often involve multiple interacting components. Detailed specification of interventions are necessary, as poorly reported interventions result in difficulty ascertaining the content (active ingredients) of the intervention (Michie et al., 2015). Even though there has been progress made regarding the specification and reporting of interventions, such as CONSORT (Moher et al., 2003), there is a need to develop a shared and standardized method for classifying intervention content (Michie et al., 2011). One method for improving the reporting of interventions content is to report the specification of BCTs, which are the proposed mechanisms of change. There are several advantages to specifying the BCTs including, identifying which BCTs are effective within a complex intervention, promotes replication of RCTs, and finally, the links between BCTs and mechanisms of action (MOA) that they target. MAOs are theoretical constructs that represent the process through which a BCT affects behaviour. MOAs are specified in theories of behaviour change, such as “knowledge” and “skills” which can mediate intervention effects. They can be characteristics of individual or of the social/physical environment. As an example, one might hypothesize that the BCT “instruction on how to perform a behaviour” might change behaviour by increasing one’s skills in the target behaviour. It is important to understand the links between MOAs and BCTs for both intervention development and evaluation. The BCW incorporates the COM-B model, TDF and BCT’s in a systematic approach in designing an intervention. The BCW is gaining popularity in developing interventions in a range of health behaviours including dietary behaviour (Costello et al., 2018; McEvoy et al., 2018).

This review discussed the role of SCMs in predicting and understanding behaviour and behaviour change. This review further discussed new approaches to intervention design based on many theories and constructs beyond that of SCMs. This new approach allows researchers to consider other relevant determinants of behaviour, such as social, environmental, and cultural which SCMs focus less on. This review highlights the BCW, a framework for designing interventions. This is an 8 step systematic approach to understanding behaviour in context, and guides researchers to link theoretical constructs to behaviour change techniques that will bring about the desired behaviour change. These findings led the researcher to further examine the MIND diet in terms of understanding the behaviour, and testing its effectiveness on cognitive function, using the BCW, which is the main focus of this thesis.

2.8 Research process

Given the above, the work conducted in this thesis will inform the design and evaluate the feasibility and acceptability of a 12 week intervention promoting adherence to the MIND diet, a diet that has been specifically designed to promote brain health (Morris et al., 2015). Keeping in line with the BCW (Michie et al., 2015) and the MRC guidelines for developing complex interventions (Moore et al., 2015), the intervention development will be informed and evaluated based on findings from four research phases: (1) A systematic review examining the effectiveness and use of psychological theory in dietary interventions that promote a whole diet; (2) a behavioural diagnosis of factors influencing MIND diet behaviour at midlife, using the COM-B model; (3) development of a 12-week online dietary intervention promoting the MIND diet in adults at midlife, using the BCW; (4) a mixed methods approach, implementing a COM-B based intervention and evaluation. The following subsections provide a summary of the aims and objectives of each phase in the research process.

2.8.1 Phase 1

The first phase of the research process aimed to provide a comprehensive assessment of the effectiveness and use of theoretical frameworks in “whole” dietary interventions. The findings were drawn upon to identify a gap in the literature, not only in terms of target behaviour, but also what theoretical models could be employed in the development of an intervention for this thesis. To achieve these aims, the objectives of this research are: 1)To describe the extent of psychological theory in the design and implementation of dietary interventions to promote whole dietary pattern; 2) to evaluate the implementation of psychological theory in the design of dietary interventions to promote whole dietary patterns; 3) to determine the effectiveness of psychological theory based dietary interventions; 4) to explore the extent to which the fidelity of the intervention is monitored in these studies.

2.8.2 Phase 2

The second phase of the research process aims to establish components of the COM-B model that influence the uptake of the MIND diet in 40-55-year olds, to prevent cognitive decline. To achieve these aims, the objectives of this research were to: (1) determine participants perceived capability to the uptake of the MIND diet in 40-55-year olds; (2) determine participants opportunity to the uptake of the MIND diet in 40-55-year olds; (3) determine participants motivation to the uptake of the MIND diet in 40-55-year olds; (4) Use this information to inform the design of an intervention to promote the MIND diet in 40-55-year olds.

2.8.3 Phase 3

The third phase of the research process aims to describe the development and rationale for a behaviour change intervention to promote adherence to the MIND diet by applying the BCW. To achieve this, we first aimed to (1) understand the target behaviour. This involved, defining the problem in behaviour terms, selecting, and specifying the target behaviour and finally, identifying what needs to change in order to change behaviour; (2) designing the intervention. This involved identifying which intervention functions, such as education or training, re most likely to be effective in changing behaviour. (3) identifying content of the intervention and mode of delivery. This involved identifying which behaviour change techniques were best suited to deliver the intervention functions to bring bout behaviour change and decide how the intervention would be delivered i.e. online.

2.8.4 Phase 4

The final phase of the research process aims assess the COM-B model effectiveness to plan and implement an intervention to facilitate adherence to the MIND diet. To achieve these aims, the objectives of this research are; (1) to assess the effectiveness of a 12-week dietary intervention designed to promote adherence to the MIND diet in 40-55-year old's; (2) to assess the usefulness of a 12-week dietary intervention to increase capability, opportunity and motivation in the uptake of the MIND diet in 40-55-year old's; (3) to assess the effectiveness of the MIND on the cognitive function, mood and quality of life; (4) to assess feasibility and acceptability of the intervention.

Having reviewed the literature and discussed the research process of this thesis, the next chapter presents the first phase (systematic review) of the research process.

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Chapter 3

Systematic Review

Are dietary interventions with a behaviour change theoretical framework effective in changing dietary patterns? A systematic review

3.1 Abstract

Introduction: The term ‘whole dietary pattern’ can be defined as the quantity, frequency, variety and combination of different foods and drinks typically consumed and a growing body of research supports the role of whole dietary patterns in influencing the risk of non-communicable diseases. For example, the ‘Mediterranean diet’, which compared to the typical Western diet is rich in fruits and vegetables, whole grains, and oily fish, is associated with reduced risk of cardiovascular disease and cancer. Social cognition models provide a basis for understanding the determinants of behaviour and are made up of behavioural constructs that interventions target to change dietary behaviour. The aim of this systematic review was to provide a comprehensive assessment of the effectiveness and use of psychological theory in dietary interventions that promote a whole dietary pattern.

Methods: A systematic review was undertaken using the Preferred Reporting Items for Systematic Reviews and Meta-Analysis to synthesize quantitative research studies found in Embase, Medline, PsycInfo, CINAHL and Web of Science. The studies included were randomised and non-randomised trials published in English, involving the implementation of a whole dietary pattern using a social cognition model to facilitate this. Two independent reviewers searched the articles and extracted data from the articles. The quality of the articles was evaluated using Black and Down quality checklist and Theory Coding Scheme.

Results: Nine intervention studies met the criteria for inclusion. Data from studies reporting on individual food group scores indicated that dietary scores improved for at least one food group. Overall, studies reported a moderate application of the theory coding scheme, with poor reporting on fidelity.

Conclusion: To our knowledge, this is the first review to investigate psychological theory driven interventions to promote whole dietary patterns. This review found mixed results for the effectiveness of using psychological theory to promote whole dietary pattern consumption. However, the studies in this review scored mostly moderate on the theory coding scheme suggesting studies are not rigorously applying theory to intervention design. Few studies reported high on treatment fidelity, therefore, translation of research interventions into practice may further impact on effectiveness of intervention. Further research is needed to identify which behaviour change theory and techniques are most salient in dietary interventions.

Key words**:** *psychological theory, whole dietary patterns, theory coding scheme*

3.2 Introduction

Major non communicable diseases (NCD) include, heart disease, stroke, cancer, diabetes, and chronic respiratory disease, and are estimated to represent 41 million deaths per annum globally (WHO, 2016). According to the World Health Organisation (WHO, 2016), a number of preventable risk factors underlie many NCDs and are the leading cause of death and disability globally regardless of economic status with one of the main risk factors considered to be poor diet attributable to 11 million deaths globally in 2017 (Murray et al., 2019). Previously, the focus of research has been on single nutrients or single food groups owing to an era when undernutrition and nutritional deficiencies were the prevailing diet-induced disease states. However, the burden of disease has switched (Murray et al., 2019) to cancer, diabetes, and cardiovascular disease, due to demographic and epidemiological transitions, which are now the leading causes of death globally. This was partly due to a shift in the food environment, with trends toward low-fat, high-carbohydrate diets (which advocated a reduction in total fat consumption without consideration of the type of fat) which ultimately led to an increased consumption of refined carbohydrates and added sugar, which can actually increase the risk of cardiometabolic diseases (Yang et al., 2014). The dietary determinants of diseases such as cancer and diabetes are different from those of undernutrition and nutrient deficiency states (Tapsell et al., 2016). Non-communicable diseases have multiple interacting dietary determinants consisting of either excess or insufficient intake, which cumulatively affect disease over time (Willet et al., 2013). Therefore, research has gone beyond the single nutrient approach and focused on whole dietary patterns, which may be more beneficial to health due to the synergism between nutrients and food groups (Mumme et al., 2019). Improving dietary quality is not easily achieved. Healthy eating patterns revolve around regular consumption of a variety of foods from key food groups including cereal and cereal products, fruits and vegetables, meat and non-meat alternatives and dairy/non-dairy alternatives with the aim of optimizing nutrient intakes conducive to reducing the risk of chronic illness (Schulze et al., 2018). Globally between 1990-2010, consumption of healthy foods has increased, however, the consumption of unhealthy foods had increased to a greater extent (Imamura et al., 2015). For the purpose of this review, a whole dietary pattern is defined as the quantities, proportions, variety or combination of different foods in relation to the 5 foods groups of the Eatwell Guide, UK (Choices et al., 2015) and the MyPlate, USA (MyPlate, 2011) (fruit & vegetables, carbohydrates/grains, protein, fats & sugar, dairy products), or an established healthy eating pattern such as the Med diet (Panagiotakos et al., 2007).

It is clear, that interventions to promote adherence to a healthy dietary pattern is warranted. There is an array of research examining and evaluating the effectiveness of dietary interventions on chronic illnesses. There is some evidence in the literature to suggest, that the reporting of psychological theory use in behaviour change intervention development is associated with larger intervention effects (Ammerman et al., 2002; Webb et al., 2010). Using psychological theory to design behaviour change interventions, provides a framework to accumulate evidence, test hypothesis, identify specific constructs that may influence behaviour and suggest which behaviour change techniques should be used in behavioural interventions (Prestwich et al., 2015).

While theory has been used to predict healthy dietary patterns (Morris et al., 2015; Omondi et al., 2011), there is less evidence in the literature examining the effectiveness of interventions that use psychological theory to promote whole dietary patterns, such as the Med (Panagiotakos et al., 2007), MIND (Morris et al., 2015), and DASH (Sacks et al., 1999) diets. SCMs (e.g. TPB) (Ajzen, 1991) are useful for explaining, predicting, and understanding dietary behaviours, and in the design of dietary interventions to promote dietary change (Conner & Norman, 2015). However, reviews in the literature show mixed results for the effectiveness of theory based dietary interventions. One meta-analysis found no association between dietary intervention effectiveness and theory use (Prestwich et al., 2014), while another meta-analysis on theory-based fruit and vegetable intervention among children, found that after considering quality of studies, theory was associated with vegetable consumption only (Diep et al., 2014). Furthermore, a previous review indicated that theory-based interventions were less effective than non-theory-based interventions (Gardner et al., 2011). However, such research is held back by limitations in the extent to which interventions report on theory use, and insufficient descriptions of intervention content (Hagger et al., 2020).

Some studies have been shown not to extensively use psychological theory in developing interventions (Avery et al., 2013). One way to examine how theory has been applied to interventions is by applying the 19-item theory coding scheme (TCS) (Michie et al., 2010). This scheme specifies whether theory is mentioned, whether theoretical constructs are targeted or measured, if theory was used to select recipients or to tailor the intervention and if theory was tested or refined. The TCS is a reliable tool to describe theory-based interventions; to inform evidence synthesis within reviews and has been used widely in systematic reviews to assess the effectiveness of theory and intervention effectiveness.

Furthermore, methodological inadequacies of behavioural interventions have been previously suggested as a barrier to the quality and advancement of behavioural research, with intervention fidelity acknowledged as a key area for improvement (Toomey et al., 2020). Treatment fidelity refers to the methodological strategies used to evaluate the extent to which an intervention is being implemented as intended (O'Shea et al., 2016). Reporting and studying implementation fidelity provide insights into the gap between theory and practice, and without details of an intervention's implementation fidelity, it is impossible to make valid interpretations regarding the efficacy of the intervention. To provide this information, specification of the intervention program is required. According to Bellg et al. (2004), five domains to assess, monitor or enhance treatment fidelity have been identified by, as part of The National Institute of Health (NIH) and Behaviour Change Consortium (BCC), which are: (1) design of study, (2) training providers (3) delivery of treatment (4) receipt of treatment (5) enactment of treatment skills.

Previous systematic reviews have assessed the effectiveness of behavioural interventions on fruit and vegetable consumption (Broers et al., 2017), reduce sugar intake (Al Rawahi et al., 2018), or only reporting on dietary behaviours using one social cognition model, such as the SCT (Stacey et al., 2015). One systematic review (Stacey et al., 2015) aimed to identify effective dietary interventions for older people. However, this review examined both whole dietary patterns and single food groups such as fruit and vegetables. Furthermore, while this review reported the delivery of educational sessions, no theory was mentioned, or theoretical constructs reported. To our knowledge, the current review is the first to assess the effectiveness of SCMs in dietary interventions that use a "whole dietary pattern". Therefore, the aim of this systematic review was to provide a comprehensive and systematic assessment of the effectiveness and use of SCMs in dietary interventions that promote "whole dietary patterns" in adults.

3.2.1 Objectives:

- To describe the extent of psychological theory in the design and implementation of dietary interventions to promote whole dietary patterns
- To evaluate the implementation of psychological theory in the design of dietary interventions to promote whole dietary patterns
- To determine the effectiveness of psychological theory based dietary interventions
- To explore the extent to which the fidelity of the intervention is monitored in these studies.
- To provide recommendations for future research to promote whole dietary patterns

3.3 Methods

The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) (Moher et al., 2009) was used to inform the design, conduct and reporting of this systematic review. No ethical approval was sought as only secondary analysis of existing datasets were involved in the study. The study protocol was registered with PROSPERO, the International Prospective Register of Systematic Reviews (crd.york.ac.uk/prospero/index.aspIdentifier; CRD42017057366).

3.3.1 Selection Criteria

In accordance with PRISMA, the PICOs (population, intervention, comparison, outcome, and study design) approach were used to formulate the selection criteria. (see Table 3.1).

Inclusion criteria: 1) study population: all adults aged 18 years or over; 2) study intervention: an intervention involving a “whole dietary pattern” such as the Med diet (Panagiotakos et al., 2007) DASH diet (Sack et al., 1999) and MIND diet (Morris et al., 2015) or foods analysed from at least 4 out of 5 of the food groups identified by the Eatwell Guide, UK (protein, grains/carbohydrates, oil and fats, dairy, fruit/vegetable; 3) study design: 4) psychological theory: studies were included that used a SCM to design their intervention (e.g. TPB); 5) study design: RCT including single arm studies, and pilot studies published in English.

Exclusion criteria: 1) study population; studies targeting a population under 18 years old were excluded; 2) study intervention: studies were not included where the dietary behaviour was a de facto medical treatment e.g. gluten free diet. Also, studies analysing data from only single food group and nutrients, such as, fruit and vegetable, or omega 3 were excluded, as these do not constitute a “whole dietary pattern”; 3) psychological theory: studies that do not mention or report on a SCM were excluded; 4) study design: studies that were not interventions, such as qualitative or cross-sectional studies were excluded from this review (see Table 3.1).

Table 3.1*:*

Description of Population, Intervention, Comparison, Outcome and Study Design for Included Studies (PICOS).

Parameter	Description
Population	All adults aged 18 years and over. Studies where participants were drawn from a population with a psychiatric condition such as an eating disorder were excluded.
Intervention	Diet: for the purpose of this review, an intervention involving a "whole dietary pattern" such as the Med diet, Dash diet, MIND diet or foods analysed from 4 out of 5 of the food groups (protein, grains/carbohydrates, oil and fats, dairy, fruit/vegetable. Studies were not included where the dietary behaviour was a de facto medical treatment e.g. gluten free diet, also single food group and nutrients diet studies such as, fruit and vegetable, or omega 3 were excluded, as these don't from a "whole dietary" pattern. Theoretical model: Studies were included that used a theoretical framework to deliver their intervention. Theoretical models such as HBM, TTM, HAPA were included.
Comparison	Usual diet, information booklet.
Outcome	Improved diet quality, increased adherence to diet.
Study design	Randomised controlled trials and non-randomised controlled trials published in English.

3.3.2 Search Strategy and Study Identification

Literature searches were conducted by (DT) between April 2019 and January 2020 using the following databases: EMBASE (1974-2020), Medline (1974-2020), PsycInfo (1974-2020), CINAHL (1937-1-2020) and Web of Science (1950-2020). ProQuest Dissertations & Thesis was reviewed to locate unpublished studies and, reference lists of the selected studies for inclusion were searched manually. The following search terms were used in different combinations. Theoretical framework, behaviour change theory, Theory of Planned Behaviour, Theory of Reasoned Action, Health Belief Model, Self-determination Theory, Stages of Change Model, Health Action Process Approach, COM-B model, Social Cognitive Theory, Control Theory, Self-Efficacy Theory, Social Ecological Model, healthy eating, dietary intervention, dietary patterns, healthy eating, whole diets, Mediterranean, DASH and MIND diet were also chosen as search terms as these are “whole dietary patterns”, they do not eliminate any food group and promote a healthy lifestyle (Schulze et al., 2018). The studies were screened by the titles and abstracts. Studies that did not meet the inclusion criteria were excluded. Two researchers (DT&ES) reviewed the abstracts independently that were ambiguous for inclusion. Any disagreements were resolved through discussion with a third researcher (JM).

3.3.3 Data Extraction.

The following information was extracted from each study: author, design, country, quality score, participants characteristics, intervention, control, dietary pattern, theoretical model, outcome measures, main findings (Table 3.2).

3.3.4 Methodological Quality

The modified version of Downs and Blacks (Downs & Black, 1998) quality checklist was used as some of the included studies were non-randomised studies. Question 27 was modified to “Did the study have sufficient power?” with one point awarded if a sample size calculation was completed (Morton et al., 2014). Two researchers (DT&ES) independently assessed the quality of the studies. The Downs and Blacks quality checklist is considered a reliable and valid tool suitable for the use in random and non-random studies (Saunders et al., 2003). Studies were assessed on quality of reporting (10 questions; partially = 1, no = 0 or yes = 2, or yes =1, no=0), external validity (3 questions; yes = 1, no = 0,unable to determine = 0), internal validity – measurement bias (7questions; yes = 1, no = 0, unable to determine = 0), internal validity – selection bias (6 questions; yes = 1, no = 0, unable to determine = 0) and power (1 question ; yes = 1, no = 0, unable to determine = 0), equating to a total achievable score of 28 (see Table 3.1). Studies that scored less than 14 were considered poor, those that scored between 14-18 were considered fair, those that scored between 19-23 were considered good and those scoring between 24-28 were considered excellent (O’Connor et al., 2015).

Table 3.2

Data Extraction: Description of Study Characteristics in Theory Based Dietary Interventions Promoting Adherence to a Whole Dietary Pattern

Author Design Country	Theoretical Model	Participants	Intervention	Control	Dietary Pattern	Primary outcome	Main findings
Abood et al., 2003 RCT USA	Health Belief Model	53 participants in the study. N= 28 intervention mean age 34, 96% women. n= 25 control mean age 38, 92% women	Pre-post-test. 8 1-hour weekly education session to promote knowledge and beliefs conducive to improving positive dietary practices. INTERVENTION 1. Risk factors and prevalence rates of CVD, nutrition to reduce risk. 2. Macronutrients: food guide pyramid and sources and benefits of recommended intakes, benefits of proper nutrition, reducing barriers to increase probability of dietary changes, 3. Macronutrients; hidden sources of fat, meal and fat alternatives, benefits of fat reduction and reduction of barriers to taking such action. 4. Fruit and veg: Health protective role of fruit and veg, frequency and portion size, fibre, vitamins, benefits of increased intake of fruit and veg and barrier reduction to taking action. 5. Health benefits of weight control. 6. Benefits of eating meal regularly; distribution and preparation of low calorie-high nutrient recipes, ideas for removing barriers to healthy eating patterns. 7. Meal planning and food label reading. 8. Integration of all previous topics; HMB constructs to change nutrition behaviours to reduce risks and for behaviour maintenance; supplements, caffeine, soft drinks.	Usual care	Dietary behaviour (Whole dietary pattern)	Modified FFQ used by Boeckner and colleagues (1990) Questionnaire on HBM.	Following the intervention, there was a significant improvement in total fat, saturated fat. No significant effect for protein, fibre, fruit, or veg.
Manios et al., 2007 RCT Greece	Health Belief	82 women aged 55-65.	Every 2 weeks in a nutrition education based on HBM and SCT over 5 months.	Usual diet	Whole diet assessed by HEI.	Healthy Eating Index (HEI)	Milk and Fat HEI scores were significantly improved. ($p<0.001$). Significant decrease in grains (0.041)

	Model (HBM) Social Cognitive Theory (SCT)	Postmenopausal. Intervention n=42 Control n=40 Mean age 60 +- 4.8 years	INTERVENTION: 7 sessions based on the HBM 1. Perceived severity (What is osteoporosis) 2. Perceived susceptibility, severity, call for action (risk for osteoporosis: lifestyle choices) 3. Perceived benefits and barriers. (dietary discussion and results so far) 4. Self-efficacy, perceived barriers. Guidelines for dietary records. 5. Self-efficacy and perceived barriers. (Discussion on dietary results and changes so far) 6. Perceived benefits (Other benefits of diet) 7. Self-efficacy and perceived barriers. (Discussion of food records and barriers and benefits participants have run into)		Grains, vegetable, fruit, milk, meat, total fat, saturated fat, cholesterol, sodium, total HEI		and total HEI (P=0.003). Decrease in total fat was more the IG than the CG (P=0.050) and also the increase in protein was more significant for the IG than the CG (p<0.001) No improvement in fruit, vegetables, saturated fat
Petrogianni et al., 2013 RCT Greece	Health Belief Model and Social Cognitive Theory	108 hypercholesterolaemia adults 40-60 years.	Randomised into 2 interventions and one control. Intervention included 7 1-hour counselling and dietary lifestyle sessions held biweekly and based on HBM and SCT. 1. Perceived severity and susceptibility; cues to action (what is CVD) 2. Perceived benefits and barriers; call for action; self-monitoring; self-efficacy, (Epidemiology of CVD and ways to reduce risk factors.) 3. Perceived benefits; self-efficacy; call for action; sell-monitoring. (meal planning, setting goals) 4. Perceived benefits; self-efficacy; call for action; self-monitoring. (Guidelines for balanced diet, focus on lipids and dietary fatty acids, fasting, setting goals. 5. Perceived barriers; self-efficacy; call for action; self-monitoring. (Balanced diet plan and setting goals. 6. self-efficacy; call for action; self-monitoring. (food labels, conservatives, setting goals) 7. Progress assessment; perceived barriers and benefits. (Benefits and barriers, they have run into).	Usual diet	Dietary intake information was collected with a 3-day recall (2 consecutive weekdays and 1 weekend day)	HEI-2005 score to assess diet quality.	Significant improvement on total HEI score (P=0.045), milk p=0.021, dark, green vegetables and legumes p=0.05

McPhail et al., 2014 RCT Australia	Health Action Process Approach. (HAPA)	87 participants attending primary care diabetes clinic with a diagnosis of T2D.	4-month intervention consisting of self-guided HAPA based workbooks in addition to 2 telephone calls to assist participants with program implementation.	Treatment as usual	Whole diet consisting of, fruit, veg, grain, meat, dairy, beverages, sodium, saturated fat, and alcohol.	Diet Guidelines Index (DGI). HAPA questionnaire.	Healthy eating was not associated with HAPA variables nor did they predict healthy eating after intervention.
Miller et al., 2016 RCT USA	Health Action Process Approach. (HAPA)	68 participants aged 18-65 years. Mean age 51. 14 males, 54 females.	16-week lifestyle intervention based on the HAPA. 60-minute weekly lifestyle coaching sessions. • The first 8 sessions presented the intervention goals, taught information about modifying energy intake and expenditure and helped participants self-monitor. • The following 8 sessions focussed on problem solving to achieving lifestyle goals, preventing relapse, motivating sustained behavioural change. • Action plans introduced at week 9 and later review of the success of action plan.	Control group received a booklet on lifestyle changes for diabetes prevention.	Whole diet assessed by the AHEI.	Alternative Healthy Eating Index, 2010. (AHEI) HAPA questionnaire	There was a significant increase in total AHEI score and in consumption of fruit and a significant decrease in red and processed meat, trans fat and sodium (p<.01).
Rodriguez et al., 2019 RCT USA	(TTM) Stage of change	533 adults with uncontrolled hypertension	Tailored Intervention: **TTM** based **MONTHLY** telephone counselling for 6 months tailored to stage of change. • **Pre-contemplation/contemplation stage**: Information and feedback about achieving DASH diet, imagery exercise designed to release emotions related to DASH diet, self/environmental evaluation (goals, values, consequences of non-adherence). • **Preparation stage:** Promoting autonomy and self-efficacy towards DASH diet by thinking about past successes in behaviour change • **Action stage:** Counterconditioning; substituting unhealthy foods for healthy foods, rewarding engagement with DASH diet, introducing prompts/cues for DASH adherence • **Maintenance**: Similar to Action stage with a focus on relapse prevention. • Decisional balance: Pros and cons of DASH diet. Each con was addressed through	Usual care	DASH diet	Improve adherence to DASH diet TTM stage	Significant improvement in overall DASH score. No improvement in individual food groups Tailored intervention effectively advanced participants stage of change

			problem solving and each pro was further explored. **NON-Tailored intervention**: Monthly calls to address hypertension management with general information on diet, exercise, medication, sun safety, sleep hygiene, vision/hearing problems				
Peters et Al., 2014 RCT USA	SCT	71 healthy post-menopausal women aged between 50-72	**One-year Intervention: Three eating patterns** Whole food plan, The Food Power eating plan, The Flax Plus eating plan. Behaviour Intervention: • **The first 14 weeks** (**adoption stage**) each group met weekly with behavioural classes alternating with cooking classes, to motivate participants to eat according to their eating plan. • **The following 2 months (maintenance stage)** included bi-weekly behavioural sessions including food demonstrations and tastings. • **The final 6 months (maintenance stage)** involved monthly sessions reviewing progress, goal setting and action planning.	N/A	Whole dietary pattern My Pyramid	Adherence to eating pattern with monthly 24 hr recall Psycho-social questionnaire	There were no changes in psychosocial factors overtime. In the whole food eating pattern, significant improvements were found in the food group, beans and meat, poultry, eggs. In the moderate fat group, significant improvements were found for fruit, vegetables, sugar.
LeBlanc et al., 2015 Non-RCT Canada	SDT	64 men and 59 premenopausal women aged between 25-50.	Non-random intervention study. 12-week nutritional program based on STD and uses a MI approach. **INTERVENTION** 3 GROUP SESSIONS 3 INDIVIDUAL SESSIONS AND 4 FOLLOW UP PHONE CALLS. 3 GROUP SESSIONS. LECTURE; EXPLAINING PRINCIPLES OF MED DIET • 3HR Med diet cooking lesson	No control	Mediterranean diet	Med score calculated based on validate FFQ The regulation of eating scale	Changes in eating-related self-determined motivation was positively associated with changes in Med score at follow up in men only.

			• 3-hour Mediterranean potluck dinner aimed at discussing barriers met in adopting dietary recommendations since the beginning. 3 individual sessions and follow up calls. • These assessed dietary changes and to determine progressive goals with the potential and realistic strategies aimed at improving the adherence to Med Diet principles. In accordance with the SDT, basic psychological needs were supported during the intervention (autonomy, competence, and relatedness)				
Schwarzer et al., 2017 Non-RCT Italy Spain Greece	HAPA	112 participants. 47 men 65 women Mean age 42 range 18-65 years.	Pilot intervention study. Single arm online intervention. The online platform delivered a lifestyle intervention that implemented theory-based behaviour change components based on the HAPA. INTERVENTION It is unclear how long the intervention was, this author used intervention mapping of behaviour change techniques to theoretical constructs. The intervention had 5 sections on Med diet and eating healthily. • Risk perception; Outcome expectancy; Self-efficacy; Planning; Action control	No control	Mediterranean Diet Adherence Screener (MEDAS)	Measures: •Dietary behaviours index •Psychological constructs 1.Positive diet-specific outcome expectancy 2.Diet specific planning 3.Diet specific action control 4.Stages of change.	The intervention showed overall improvements in Med diet adherence.

RCT: Randomised control trial. REP(Reporting), IV (Internal validity), EV (External validity). TTM= Transtheoretical Model, N=9

In addition to study quality being formally assessed, the TCS (Michie & Prestwich, 2010) was used to assess the extent to which theory was used to design behaviour change interventions within each study. The TCS consists of 19 items across 6 categories relating to; whether a theory was mentioned, if the relevant theoretical constructs are targeted, if theory was used to select participants and/or tailor interventions and if the relevant constructs were measured, if theory was tested and if theory was refined. Responses to all items except for item 7 and 10 with a "yes" were given 1 point and those responded with a "no" and "don't know" were given 0 points. Items 7 (All intervention techniques are explicitly linked to at least 1 theory-relevant construct) and 10 (All theory-relevant constructs are explicitly linked to at least 1 intervention technique) were given 2 points if the criteria were met (see Table 3.4). Similar scoring has previously been applied (Alageel et al., 2017). Each study was categorised as having weak, moderate, or strong levels of theory use based on total TCS scores (weak = 0–7; moderate = 8–15; and strong =16–23) (Willmott et al., 2019). There was an initial 95% agreement of codes, which demonstrates an acceptable level of agreement. Discussion between researchers resolved any differences within the coding process.

3.3.5 Treatment fidelity

Treatment fidelity was assessed using a 29-item checklist (Borrelli et al., 2011) which mapped onto 5 domains identified by Bellg (2004). 1) treatment design (6 items); 2) treatment providers (7 items); 3) delivery of treatment (9 items); 4) receipt of treatment (5 items); enactment of treatment skills (2 items). Lack of attention to any one domain heightens the risk of the inability to draw solid conclusions from the study (Borelli et al., 2011) (see Table 3.5).

3.4 Results

3.4.1 Study Characteristic

The basic characteristics of included studies are shown in Table 3.2.

3.4.2 Type of Studies

Nine studies met the inclusion criteria (see Figure 3.1). Seven of the included studies were RCT's (Abood et al., 2003; Manios et al., 2007; MacPhail et al., 2014; Miller et al., 2016; Peters et al., 2014; Petrogianni et al., 2013; Rodriquez et al., 2019) and 2 non-RCT's (Le Blanc et al., 2015; Schwarzer et al., 2017).

3.4.3 Type of Participants

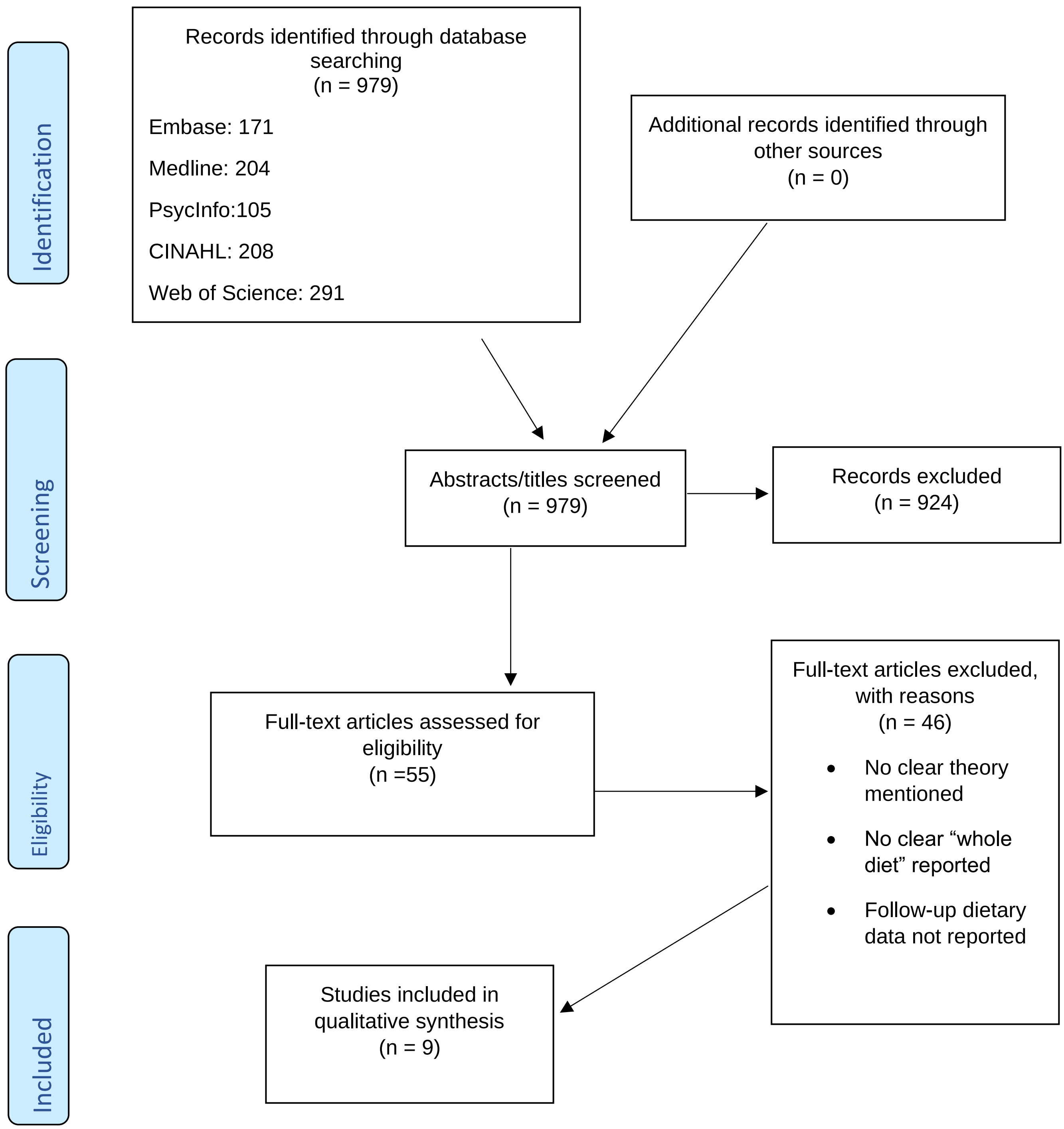
In all studies, participants had a mean age ranging from 34 to 72 years. Females represented between 45-100% of the overall sample. One study (Petrogianni et al., 2013) did not state the number of males and females who participated. Six of the included studies had apparent healthy participants (Abood et al., 2003; Le Blanc et al., 2015; Manios et al., 2007; Miller et al., 2016; Peters et al., 2014; Schwarzer et al., 2017). Three of the included studies had participants with a clinical diagnosis (MacPhail et al., 2014; Petrogianni et al., 2013; Rodriquez et al., 2014). Of the nine studies, one was carried out in Australia (MacPhail et al., 2014), four in the USA (Abood et al., 2003; Miller et al., 2016, Peters et al., 2014; Rodriquez et al., 2019), one in Canada (Le Blanc et al., 2015) and three in the Mediterranean (Greece, Italy and Spain)(Manios et al., 2007; Petrogianni et al., 2013;Schwarzer et al., 2017).

3.4.4 Type of Dietary Pattern

All studies included a whole dietary pattern that took into consideration the main food groups: protein, grains/carbohydrates, oil and fats, dairy, fruit/vegetable (n=9). Two of the nine studies specifically examined the Mediterranean diet (Le Blanc et al., 2015; Schwarzer et al., 2017), and one examined the DASH diet (Rodriguez et al., 2019).

Figure 3.1

PRISMA flow chart identifying and screening studies, eligibility of studies and included studies n=9.



3.4.5 Type of Primary Outcome.

Outcome measures varied across studies. Two studies used the HEI-2005 to assess overall diet quality and adherence to the recommended diet (Manios et al., 2007; Petrogianni et al., 2013), with higher scores representing better diet quality. One study assessed adherence to the Med diet with the Mediterranean Diet Adherence Screener (MEDAS) (Schwarzer et al., 2017), with higher scores representing higher adherence to the Med diet. One study used the Diet Guidelines Index (DGI) to measure adherence to healthy recommendations over the previous month. A diet score is obtained with a range of 0-150, with higher scores representing higher levels of healthy eating (MacPhail et al., 2014). One study assessed dietary behaviour with a food frequency questionnaire (Boeckner et al., 1990) and compliance to USDA Food Pyramid (Abood et al., 2003; Pyramid et al., 1992). One study used the AHEI-2010 to assess diet quality (Miller et al., 2016) with a total score between 0-110, with the higher score representing better diet quality. One study (Le Blanc et al., 2015) assessed the level of adherence to the Med diet with a Medscore, which was calculated based on the food frequency questionnaire used in the study. Scores ranged from 0-44, with higher scores representing higher adherence to the Med diet. One study captured recommended foods by a 24-hour recall questionnaire and compliance with USDA Food Pyramid (Peters et al., 2014; Pyramid et al., 1992). Finally, one study (Rodriquez et al., 2019) used the Willett Food frequency Questionnaire (Willet et al., 1985) to derive a DASH adherence score, with a potential DASH score of 1-40 over 8 food components. Each component score between 1-5, with a higher score representing higher adherence.

3.4.6 Quality of Studies.

Out of a total score of 28, all 9 included studies scored between 15 and 25 on the Black and Downs quality assessment checklist (see Table 3.3), with one study scoring 25 which is considered excellent quality (Miller et al., 2016). Four studies scored between 19-23 which is considered good quality (Abood et al., 2003; MacPhail et al., 2013; Le Blanc et al., 2015; Peters et al., 2014), and the remaining four studies scoring between 14-18 which is considered fair quality (Manios et al., 2007; Petrogianni et al., 2013; Rodriquez et al., 2019; Schwarzer et al., 2017). Overall, the 9 included studies scored high on the first subscale of the checklist (reporting). None of the included studies met the criteria for “external validity” subscale, with two studies scoring zero (Manios et al., 2007; Petrogianni et al., 2013). The following section is internal validity-bias which studies scored relatively high on this subsection with scores between 4-6 out of a possible 7. The following subsection is internal validity-confounding (selection bias), which yielded the most variety of scores, which may be due to having different experimental designs. Only one of the RCTs (MacPhail et al., 2014) reported sufficiently on randomised intervention assignment concealment. Lastly, power to detect a significant effect was reported by 4 studies (Abood et al., 2003; Le Blanc et al., 2015; Miller et al., 2016; Peters et al., 2014).

Table 3.3

Quality checklist scores for included studies

Author	Reporting	Internal Validity (Bias)	Internal Validity (Confounding)	External validity	Power	Total
Abood et al.(2003)	7	6	4	2	1	20
Manios et al.(2007)	8	5	2	0	0	15
Petrogianni et al. (2013)	9	5	3	0	0	17
McPhail et al. (2014)	11	5	5	2	0	23
Miller et al. (2016)	11	6	5	2	1	25
Rodriguez et al. (2019)	7	5	4	1	0	17
Peters et al. (2014)	8	5	3	3	1	20
LeBlanc et al. (2015)	10	5	3	1	1	20
Schwarzer et al. (2017)	9	4	3	1	0	17

Quality checklist Black and Downs n=9

3.4.7 Impact of intervention on dietary behaviour

Two studies (Le Blanc et al., 2015; Schwarzer et al., 2017) examined the impact of a theory-based intervention on adherence to the Mediterranean diet. Both studies calculated an overall Medscore pre-post intervention, calculated from the MEDAS (Schwarzer et al., 2017), or a food frequency questionnaire (FFQ) (Le Blanc et al., 2015). Both studies reported a significant increase in Medscore post intervention. One study (Rodriquez et al., 2019) examined the impact of a tailored behavioural intervention (TBI) on adherence to the DASH diet, compared to a non-tailored intervention (NTI) and usual care (UC) group. At 6 months follow-up, TBI had a higher DASH score than UC and NTI. However, for individual components of the DASH diet such as fruit and vegetables, and wholegrains, there was no significant difference between groups on scores at 6-month follow-up. The remaining 6 studies examined individual components of dietary behaviours based on AHEI (Miller et al., 2016), HEI (Manios et al., 2007; Petrogianni et al., 2013) DGI (MacPhail et al., 2014), FFQ (Abood et al., 2003) and 24hr recall/MyPyramid (Peters et al., 2014). From theses 6 studies, one study reported no improvement in dietary behaviour (MacPhail et al., 2014). Only one study reported a significant improvement in fruit (Miller et al., 2016), vegetable intake (Petrogianni et al., 2013), carbohydrates/grains (Manios et al., 2007) and dairy (Manios et al., 2007). Two studies reported improvements in protein (fish, poultry, beans, meat, or eggs) (Miller et al., 2016; Peters et al., 2014), and total fats (Abood et al., 2003; Manios et al., 2007).

3.4.8 Extent of theory use

The extent to which theory was used within the selected studies was assessed using the TCS (Table 3.4) (Michie & Prestwich, 2010). From the 9 included studies, the mean total use of theory score was 11, which is a moderate application of theory. One study (Manios et al., 2007) was classified as having a weak application of theory, seven studies (Abood et al., 2003; Petrogainni et al., 2013; MacPhail et al., 2013; Miller et al., 2016; Peters et al., 2014; Le Blanc et al., 2015; Schwarzer et al., 2017) were moderate, and one study showed a strong application of theory (Rodriquez et al., 2019). These scores suggest that most studies are not explicitly reporting theory use in sufficient detail and/or fail to rigorously apply theory to intervention design and implementation. The following section describes the use of theory within the selected studies in terms of the 6 categories of coded items of the TCS (Michie & Prestwich, 2010): (1) mention of theory; (2) targeting of theoretical constructs;(3) using theory to select recipients or tailor interventions; (4),measurement of constructs; (5) testing of mediation effects; (6) and refining theory.

3.4.8.1 Category 1: Mention of theory (Items 1-3)

All studies (N=9) mentioned a theory (item 1, Table 3.4), with only 6 studies referring to theory as a predictor of behaviour and provided evidence of the association of the theory or theoretical construct and target behaviour. For example, one study using the HBM (Abood et al., 2003) stated that the best predictor of nutrition related behaviour change is the benefit-cost ratio, and for a change in nutrition behaviour to occur, the perceived benefits must outweigh the barriers. Out of the 9 studies, 7 were reported to be a single theory (item 3, Table 3.4) such as HAPA, SDT and TTM, while 2 studies combined theories (HBM and SCT).

3.4.8.2 Category 2: Are relevant constructs targeted (Item 5, 7-11)

Eight of the studies used theory or predictors to select/develop intervention techniques (Item 5, Table 3.4). Regarding linking intervention techniques to theoretical constructs, only 4 studies explicitly linked all intervention techniques to at least one theoretical construct (Item 7, Table 3.4), with a further 5 studies linking at least one, but not all, intervention techniques to at least one theoretical construct (Item 8, Table 3.4). Three studies linked a group of techniques to a group of constructs (Item 9, Table 4). Only 4 studies explicitly linked all relevant theoretical constructs to at least one intervention technique (Item 10, Table 3.4), with a further 4 studies linking at least one, but not all, constructs with at least one technique (Item 11, Table 3.4). For example, one study (Abood et al., 2003) used the HBM to develop an educational intervention to improve dietary practices for CVD prevention. However, the intention focused on perceived benefits and barriers and neglected other key concepts such as susceptibility and severity of illness, health motivation and perceived control. Another study (Peters et al., 2014) used the SCT model to develop a dietary intervention and focused their intervention techniques on self-regulation techniques, such as self-monitoring and goal setting, neglecting concepts such as outcome expectancy. Therefore, more than half (n=5) of these studies did not utilise the full predictive power of their chosen theory.

3.4.8.3 Category 3: Is theory to select participants or tailor interventions.

None of the included studies used theory to select participants (Item 4, Table 3.4), and only 1 study tailored intervention techniques to the participants. Therefore, the intervention differed for subgroups of participants that varied for a particular construct at baseline (Item 6, Table 3.4). This study was based on the TTM, and the intervention delivered to each participant varied depending on their stage of change at baseline.

3.4.8.4 Category 4: Are relevant constructs measured

Seven of the studies reported measuring theoretical constructs pre-post intervention (Item 12, Table 3.4), and reporting on the validity and reliability of the scales used to measure constructs/predictors (Item 13, Table 3.4).

3.4.8.5 Category 5: Testing theory

Seven of the studies reported randomisation, two studies were non-RCTs (Item 14, Table 3.4). Four of the studies interventions changed the target theoretical constructs. For example, one study (Abood et al., 2003) using the HBM significantly increased perceived benefits of adoption of positive dietary behaviours and increased nutrition knowledge of CVD and cancer. Also, another study (Miller et al., 2016) reported that HAPA outcomes in the intervention group reported significantly greater frequency of action planning, and action and coping self-efficacy at follow-up (Item 15, Table 3.4). Seven of the studies discussed the results in relation to theory (Item 16, Table 3.4) and three provided support for theory (Item 17, Table 3.4). That is, theory-relevant constructs were reported to significantly mediate the relationship between the intervention and observed behavioural change. For example, one study (Le Blanc et al., 2015) that used SDT found that eating related self-determined motivation was associated with an increased adherence to the Med diet.

3.4.8.6 Category 6: Refining theory

No study reported using intervention results to build and/or refine the theory upon which the intervention was based, or formulate suggestions for future refinement (Item 18, Table 3.4).

Table 3.4:

Assessment of Theory Application in Included Studies Using the Theory Coding Scheme (TCS)

Application	Abood 2003	Manios 2007	Petrogianni 2013	MacPhail 2014	Miller 2016	Rodriquez 2019	Peters 2014	Le Blanc 2015	Schwarzer 2017
1.Theory mentioned	1	1	1	1	1	1	1	1	1
2.Targeted construct mentioned as predictor of behaviour	1	0	0	1	0	1	1	1	1
3.Intervention based on single theory	1	0	0	1	1	1	1	1	1
4.Theory used to select recipients for the intervention	0	0	0	0	0	0	0	0	0
5. Theory used to select/develop intervention techniques	1	1	1	1	0	1	1	1	1
6. Theory used to tailor intervention techniques to recipients	0	0	0	0	0	1	0	0	0
7. All intervention techniques are explicitly linked to at least 1 theory-relevant construct	0	2	2	2	0	2	0	0	2
8. At least 1, but not all, of the intervention techniques are explicitly linked to at least 1 theory-relevant construct	1	0	0	0	1	1	1	1	0
9. Group of techniques is linked to a group of constructs	0	1	1	0	0	0	0	0	1
10. All theory-relevant constructs are explicitly linked to at least 1 intervention technique	0	2	2	2	0	2	0	0	2

11. At least 1, but not all, theory-relevant constructs are explicitly linked to at least 1 Intervention technique	1	0	0	0	1	1	0	1	0
12. Theory-relevant con0s1tructs are measured	1	0	0	1	1	1	1	1	1
13. Quality of measures	1	0	0	1	1	1	1	1	1
14. Randomization of participants to condition	1	1	1	1	1	1	1	0	0
15. Changes in measured theory-relevant constructs	1	0	1	0	1	1	0	1	0
16. Mediational analysis of constructs	0	0	0	1	1	0	0	1	1
17. Results discussed in relation to theory	1	0	1	1	1	1	1	1	1
18. Appropriate support for theory	0	0	0	0	1	0	0	1	1
19. Results used to refine theory	0	0	0	0	0	0	0	0	0
Total	11	7	8	13	11	16	9	12	14

Nineteen items of the theory coding scheme (TCS) Michie et al. (2010). 9 included studies

3.4.9 Fidelity of interventions

Of the 9 included studies, two studies included an assessment on all 5 domains (Le Blanc et al., 2015; Miller et al., 2016). One study included an assessment on only one domain (Schwarzer et al., 2017). Two studies included an assessment on two domains (Abood et al., 2003; Manios et al., 2007). Three studies included an assessment on three domains (MacPhail et al., 2014; Petrogianni et al., 2013; Rodriquez et al., 2019). One study included an assessment on four domains (Peters et al., 2014) (see Table 3.5).

3.4.9.1 Study design

All studies made an assessment on study design (Abood et al., 2003; Manios et al., 2007; MacPhail et al., 2014; Miller et al., 2016; Peters et al., 2014; Petrogianni et al., 2013; Rodriquez et al., 2019; Le Blanc et al., 2015; Schwarzer et al., 2017), with studies providing information about treatment dose in the intervention condition, and two providing information on treatment dose in the comparison group (Miller et al., 2016; Peters et al., 2014). All studies reported underpinning theory (Abood et al., 2003; Manios et al., 2007; MacPhail et al., 2014; Miller et al., 2016; Peters et al., 2014; Petrogianni et al., 2013; Rodriquez et al., 2019; Le Blanc et al., 2015; Schwarzer et al., 2017). None of the studies trained more than one provider to allow for setbacks.

3.4.9.2 Training providers

Two studies provided information on training providers (Le Blanc et al., 2015; Miller et al., 2016). These studies provided information on how trainers were trained and standardisation of provider training. Strategies to enhance training providers included, using the same provider throughout the intervention (Le Blanc et al., 2015), use of certified trainers (Le Blanc et al., 2015), and train all providers together (Miller et al., 2016).

3.4.9.3 Delivery of treatment

Eight of the studies made at least one assessment on the delivery of treatment design (Abood et al., 2003; Manios et al., 2007; MacPhail et al., 2014; Miller et al., 2016; Peters et al., 2014; Petrogianni et al., 2013; Rodriquez et al., 2019; Le Blanc et al., 2015), which was assessed through direct observation of the intervention. Methods to ensure the content and dose of the intervention is delivered as specified being the most reported item in this domain. Various criteria were used to evaluate the treatment delivery. For example, one study (Peters et al., 2014) used a checklist after each session to measure degree of adherence, and class attendance (Manios et al., 2007; Peters et al., 2014). In another study, participants reported on the acceptability of the intervention (MacPhail et al., 2014), and how the participants rated the overall delivery of the intervention (Le Blanc et al., 2015). Other strategies used to assess delivery of treatment were the use of manuals to aid delivery (Abood et al., 2003; MacPhail et al., 2014; Miller et al., 2016; Rodriquez et al., 2019).

3.3.9.4 Receipt of treatment

Six studies made at least one assessment on the receipt of treatment. Various strategies were used to assess receipt between authors and included ensuring that participants understood the intervention (MacPhail et al., 2014; Miller et al., 2016; Peters et al., 2014; Petrogianni et al., 2013; Rodriquez et al., 2019; Le Blanc et al., 2015), and providing resources to enable participants to perform the behaviour (Le Blanc et al., 2015; Peters et al., 2014). Other strategies to assess receipt of treatment included reviewing self-monitoring data, and assessing confidence in behavioural skills (MacPhail et al., 2014; Miller et al., 2016; Peters et al., 2014; Rodriquez et al., 2019).

3.4.9.5 Enactment of treatment skills

An assessment of enactment of treatment skills was included in three of the studies in this review. Performance of intervention skill was observed in real life settings in two of the studies (Le Blanc et al., 2015; Peters et al., 2014). Other strategies to assess whether treatment was being enacted were daily self-monitoring and tracking devices (Miller et al., 2016).

Table 3.5

Fidelity of studies across 5 domains

Author	Study design	Training providers	Delivery	Receipt	Enactment	Number of components
Abood et al., 2003	✓		✓			2/5
Manios et al., 2007	✓		✓			2/5
Petrogianni et al., 2013	✓		✓	✓		3/5
MacPhail et al.,2014	✓		✓	✓		3/5
Miller et al., 2016	✓	✓	✓	✓	✓	5/5
Rodriquez et al., 2019	✓		✓	✓		3/5
Peters et al., 2014	✓		✓	✓	✓	4/5
Le Blanc et al., 2015	✓	✓	✓	✓	✓	5/5
Schwarzer et al., 2017	✓					1/5

Five domains of treatment fidelity, n=9

3.5 Discussion

To our knowledge, this is the first systematic review to assess the effectiveness of dietary interventions promoting a whole dietary pattern using a social cognition model. This review has systematically investigated the extent and type of theory use in interventions to increase adherence to whole dietary patterns, as well as associations between theory use and intervention effectiveness. This review also explored the extent to which the 5 domains of treatment fidelity are reported in the selected studies. This review found that the overall scores, across the 9 included studies, measured by the TCS averaged 10 out of a possible 21 points. This suggests that the studies were not explicitly theoretically informed or used to their full extent, even though theory was explicitly mentioned. This review also found that only two studies made at least one assessment on all five fidelity domains. As all five components of fidelity are mutually exclusive, a lack of attention or consideration in any one of the fidelity domains, could compromise the validity of the study (Borrelli, 2011).

Five behaviour change theories were used in the studies of the current review (HAPA, HBM, SCT, SDT, TTM), with HAPA used by 3 of the 9 included studies. Out of the 9 studies, one study (MacPhail et al., 2014) showed no improvements in diet following the intervention based on the DGI to create an overall single score of diet quality. Previous research has stated that the way in which dietary scales score individual food groups to create a single score can be problematic (Arvanti et al., 2008), as observed associations could be due to single components rather than the overall dietary pattern (Schulze et al., 2018). It has been suggested that small-scale scores are not so informative since they fail to capture the extremes and the inherent characteristics of a pattern or a behaviour (Schulze et al., 2018). Furthermore, research has shown that participants had better control of their diet and ate more healthily compared to the general population and therefore, changes in diet quality could not be detected (MacPhail et al., 2014). Also, those in the intervention group perceived less risk awareness to those in the control group, which could have affected their engagement in the intervention (MacPhail et al., 2014). Awareness of the importance of balanced nutrition is shown to be an important factor that may influence dietary choices (Alkerwi et al., 2015; Paquette et al., 2005).

Five of the studies used a dietary scale that reported individual food group scores. All five studies improved dietary scores for at least one food group. One study found a significant improvement in fruit intake (Miller et al., 2016), vegetable intake (Petrogianni et al., 2013), carbohydrates/grains (Manios et al., 2007), and dairy (Manios et al., 2007). Two studies reported improvements in protein (fish, poultry, beans, meat, or eggs) (Miller et al., 2016; Peters et al., 2015), and total fats (Abood et al., 2003; Manios et al., 2003). These findings are consistent with a previous review which found that out of half the studies examined, at least one aspect of diet had not improved, with a further 5 studies showing no improvement in diet quality. However, in the same review, one quarter of the studies were found to be explicitly theoretically informed (based on the TCS), and significantly improved diet quality. Of these 10 studies, 8 reported improvements in fruit and vegetables (Avery et al., 2013) suggesting that interventions that use behaviour change theory rigorously, lead to better outcomes in trials.

The current review found limited association between the use of psychological theory and improved intervention outcomes, with only three of the studies in this review reporting an association between theory and intervention effectiveness (assessed through individual TCS items). One possible explanation for the relatively limited effectiveness of the interventions reviewed in the present review is that they apply theory insufficiently. The current review showed that the included studies revealed theoretical implementation weaknesses. Most notably, linking all BCTs to theoretical constructs were met by only 4 out of the 9 studies. Compared to previous findings (Demmelmaier et al., 2018; Prestwich et al., 2014), this review observed a closer link between intervention and theory, measured by a higher percentage of studies reporting on linkage between theoretical constructs and intervention techniques (TCS items 7-11). However, in the current review, only studies that explicitly mentioned theory were included. Previous research targeted interventions whether theory was mentioned or not for the target behaviour, with only half the studies reported to be explicitly based on theory, and of those, few targeted all theoretical constructs or linked all BCTs to theoretical constructs (Prestwich et al., 2014).

Theory based interventions can help us understand processes and effectiveness of interventions (Michie & Prestwich, 2010) by identifying key constructs that are shown to be related to behaviour and behaviour change techniques related to the relevant constructs, that can be used as a target for intervention design. Research has found that interventions tailored on theoretical concepts were more effective than those tailored on behaviour alone (Noar et al., 2008). However, as more than half of the included studies in the current review did not report on this concept fully, the findings limit the extent of evidence of behaviour change factors (Lippke et al., 2008). Overall, these finding highlight the need for clearer selection, application, and reporting of theory use in the design, implementation, and evaluation of dietary intervention.

Linking BCT's to theory provides an opportunity to refine theory (Michie & Prestwich, 2010) and while the current review found that most of the studies linked at least one BCT to theoretical constructs, none of the studies used the results to refine theory. It is important to address this, as not only is theory important in the developmental stages of intervention design and future interventions, but to the advancement of our understanding of how interventions affect behaviour. This lack of refining theory from interventions is common, with similar results found in recent research (Baron et al., 2018; Casey et al., 2108; Lippke et al., 2008).

A second explanation to the relatively limited effectiveness of the interventions reviewed in the present review is that the interventions may not have been delivered as the designers intended. This cannot be ruled out as monitoring of treatment fidelity was poorly reported in the included studies. According to Borrelli, (2011) there are five domains of treatment fidelity: study design, training, delivery, receipt, and enactment, and as all five components of fidelity are mutually exclusive, inattention to any one of the domains could potentially compromise the validity of the study. The overall reporting of treatment fidelity in the current review is poor, with only 3 studies reporting on more than three of the five domains. This finding is similar to other reviews considering fidelity (Borelli, 2011; JaKa et al., 2016). Overall, we found that regardless of the TCS score, those studies that reported high on fidelity, reported improvements in more food groups than those with lower fidelity. For example, one study (Rodriquez et al., 2019) that scored the highest in the theory coding scheme but low on fidelity, reported a significant improvement in overall DASH score, but not in any of the individual food groups. Furthermore, two of the included studies that scored relatively low on the theory coding scheme and high on fidelity, reported better adherence to the Mediterranean diet (Le Blanc et al., 2015), and improvement to several of the food groups including fruit, red meat, processed meat and total AHEI scores (Miller et al., 2016). Moreover, two studies scoring the lowest on fidelity (Abood et al., 2003; Manios et al., 2007), reported improvements on less food groups, which did not include fruit or vegetables. However, these two studies also scored relatively low on the TCS. This finding demonstrates that, while the TCS addresses fidelity of treatment such as, explicitly identifying and use of theory as a basis for intervention design, there are other factors that are not addressed. For example, if insignificant results were found in an intervention and only one or two of the domains were of high fidelity, it is possible that lack of consideration in other domains may have caused the insignificant results (O'Shea et al., 2016), such as the training providers may not have been adequately trained. Therefore, we recommend researchers include a plan to assess and monitor study fidelity, based on these domains, to enhance the translation from theory to practice and reduce the likelihood of ambiguous results.

One common criticism of attempts to use theory to develop health behaviour interventions is that while they specify what should be changed (i.e., the theoretical constructs) to change behaviour, they typically do not specify how to change these constructs. Accordingly, recent reviews have started to identify the best means of changing specific theoretical constructs such as self-efficacy (Prestwich et al., 2014) and social influences (Prestwich et al., 2016). These efforts may help to identify evidence-based techniques to change theoretical constructs and thereby increase the effectiveness of theory-based interventions. It has been suggested, those that target change mechanisms at population, community and individual levels are the most effective (NICE, 2007), suggesting that behaviour change interventions may benefit from drawing on a wider range of theories than Social Cognition Models (Conner & Norman, 2015). Recently, new approaches to behaviour change, and the implementation and evaluation of interventions has been developed, in particular, the Behaviour Change Wheel, COM-B model and the BCT taxonomy which helps build the bridge between predicting behaviour and actual behaviour, by specifying the "active ingredients" of the intervention, and this classification will facilitate replication of interventions (Prestwich et al., 2016). The BCW seeks to provide a framework, that other theories can be considered. SCMs constructs mainly fall into the reflective motivation component of the COM-B model and either minimally or not at all into the other 5 components (Conner & Norman, 2015). The COM-B model is an holistic approach for changing behaviour, based on a model of an individual, rather than a mechanistic process of identifying determinants of behaviour based on factors accounting for variation in current behaviour between individuals (Conner & Norman, 2015). The BCW incorporates the COM-B model, TDF and BCT's in a systematic approach in designing an intervention. The BCW is gaining popularity in developing interventions in a range of health behaviours including dietary behaviour (Costello et al., 2018; McEvoy et al., 2018). Therefore, more research is needed, using new approaches to understand dietary behaviour, and in the development and evaluation of complex interventions (Craig et al., 2008).

3.5.1 Strengths and Limitations

A major strength of the current review is the use of the TCS, which allowed for a deeper exploration of the extent of psychological theory driven interventions, and also our understanding of shortcomings in the reporting and implementation on the use of psychological theory. This review did not conduct a meta-analysis, however, the differences found in the included studies populations, interventions and behavioural theories would make the average effect across studies difficult to interpret (Cochrane Collaboration, 2011). Relevant studies may have been excluded due to selection criteria and search terms. For example, studies that are not in English but used theory and relevant to this review would be missed and studies that failed to report they used a behaviour change theory. However, full articles were obtained for possible inclusion for potentially relevant articles, even if theory was not explicitly mentioned in the abstract, further minimising potential bias. Coding of the TCS may be subject to misclassification bias, however, two researchers (DT&LS) interpreted and coded the TCS items to reduce any bias

3.6 Conclusion

To our knowledge this is the first review to examine psychological theory driven interventions that use a whole dietary pattern. We have found that, while all the included studies mentioned theory, total use of theory scores suggest studies are not rigorously applying theory to intervention design, implementation, and evaluation, and/or are failing to explicitly report theory use in sufficient detail. We recommend designing interventions with more explicit links between theory and outcome in future research to identify which behaviour change theory and intervention techniques are the most salient in dietary interventions, advancing our understanding of behaviour change. We recommend researchers use a fidelity framework to guide the reporting of treatment fidelity in future research, that will ultimately enhance the translation of theory into practice. Mixed results were observed for the effectiveness of theory-based interventions. With the small number of included studies, only one of which was high quality, findings should be interpreted with caution. Future reviews should include both theory and non-theory interventions, to provide evidence of the effectiveness of psychological based interventions compared to no theory use.

This review highlighted weakness in studies theoretical implementations, and that the common SCMs may not be the most effective models to use to change dietary behaviour. This review highlighted that common SCMs tell you what theoretical constructs to change but not how to change them, and that the lack of theory application to design dietary interventions may have led to ineffective outcomes. Based on this information, this systematic review informed the use of the Behaviour Change Wheel to design, implement and evaluate the behaviour change intervention in this thesis, to address some of the disadvantages of other common SCMs. Having identified a gap in the literature in terms of whole dietary patterns that have been examined and theories that have been used to design interventions. The next chapter uses the COM-B model to explore factors that may influence uptake of the MIND diet.

3.7 References

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Chapter 4

Using the COM-B model to identify barriers and facilitators towards adoption of a diet associated with cognitive function (MIND diet)

4.1 Abstract

Objectives: The aim of the study was to identify components of the COM-B model, that influence behaviour to modify dietary patterns in 40-55-year olds living in the UK, in order to influence the risk of cognitive decline in later life.

Design: This is a qualitative study using the COM-B model and TDF to explore beliefs to adopting the MIND diet.

Participants: Twenty-five participants were recruited onto the study, to take part in either a focus group or an interview. Participants were men and women aged between 40-55 years. Participants were recruited via e-mail, Facebook, and face to face.

Setting: Northern Ireland

Results: Content analysis revealed that the main perceived barriers to the adoption of the MIND diet were; time, work environment, taste preference and convenience. The main perceived facilitators reported were; improved health, memory, planning and organisation, and access to good quality food.

Conclusion: This study provides insight into the personal, social, and environmental factors that participants report as barriers and facilitators to adoption of the MIND diet among middle aged adults living in UK. More barriers to healthy dietary change were found than facilitators. Future interventions that increase capability, opportunity and motivation may be beneficial. The results from this study will be used to design a behaviour change intervention using the subsequent steps from the Behaviour Change Wheel.

Keywords: MIND diet, COM-B model, dementia, adherence, brain health

4.2 Introduction

Maintaining healthy dietary behaviours is crucial for population health and the prevention of non-communicable disease. The most recent statistics show that there are around 850,000 people in the UK with dementia (WHO, 2017). The number of people with dementia is increasing because people are living longer with estimations showing that by 2025, the number of people with dementia in the UK will have increased to around 1 million (WHO, 2017). It is estimated that by 2025, 20% of the population will be over 65 years and, with this increased longevity, there is a need to identify potential variables such as diet to promote healthy ageing.

Many of the epidemiological studies of dietary patterns have investigated the impact of the Med diet (Panagiotakos et al., 2007) and the DASH diet (Sacks et al., 1999) on cognitive function (Morris et al., 2016). Research found that higher adherence to the respective diets were significantly associated with less cognitive decline in midlife over a 4-month period (Smith et al., 2010) and also in older adults over a 4-year period (Tangney et al., 2014).

The MIND diet (Morris et al.,2014) is a hybrid of the Med diet and DASH diet. Findings from research on the Med and DASH diets, showed that protective effects on cardiovascular conditions that may adversely affect brain health. However, the dietary components of both individual diets may not capture the levels and types of foods shown to optimize brain health (Morris et al., 2014).Therefore, the MIND diet was designed to emphasize the dietary components and servings linked to neuroprotection and dementia prevention (Morris et al., 2014). The MIND diet consists of 10 healthy foods (leafy greens, other vegetables, nuts, berries, fish, poultry, olive oil, beans, whole grains, red wine) and 5 other foods which are to be limited (red meat, butter, cheese, pastries and sweets, fried foods).

There has been limited research investigating the MIND diet, however, recent research with older adults found that the MIND diet can slow cognitive decline over an average of 4.7 years (Morris et al., 2015). This study found that the MIND diet score was more predictive of cognitive decline than either the Med diet or DASH diet. Research found a 53% lower risk for AD with high adherence to the MIND diet (Morris et al., 2015). Furthermore, a 35% lower risk of AD was shown for a moderate adherence to the MIND diet (Morris et al., 2015), whereas no significant association with AD was shown for the Med or DASH diet (Van den Brink et al., 2019). Further support for a lower risk of cognitive decline with both moderate and high adherence to the MIND diet was shown in Adjibade et al. (2019). This study showed that 72% of the large sample (6011) adhered at least moderately to the MIND diet (Adjibabe et al., 2019). Interestingly, recent research found that the MIND diet and not the Med diet, protected against 12-year incidence of mild cognitive impairment and dementia in older adults (Hosking et al. 2019). A longitudinal study with older adults found higher adherence to the MIND diet was associated with less cognitive decline after a 6 year follow up (Shakersian et al., 2018), and that greater long-term adherence to the MIND diet was associated with better verbal memory over 6 years in older adults (Berendsen et al., 2018).

Little is known about the social, environmental, and cultural perspectives of adopting the MIND diet in the UK. However, research has found that adopting a Mediterranean style diet has social, cultural, and environmental barriers. Research found that participants reported British culture to be non-conducive to a Mediterranean dietary pattern (Middleton et al., 2015) and that factors such as time, work and convenience were barriers to consuming a Mediterranean style diet (Nicholls et al., 2017; Phino et al., 2018). The cost of food is suggested to play a role in peoples food choices (Kearney et al., 2000) and that a healthy diet may be costlier than a less healthy diet (Conklin et al., 2016; Rao et al., 2013). Therefore, budget could be a barrier to eating a Mediterranean style diet, especially for those of low socio-economic status. However, previous research has found, that while consuming a healthier diet such as increasing fruit and vegetables, may be more expensive, this cost could be offset with the reduction in meat product cost (Kretowicz et al., 2018)

This study seeks to explore the perceived barriers and facilitators to adopting the MIND diet at midlife (40-55 years) in this non-Mediterranean country. This research could also add support to the dementia strategy research by exploring modifiable risk factors in the prevention of dementia, which could be applied globally.

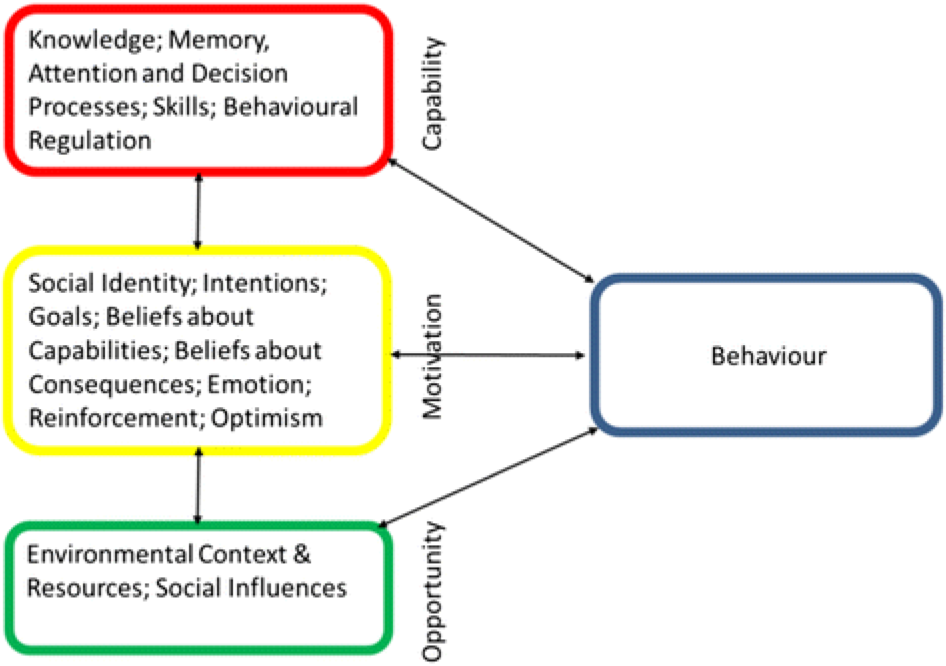
4.2.1 Theoretical Framework

The BCW is a framework for designing and evaluating interventions. At the BCW core, is a model of behaviour known as COM-B model, which stands for Capability (C), Opportunity (O), Motivation (M) and Behaviour (B) and posits that all 3 components influence behaviour, which accounts for all the factors outside the person that make the behaviour possible. The model also posits that both capability and opportunity influence motivation making it the central mediator of the model, therefore, capability and opportunity affect behaviour both directly and indirectly. According to the COM-B model, in order to change behaviour, one or more of the COM-B components need to change, relating to either the behaviour or behaviours that support or compete with it (Michie et al., 2014). In this study the COM-B model is used to explore perceived barriers and facilitators to identify potential levers for change for adoption of the MIND diet to occur. A “behavioural analysis” of the determinants of

MIND diet behaviour will help define what needs to change in order for adoption of MIND diet to occur. This will be a new behaviour to many, as this diet is very new and has not been investigated in this way before. The COM-B model can be further elaborated by the TDF (Cane et al., 2012) (see Figure 4.1). Although the TDF is descriptive and fails to postulate the link between domains (Francis et al., 2004), it consists of 14 domains covering the spectrum of behavioural determinants and can be mapped directly onto the COM-B components (Cane et al., 2012), which specifies the relationship between domains in regards to a person's capability, motivation and opportunity to enact a behaviour (Michie et al., 2014) and includes constructs aligned with other behaviour change theories such as the TPB (Ajzen, 1991). Each domain of the TDF is further elaborated by several core components such as; belief about capabilities which include, self-efficacy, control of behaviour and confidence (Cane et al., 2012). The comprehensive coverage of the TDF allows researchers to analyse the most important domains specific to their target behaviour, allowing a crucial step in predicting, and ultimately changing dietary behaviour. By providing a wider range of behavioural determinants, researchers gain a deeper understanding of factors influencing behaviour which can be addressed fully in intervention design.

Figure 4.1

TDF domains and corresponding mapping onto the COM-B component



Michie et al. (2014) Cane et al. (2012)

Several qualitative studies have used the COM-B model and TDF to explore barriers and facilitators to dietary behaviour change (Alexander et al., 2014; Bentley et al., 2019; Rawahi et al., 2018). These studies found that the COM-B model and TDF provided a comprehensive framework for describing barriers and facilitators to reducing sugar intake in young adults (Alexander et al., 2014), delivery of a healthy kids check to pre-schoolers (Rawahi et al., 2018) and to athlete nutritional adherence from the sports nutritionist perspective in 26-52 year olds (Bentley et al., 2019). These studies found the COM-B and TDF useful to inform an intervention to promote behaviour change. Furthermore, studies have designed dietary interventions based on the COM-B model to promote the Med diet in adults at risk of cardiovascular disease (McEvoy et al., 2018), an app to improve eating habits of adolescents and young adults (Rohde et al., 2019), and a text messaging service targeting healthy eating for children in a family intervention (Chai et al., 2019).

This study investigates the perceived barriers and facilitators to adopting the MIND diet in midlife (40-55 years). As we are looking to promote healthy ageing, we are investigating modifiable risk factors in the prevention of cognitive decline. Research has found that a good quality diet at midlife seems to be strongly linked to better health and well-being in older life (Samieri et al., 2013). Previous research found that adherence to a healthy dietary pattern in midlife was positively associated with cognitive functioning (Kesse-Guyot et al., 2012).

There is currently no study investigating adoption of the MIND diet in midlife. This study addresses this gap in the literature and highlights the perceived barriers and facilitators to adopting a diet that may promote brain health at midlife and will be used to inform an intervention design.

The aim of this study was to explore perceived capability, opportunity, and motivation to adopting the MIND diet among middle-aged (40-55 years) adults. The resulting information will be used to inform the design of an intervention to promote the MIND diet in middle-aged adults in the UK.

4.3 METHOD

4.3.1 Design

A mixed methods qualitative design was used to elicit beliefs surrounding Capability, Opportunity, Motivation and Behaviour (COM-B) with adopting the “MIND” diet. Capability, motivation, and opportunity were further elaborated into 14 domains, using a more detailed tool to understand behaviour, the Theoretical Domains Framework. (TDF). Interviews and focus groups generate different information from participants.

Research shows that while focus groups generate a wider range of ideas and views than that of interviews (Krueger, 2014), one to one interviews capture more detail than focus groups and offer more insight into participants personal thoughts and experiences (Kidd &Parshall, 2000). In accordance with the COM-B framework, collecting information to understand the target behaviour, data should be collected from different sources as the most accurate picture will be informed by multiple perspectives, therefore, both focus groups and interviews were conducted (Michie et al., 2015) and lasting between 30-60 minutes each (see Table 4.1). The interview and focus group questions were based on guidance using the COM-B (Michie et al., 2014) model and TDF (Cane et al., 2012) (Table 4.1). The model and framework were used both in developing the interview schedule and informing the content analyses used. A topic guide was developed using the TDF (Cane et al., 2012). The TDF consists of a comprehensive set of 14 domains into which all determinants of adherence to implementation of a behaviour can be organised (see Table 4.1). The TDF can be mapped onto the overarching COM-B model (Michie et al., 2015), which posits that three key components are necessary for any behaviour—capability, opportunity, and motivation.

Table 4.1

Interview/Focus Group Questions asked to Participants in Accordance with the TDF and COM-B model.

COM-B	TDF	QUESTION
Psychological Capability	Knowledge.	What is your understanding of the MIND diet?
Psychological Capability	Memory, attention, and decision processes.	To what extent is eating a diet to promote brain health something you normally do? ➢ Prompt: Do you eat foods that promote brain health each day ➢ What brain healthy foods do you eat?
Psychological Capability	Behaviour regulation	To what extend do you have a way to monitor whether you are eating foods that promote brain health? App?

Physical Capability	Skills	To what extent are you confident in cooking/eating a diet that promotes brain health? Prompt: What has made you confident?
Social Opportunity	Social influences	To what extent do/would your family or friends help or hinder you eating a diet that promote brain health? ➢ Prompt: Does/would your family support you in eating a diet that promotes brain health?
Physical Opportunity	Environmental context and resources.	Discuss anything in your work or/and home environment that might help or hinder you eating foods that promote brain health? i.e. budget, time
Reflective Motivation	Social/Professional role and identity	To what extent would eating a diet that promotes brain health be accepted by your friends and family? ➢ Prompt: Do you think your family/friends influences what you eat?
Reflective Motivation	Belief about capabilities	How difficult/easy would it be for you to eat a diet that promotes brain health? ➢ Prompt: What are the barriers to consuming a diet that promotes brain health? ➢ Prompt: What are the facilitators to consuming a diet that promotes brain health?
Reflective Motivation	Optimism	To what extent are you confident that any barriers you may have to eating a diet that promotes brain health can be solved? Prompt: What has made you confident?
Reflective Motivation	Intention	To what extend do you intend to follow the MIND diet to promote brain health?
Reflective Motivation	Goals	To what extent would you like to follow the MIND diet?
Reflective Motivation	Belief about consequences	What do you think will happen if you eat a diet to promote brain health? ➢ Prompt: Are there any benefits to eating a diet that promotes brain health?
Automatic Motivation	Reinforcement	Discuss any incentives for you to eat a diet that promotes brain health? Prompt: What are your motivations to eat brain healthy foods?
Automatic Motivation	Emotion	How do you feel about eating a diet to promote brain health? Would you feel positive? Would you feel negative?

COM-B: Capability (C): Psychological or physical ability to enact behaviour; Opportunity (O): Physical and social environment that enables behaviour. Motivation (M): Reflective or automatic mechanisms that activate or inhibit behaviour; Behaviour (B). TDF: Theoretical Domains Framework.

4.3.2 Participants

According to similar behaviour change theories, the ideal sample size for elicitation studies is 25 (Francis et al., 2004). Also, similar to other qualitative studies using the COM-B and TDF (Alexander et al., 2014; Rawahi et al., 2018), twenty-five participants were recruited onto the study, to take part in either a focus group or an interview. Participants were selected for interview or focus group based on their convenience to attend, which took place either in their local community hall, library, workplace, or home. Participants were both Caucasian men and women aged between 40-55 years. Participants were recruited via e-mail, Facebook, and face to face, which took place in a supermarket. Interested participants were emailed a participant information sheet (PIS), consent form and a "MIND DIET" booklet, explaining the elements of the MIND diet. Participants approached face to face were given the booklet explaining the MIND diet and asked to contact the researcher if interested in taking part, at which time, were emailed the PIS and consent form. All interested participants were asked to contact the researcher by email. Dates, times, and venue were arranged for focus groups and interviews.

Inclusion criteria: Male or female aged between 40-55 years old living in Northern Ireland, who have no food allergies or intolerances.

Exclusion criteria: Participants following specific diets that excluded food groups, such as veganism, vegetarian, Atkins were excluded from the study as these diets exclude foods such as fish, poultry, and wholegrains, which are specific to the MIND diet. Participants with food allergies and/or intolerances were also excluded from the study.

4.3.3 Procedure and Materials

Participants were contacted by e-mail, Facebook, and face to face. All participants were asked to complete a personal information form which further asked if they followed a specific diet and sign the consent form before the interview/focus group began. Before interview/focus group began, there was an in-depth discussion on the MIND diet and its components between participant and researcher to ensure participants understood what the diet entailed. Participants were informed of what foods to eat, how often to eat foods and portion sizes required. There was also discussion on dementia risk factors and prevalence in the UK. The questions tapped into the components of the COM-B and TDF, that of capability, opportunity, motivation, and behaviour towards consuming a healthy diet. Interviews/focus groups were approached the same in terms of discussion and questions asked, and were audio recorded using a hand-held recorder.

Participants were informed that the study was voluntary and that they were free to withdraw at any time. They were assured of confidentiality regarding any personal information they supplied to the researcher.

4.3.4 Data Analyses

The data was transcribed verbatim and analysed using content analyses. Both researchers have extensive experience and training in content analysis employed within theory of behaviour change frameworks and to inform intervention design. Researchers attended specific workshops on the COM-B framework. LS is a Health Psychologist and DT a trainee Health Psychologist, with an array of skills and experience in qualitative research analysis and the use of behaviour change theories. Two researchers independently read through the entire dataset and coded the data from each transcript and assigned initial “code names”. Researchers kept a reflective diary to ensure a clear overview of the material. Each code was noted as either “barrier” or “facilitator”, depending on the context in which the code occurred. A deductive approach was applied in the form of existing constructs (e.g., capability) and theoretical domains (e.g., skills). However, there was scope to define subthemes which arose within each domain. There was an initial 95% agreement of codes, which demonstrates an acceptable level of agreement (Hartmann, 1977). Discussion between researchers resolved any differences within the coding process. After agreement on codes had been made, an additional step in analysis was taken by applying summative content analysis (Hsieh & Shannon, 2005) which involved both researchers searching the text for occurrences of codes and frequency counts for each identified code was calculated. Using a common approach (Brussiers et al., 2012; Lake et al., 2017). TDF domains were judged based on the frequency count of coding for each TDF domain, which had been aggregated from all the factors and behaviour-specific belief statements within that domain. TDF domains were then rank ordered according to the frequency coding to identify which components and domains of the theoretical models were the main barriers and facilitators to adoption of the MIND diet (see Table 4.2 and 4.3).

Table 4.2

Facilitators in rank order of utterances in relation to MIND diet in 40-55-year olds: COM-B and TDF domains

COM-B	TDF	Rank order	Frequency of utterances relating to codes	%utterances
	Facilitators			
Reflective motivation	Belief about consequences	1	28	17
Reflective motivation	Belief about capabilities	2	27	16
Physical opportunity	Environment context and Resources	3	22	13
Social opportunity	Social influences	4	21	13
Physical Capability	Skills	5	20	12
Automatic motivation	Emotion	6	15	9
	Reinforcement	7	10	6
	Intention	8	6	4
	Behaviour regulation	9	4	2
	Optimism	10	4	2
	Social/Professional and identity.	11	3	2
	Knowledge	12	3	2
	Memory	13	1	1
	Goals	14	0	0
	TOTAL		164	100

Information above the thick black line represents the top 6 reported domains of the TDF and corresponding COM-B components. Eighty percent of the data fell into the top 6 TDF domains:

Table 4.3

Barriers in rank order of utterances in relation to MIND diet in 40-55-year olds: COM-B and TDF domains

COM-B	TDF	Rank order	Frequency of utterances	%utterances
	Barriers			
Physical opportunity	Environment context and Resources	1	90	29
Reflective motivation	Belief about capabilities	2	46	15
Psychological capability	Knowledge	3	37	12
Psychological capability	Memory, attention, decision process	4	30	10
Psychological capability	Behaviour regulation	5	24	7
Physical capability	Physical skills	6	17	6
	Social	7	15	5
	Belief about consequences	8	12	4
	Social/professional and identity	9	12	4
	Intention	10	9	3
	Optimism	11	6	2
	Goals	12	5	2
	Emotion	13	3	1
	Reinforcement	14	1	0
	TOTAL		307	100

Information above the thick black line represents the top 6 reported domains of the TDF and corresponding COM-B components. Eighty percent of the data fell into the top 6 TDF domains; COM-B: Capability (C): Psychological or physical ability to enact behaviour; Opportunity (O): Physical and social environment that enables behaviour. Motivation (M): Reflective or automatic mechanisms that activate or inhibit behaviour; Behaviour (B). TDF: Theoretical Domains Framework.
Utterances: Spoken word/words in relation to codes/themes/subthemes emerging from questions asked regarding MIND diet.

4.4 RESULTS

A total of 25 participants took part in the study. Fifteen individual interviews and two focus groups. One focus group included six participants and the second focus group included four participants. Participants were both male (40%) and female (60%) aged between 40-55 years old with an average age of 45 years. Forty percent of participants were of low socio-economic status. Forty four percent of participants had children living at home and fifty six percent of participants lived rurally compared to forty four percent living in an urban area (see Table 4.4 for participants characteristics).

Table 4.4

Summary Characteristics of Interview/Focus Group Participants(n=25)

Characteristic		Percentage of sample (N=25)
Age		
40-44		60(15)
45-49		16(4)
50-55		24(6)
Gender		
	Male	40(10)
	Female	60(15)
Occupation		
	Professional	44(11)
	Skilled	16(4)
	Unskilled	40(10)
Education		
	Higher education	36(9)
	Further education	28(7)
	No formal qualifications	36(9)
Marital status		
	Married	44(11)
	Co-habiting	4(2)
	Separated	4(2)
	Single	32(8)
	Widowed	4(2)
Living	Urban	44(11)
	Rural	56(14)
Children	Yes	44(11)
in household	No	56(14)

Education: Level of education obtained within a discipline or profession. Higher education= undergraduate/postgraduate degree: Further education= any study after secondary school that does not include higher education, such as higher national diploma, higher national certificate, apprentices for industry such as hairdressing, plumbing. N=25

4.4.1Theoretical Framework

The transcripts provided data from all the 14 domains of the TDF and all the components of the COM-B model. All the perceived facilitators and barriers could be fitted into one of the TDF domains and mapped onto the COM-B model, with 65% of all mentions reported as barriers to adopting the MIND diet, compared to 35% of mentions reported as facilitators. The most commonly reported domains were, belief about consequences, belief about capabilities and environmental context/resources, and the least commonly reported domains were, goals and optimism (see Table 4.5 and 4.6 for quotes).

Table 4.5

Key facilitators, themes, and quotes

COM-B	TDF	SUB-THEME	QUOTE
Reflective motivation	Belief about consequences	1. Feel better generally 2. Improve psychological health 3. Improve memory	“I think the diet would just help you feel better generally” (male 41, low education, I: P12) “And even help your head, less stress and worry” (male 55, low education, I: P21) “Well if it helps with dementia and we are heading for that” (female 40, higher education, I:14)
Reflective motivation	Belief about capabilities	1. Planning/ preparation/ organisation	“Organisation and preparation the night before, so having your berries and salad ready for work” (female 48, low education, I: P20) “I buy frozen cabbage, spinach, the things that I eat and just throw them in at the end and that is that” (female, 49, higher education, FG2: P8) “Preparation is a massive thing, because if you know what you are going to be eating, you can prepare for that. And you know what you are going to have for a snack or lunch”. (female 41, higher education, FG1: P4).
Physical opportunity	Environment context	1. Accessibility fresh/frozen food 2. Bring lunch to work	“I would go to Lidl, because it is cheaper and better quality” (female 40, higher education, FG1: P3) “In my work, you need to be prepared and bring lunch with you” (female 42, higher education, FG1: P5)
Social opportunity	Social influence	1. Family support/influence	“My mum is always cutting out articles showing me research on good and bad foods for your health (male 51, low education, I: P13 “I think my family would support me if I wanted to do it yes”. (male 48, low education, I: P15).
Physical capability	Skills	1. Confident cook	“I am pretty confident cooking these foods” (female 41, higher education, FG1: P6) “Well I am a confident cook, but not always the best cook, but if I see recipe, I will have a try”. (female 43, low education, I: P22) “You can google what ingredients you have and google will give you a recipe”. (female 42, higher education, FG1: P5).
Automatic motivation	Emotion	1. Positive	“I would be positive about it, I get excited trying new things” (female 50, higher education, FG2: P9) “I feel positive about it, I do intend to follow it, but not religiously, there is no point telling a lie, I am not a robot, a walking talking machine”. (male 40, low education, I: P12)

COM-B= Capability, Opportunity, Motivation, Behaviour TDF= Theoretical Domains Framework n=25 FG1=focus group 1, FG2= focus group 2 I=interview P=participant

Table 4.6

Key barriers, themes, and quotes

COM-B	TDF	SUB-THEME	QUOTE
Physical opportunity	Environmental context	1. Time 2. Food environment at work/canteen 3. Budget 4. Treats in for kids.	"For me it is time, by the time you get home from work, and maybe have done overtime, you couldn't be bothered" (male 40, further education, FG1: P1) "There is nothing healthy in a canteen" (male 50, higher education, FG2: P10) "I am on my own here with 4 kids, so budget is definitely a factor." (female 40, low education, I: P18) "There are always buns, biscuits in the cupboards, for visitors and kids." (female 48, further education, I: P20)
Reflective motivation	Belief about capabilities	1. Convenience 2. Taste preference 3. Mindset	"Kids don't want healthy stuff, so sometimes I have convenience stuff to make it easier for me" (female 40, low education, I: P17) "I think if I was going to change my diet, I would have to be in the right frame of mind" (male 51, low education, I: P13) "There is stuff there I won't eat and that is that" (male 51, further education, FG2:P7)
Psychological capability	Knowledge	1. Lack knowledge of MIND diet and foods	"If you don't know what is healthy for your brain, you won't eat that way" (male 40, further education, FG1: P2) "Well probably mainly cos I didn't know it would have any benefit on my brain". (Female 45, low education, I: P23)
Psychological capability	Memory, attention, and decision process	1. Alcohol 2. Tired 3. Holidays	"If I had a drank alcohol at the weekend, it would take Tuesday or Wednesday to get over it, and I wouldn't want to eat this food" (female 40, higher education, FG1: P3) "Well ye know, if I have been out all day with the kids and I am tired, and I haven't the slow cooker on, there'll be a fast food takeaway then, and that's the reality of it". (female 40, higher education, I: P17) "And like holidays like Christmas, you just eat for the sake of it." (female 41, higher education, FG1: P4)
Psychological capability	Behaviour regulation	1. Lack monitoring of food consumption	"No, I don't, and sure, when I go to weight watchers, I don't even do it" (female 41, low education, I: P16) "No, but trying to be very aware of it, you know, but not recording it". (female 40, low education, I: P14)
Physical capability	Skills	1. Lack cooking skills	"I couldn't cook that, if you handed me all the ingredients, I would be like, what am I doing with it" (male 51, further education, FG2: P7) "No, I wouldn't be confident, I can cook basic meals, but I am not very versatile with those foods on that diet". (male 55, low education, I: P21).

COM-B= Capability, Opportunity, Motivation, Behaviour TDF= Theoretical Domains Framework n=25 FG1=focus group 1, FG2= focus group 2, I=interview, P=participant

4.4.1.2 Capability

According to the COM-B model, for behaviour to occur, there must be the capability to do it. Capability can be either psychological (knowledge, psychological skills, or stamina) to perform the behaviour, or “physical” (having the physical skills, strength, or stamina) to perform the behaviour.

Psychological Capability. Psychological capability was a COM-B component identified as a barrier to participants adoption of the MIND diet. Twenty nine percent of barriers to adopting the MIND diet fell into the psychological capability component of the COM-B model. These barriers also fell into 3 of the 14 TDF domains, knowledge, memory, attention and decision processes, and behavioural regulation.

Knowledge. All participants reported that they had never heard of the MIND diet prior to the current study. Most participants reported that they did not know that certain foods were associated with brain health.

Memory, attention, and decision processes. The current study defined memory, attention and decision processes as the role of memory and attention to ensure adoption of the MIND diet, and “life distractions”, such as alcohol and tiredness, which may limit attention control with respect to eating foods that promote brain health. Several of the participants reported that alcohol is a barrier to eating brain healthy foods. Another “distraction” reported by participants was being tired. This was mainly due to participants being at work all day or having a long day with the children and too tired to cook when they came home. One participant reported eating sugary foods because of tiredness, to keep him going throughout the day.

Behaviour regulation. In terms of dietary patterns, behaviour regulations are the steps taken to ensure that food intake is remembered and conducted, and steps taken to break unhealthy habits. In this study, most of the participants did not monitor their food intake. However, most of the participant's viewed monitoring of food, with weight management programs. However, several participants stated that while they did not record their food intake, they were aware of what they ate.

Physical Capability: Skills. Physical skills are defined as the level of self-efficacy in cooking/eating with MIND diet foods. Six percent of the barriers to adoption of the MIND diet fell into the TDF skills domain and mapped onto the physical capability component of the COM-B model. Cooking skills were reported to be a barrier to adoption of the MIND diet. Those participants who reported cooking skills as a barrier, tend to be married men. However, most of the participants that reported lack of cooking skills, were particular to a food in the MIND diet that they usually did not eat. Skills was also reported to be a facilitator in this study, with 12% of all facilitators falling into the TDF skills domain. Most participants felt confident with cooking with the MIND diet foods. Also, many participants reported that if they did not know how to cook something, they were confident that they could follow a recipe.

4.4.1.3 Opportunity

The COM-B model states that for behaviour to occur, there must be the opportunity for the behaviour to occur in terms of a conducive physical and social environment.

Physical Opportunity. Barriers relating to physical opportunity was the most commonly reported barrier in this study, with 29% of all barriers falling into this component. Physical opportunity is defined in terms of what the environment facilitates in terms of time, resources, location, physical barriers etc. The TDF domain related to this component is environmental context and resources.

Environmental context and resources. This domain is defined as any circumstance of a person's situation or environment that discourages or encourages the development of skills and abilities, independence, social competence and adaptive behaviour, environmental stressors, resource's, salient events and person x environmental interaction. For example, cost of foods, lack of time, does not do the shopping or cooking, accessibility of cheap fresh foods. Several participants reported that their work environment was a barrier to eating MIND diet foods. In particular, their facilities to cook at work and the canteen at work.

Time was another major barrier, most participants, especially those who were in employment. Participants reported that having worked all day, they did not have the time to cook fresh food all the time. Also, those participants who have children, reported time to be a barrier. Participants reported that getting children ready for school or after school, homework, and activities, took the time away from cooking healthy meals.

Having treats in the house and in the workplace is reported to be a major barrier in eating MIND diet foods. All participants with children reported having treats in for the kids but would eat the treats themselves. Also, all those participants that were employed, reported that treats at work was a barrier to eating MIND diet foods. Budget was reported to be a barrier to buying some of the MIND diet foods, such as berries and nuts, as these foods are reported as expensive. This was the view of those participants who were either not working or in low paid jobs.

Environmental context and resources domain were also reported as being a facilitator to adoption of the MIND diet. Participants reported that, having access to cheap fresh/frozen foods would be a facilitator. Some participants reported that, with stores like Lidl and markets where there are cheaper foods, that there is really no "excuse" to not eat healthy. Participants also reported that, a lot of food can be bought frozen, such as fruit, vegetables, chicken, and fish and that it is cheaper and a good way of preparing meals for the week ahead. Participants also reported that a facilitator to adopt the MIND diet under this domain was, to bring lunch to work. Participants felt that, in order to consume the MIND diet foods at work, they would need to bring lunch with them, to avoid eating out or from a canteen.

***Social Opportunity*.** Social opportunity was reported as a key facilitator in this study, with 13% of all facilitators falling into this component. The TDF domain related to this component is, social influence. Participants reported, family support/influence as a key facilitator to adoption of the MIND diet. Participants reported that they felt that family would support them if they were to adopt the diet. Participants also reported that family influence would facilitate them in consuming the MIND diet.

4.4.1.4 Motivation.

Motivation is a component of the COM-B model and there must be strong motivation for the behaviour to occur. Motivation can be divided into “reflective” or “automated”.

Reflective Motivation. Reflective motivation involved self-conscious planning and evaluations. (Beliefs about what is good or bad). Participants reported reflective motivation to be a barrier to the adoption of the MIND diet and 15% of barriers fell into this component of the COM-B model.

Belief about capabilities. Acceptance of the truth/reality about or validity of an ability, talent or facility that a person can put to constructive use: Self-confidence, perceived competence, perceived behavioural control, self-efficacy: The extent to which the individual believes they are able to adopt the MIND diet.

Participants reported that convenience was a barrier to adoption of the MIND diet. Those participants with children reported that, their children did not like healthy food or would not eat the MIND diet foods, and rather than making two meals, they ate what the children wanted out of convenience.

Taste preference was also a key barrier to the adoption of the diet under this domain. Some participants reported not liking some of the MIND diet foods, such as leafy greens, nuts, or fish. Others were not willing to try different foods or try a different way of cooking those foods. Mindset was another key barrier reported to adoption of the diet within this domain. Participants reported that to change their diet and consume the MIND diet, they would have to be in the right frame of mind. They would need to want to change their diet for a reason and be determined to do so.

There were more facilitators than barriers that fell into the motivation component of the COM-B model. Forty two percent of the facilitators in this study fell into the motivation component of the COM-B model. Seventeen percent of facilitators fell into the TDF belief about consequences, 16% of facilitators fell into belief about capabilities and 9% of facilitators fell into TDF emotion.

Belief about consequences. This domain is defined as the, *anticipated outcomes of not eating brain healthy foods, anticipated or experienced outcomes of eating brain healthy foods. (positive or negative).*Participants reported that, if they were to consume the MIND diet, they felt that this would make them feel better generally and improve memory. Some participants also reported that with the better quality of food in the MIND diet, and the reduction of fat and sugar, they felt, their psychological health would improve.

Belief about capabilities. It was reported that in order to facilitate participants adopting the MIND diet, they would need to be, prepared, organised and plan. Participants reported leading busy lives, with work and children and while time and convenience were a barrier to consuming the diet, if they were to have the MIND diet foods in the house, organise and prepare meals in advance or at least have an idea of what to cook, this would help facilitate adoption of the MIND diet.

Automatic Motivation. Automatic motivation was reported as a facilitator to adoption of the MIND diet, with 9% of facilitators falling into the TDF emotion domain. Automatic motivation involves wants and needs, desires, impulse and reflex responses.

Emotion. Most participants reported feeling positive when asked how they feel about the prospect of adopting the MIND diet. However, this did not necessarily coincide with their intention to do so.

4.5 DISCUSSION

This study sought to elicit factors influencing adoption of the MIND diet in midlife in the UK. This is the first theory-based qualitative study to explore participants' barriers and facilitators to adopting the MIND diet. Results found that, 80% of barriers and facilitators fell into 6 of the TDF domains, with the main barriers reported as; environmental context and resources, belief about capabilities, knowledge, memory, attention and decision making, behaviour regulation and physical skills, and the main facilitators reported as; belief about consequences, belief about capabilities, environmental context and resources, social influences, skills and emotion. Results confirmed earlier findings regarding common barriers and facilitators to adopting or adherence to dietary change, including budget (Petroka et al., 2017), time and taste preference (De Mestral et al., 2016), and convenience and cooking skills (Hibbs-Shipp et al., 2015).

Participants reported having no knowledge of the MIND diet prior to the study and lacked knowledge in brain healthy foods. Lacking cooking skills was also reported as a barrier, highlighting that "capability" was a key barrier to adopting the MIND diet.

Previous research found that a major barrier to meeting dietary recommendations, was lack of knowledge regarding dietary recommendations and health benefits (Nickles et al., 2013), and lack of information on healthy foods.[44] Previous research found that not knowing what to eat or how to eat or cook healthily was a barrier to healthy eating (Baruth et al., 2014). Many participants reported not eating beans and lentils, which are part of the MIND diet. This was mainly due to lack of knowledge on how to prepare beans and how to make them tasty. This finding is similar to previous research that found lack of knowledge on how to prepare pulses, a barrier to their consumption (Desrochers et al., 2000; Phillips et al., 2014). Beans may not be a common staple in the Northern Irish population, and, therefore, may explain why families report similar barriers regardless of income or where they live.

Participants reported a lack of monitoring their food intake which also highlights “capability” as a key barrier to adoption of the MIND diet. Research found that behaviour regulation was associated with changes in dietary outcomes (Greaves et al., 2011), and that self-monitoring specifically showed a positive change in diet (Maas et al., 2013). Maas et al. (2013), found that self-monitoring reduced snack eating but not alcohol consumption. However, this finding is in line with other research that suggests self-monitoring of alcohol consumptions to be weak (Korotitsch & Nelson-Gray, 1999) or absent (Huuford et al., 2002; Simpson et al., 2005).

Opportunity was highlighted as a barrier and facilitator to the adoption of the MIND diet, with physical opportunity reported as the main barrier. A major theme to emerge was environmental context and resources, with “budget” being a significant factor, mainly due to the expense of the healthy components of the MIND diet, such as fruit, nuts, and fish. Budget was only reported as a barrier by those participants who were of low socioeconomic status. These findings are in line with previous research, that found food cost to play an important role in determining people's food choice and consumption (Kearney et al., 2000) and that it is the healthy component of a whole dietary pattern such as, fruit and nuts of the Med diet, that is associated with higher cost (Tong et al., 2018). This finding is supported in the literature in a recent meta-analysis (Conklin et al., 2016) that found healthy foods such as fruit, vegetables, and nuts to be more expensive than processed foods, refined grains, and meat. Therefore, this suggests that budget could be a main barrier to adopting a healthy dietary pattern amongst those of low socio-economic status.

However, previous research compared the actual cost for a four-member family with the cost of the same family following a Med diet and found that the monthly expenditure was slightly higher on the Med diet in the overall budget (Germani et al., 2014). However, after increasing the budget for fruit and vegetables, and reduced budget for processed meat and sweets, the overall budget for both diets were similar and therefore, it was concluded that lower adherence to the Med diet was not related to budget, but rather, a substantial difference in allocating budget to the different food groups, for example, less money on fruit and vegetables. Similar findings were found in other research (Bernstein et al., 2010; Goulet et al., 2008; Kretowicz et al., 2018).

Physical opportunity was also reported to be a facilitator is this study, with environmental context and resources also emerging as a theme. Access to fresh cheap produce was reported as a barrier and facilitator in the current study. The results found that those living in rural areas to be a barrier more than those living in a city, where there may be more access to markets and bigger stores within reach. Research found that stores with more nutritious food is a longer distance away from rural areas (Maley et al., 2010; Neil et al., 2011). However, those who could grow their own food or had access to farmers' markets, was a facilitator to healthy eating (Sequin et al., 2014). Participants who received nutrition education and access to a garden to eat fruit and vegetables, reported to eat the recommended daily fruit and vegetables (Barnridge et al., 2015).

Social influence was reported as a key facilitator in this study with social influence emerging as a theme. Participants reported that family support and influence was a factor that would help them adopt the MIND diet. This finding in consistent with previous research that found family influence as a facilitator in nutritional knowledge and healthy habit (Doldren et al., 2013). Other research found that those who perceived family support were more likely to eat more fruit and vegetables, wholegrains and consume less meat and fats (Pawlak et al., 2009, Walker et al., 2006). However, family has been found to be a barrier to healthy eating (Baruth et al., 2014). It was reported that women were pressurised to eat more and that they were not supported if they were trying to eat a healthy diet (Baruth et al., 2014). However, the sample in this study was with African American women, and they may feel pressure to eat more, as food and the context of eating their traditional food is important to their cultural identity. The women in this study reported that larger curvaceous bodies are the ideal body type for African American women and that food was a big part of their customs (Baruth et al., 2014).

Motivation was also highlighted as a barrier and facilitator to the adoption of the MIND diet. Belief about capabilities was a major theme to emerge as a barrier. Participants reported convenience to be a factor associated with their ability to adopt the MIND diet. Previous research also found convenience to be a barrier to healthy food choices (De Mestral et al., 2016), and that fast food and unhealthy snacks were more convenient (Sequin et al., 2014).

The results from this investigation has created a “behavioural diagnosis” of what needs to change from the COM-B analysis in order for dietary behaviour change to occur. The COM-B model and TDF are used as a starting point to understand behaviour in the context in which it occurs. This behavioural diagnosis has identified that all 3 components of the COM-B model can be targeted as potential levers of change. Linking the COM-B model to the BCW allows for a systematic approach in subsequent intervention development and evaluation (Michie et al., 2015). The BCW helps guide the transition from theory to practice and, in designing the intervention, the COM-B components to be targeted will be mapped onto intervention functions and policy categories suggested by Michie et al. (2015) that are expected to be effective in bringing about change, such as education, persuasion, and coercion. Following the identification of intervention function and policy categories, the content of the intervention will be identified in terms of which behaviour change techniques and mode of delivery are best to promote behaviour change.

4.5.1 Limitations

This study was undertaken in a small sample of men and women, although in line with other COM-B studies (Avery et al., 2018) and dietary studies (Kretowicz et al., 2018). Furthermore, while we were able to include participants with different sociodemographic backgrounds, this study was conducted only with a white Irish sample. However, 98% of the population in Northern Ireland are white, with 88% born in Northern Ireland (Country et al., 2020) therefore, the current studies sample reflects the majority of the NI population. Further research to collect data from a more ethnically diverse population is needed. Moreover, our findings may be context based and, therefore, not generalisable to the whole population. However, our study did not aim to find generalisability, rather to find a deeper understanding of the people's attitudes in midlife towards the adoption of the MIND diet that might need addressing in future interventions. Researcher subjectivity may be a limitation to our study; however, codes and themes were identified by a second researcher which suggest that the themes drawn have credence beyond interpretation of the lead researcher. Focus groups run the risk of introducing bias (Harrison et al., 2015) resulting from an individual's desire to conform to social acceptability (Acocella et al., 2012). However, in this study, focus group participants were acquaintances, and therefore, may reduce the risk of social acceptability. Barriers and facilitators reported in this study are "perceived" and, therefore, may have limited value in predicting uptake of the MIND diet. While there was a discussion on prevalence rates of dementia in the UK with participants, their perceived risk of dementia was not addressed in this study. Nevertheless, participants felt their knowledge of dementia increased, as had their knowledge of brain healthy foods. Further research should address perceived risk of dementia and its association with intention to eat a brain healthy diet.

4.5.2 Strengths

The COM-B model is an established method for understanding behaviour and used extensively in behaviour change interventions, including dietary studies (Cha et al., 2018; Kretowicz et al., 2018). To our knowledge, this study is the first study to explore barriers and facilitators to adopting the MIND diet, and the first study to use the behaviour change wheel to investigate the MIND diet. This was the first study to apply the TDF to explore peoples understanding and perceptions of a whole dietary pattern. Moreover, this study used the COM-B model as an additional step in the thematic analysis, which increased the study's efficiency and showed that the entire framework was adequate for purpose.

4.6 CONCLUSION

Findings from this study provide insight into the personal, social, and environmental factors that participants report as barriers and facilitators to adoption of the MIND diet among middle aged adults living in the UK. Using the TDF and COM-B model is a starting point for understanding behaviour in specific contexts and is able to make a 'behavioural diagnosis' of what needs to change, to modify behaviour. The TDF and COM-B model has allowed us to gain deep understanding and increased awareness of the current situation and has clarified which barriers and facilitators can be targeted to improve adherence to the MIND diet. The results presented above suggest that there is potential to optimise all three components of the COM-B model to increase adherence to the MIND diet, highlighting the importance of addressing these factors when designing behaviour change interventions. Furthermore, understanding barriers and facilitators to the adoption of the MIND diet may help health professionals working with individuals/communities to help prevent or reduce the risk of cognitive decline. The results from this chapter will be mapped onto the BCW to systematically design and develop an intervention to increase adherence to the MIND diet, which is presented in chapter 6. This research was repeated in an Italian sample to compare factors influencing MIND diet behaviour in adults at midlife, which is presented in the next chapter (Chapter 5).

4.7 References

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Chapter 5

Cross cultural "behavioural diagnosis" examining the uptake of the MIND diet, using the COM-B model to inform an intervention.

5.1 Abstract

Background: The aim of the study was to identify and compare components of the COM-B (capability, opportunity, motivation and behaviour) model, that influence behaviour to modify dietary patterns in 40-55-year olds living in the UK and Italy, in order to reduce the risk of cognitive decline in later life. This study also sought to identify intervention functions and behaviour change techniques (BCTs) that are likely to be effective in changing *Mediterranean-DASH Intervention for Neurodegenerative Delay* (MIND) diet behaviour.

Methods: This was a qualitative study that was used to elicit beliefs surrounding capability, opportunity, motivation and behaviour with adhering to a diet associated with a reduced risk of cognitive decline, the MIND diet. This study further elaborated the COM-B components into the 14 domains of the Theoretical Domains Framework to further understand behaviour. Twenty-five Northern Irish and Italian participants were recruited onto the study, to take part in either a focus group or an interview. Participants were both male and female aged between 40-55 years.

Results: Thematic analysis revealed that the main barriers to the uptake of the MIND diet were; time, work environment (opportunity), taste preference and convenience (motivation). Culture (motivation), seasonal foods and lack of family support (opportunity) to be a barrier to the Italian sample only. The main facilitators reported were; improved health, memory, planning and organisation (motivation) and access to good quality food (opportunity). Cooking skills, knowledge (capability) and heathy work lunch (opportunity) being a facilitator to the Italian sample only. Five intervention functions and fifteen BCTs were identified for possible inclusion in intervention development.

Conclusions: The "behavioural diagnosis" provides comparisons and valuable insight into the personal, social, and environmental factors that participants report as barriers and facilitators to the uptake of the MIND diet in the two samples. More barriers to healthy dietary change were found than facilitators. There is a need for interventions that increase capability, opportunity, and motivation to aid behaviour change. The "behavioural diagnosis" from this study will be used to design a behaviour change intervention using the subsequent steps from the Behaviour Change Wheel.

Keywords*: MIND diet, COM-B model, dementia, adoption, brain health, behaviour change wheel*

5.2 Introduction

The global ageing population is increasing, with approximately 50 million people worldwide currently living with dementia, which is predicted to rise to 131 million by 2050 (WHO, 2017). Longevity is increasing worldwide, therefore, there is an urgent need to identify potential modifiable risk factors such as diet to promote brain health from an earlier age. The latest statistics on prevalence of dementia in Europe have shown that overall, Italy has the highest percentage (2.09%) of people living with dementia, compared to the average percentage of the rest of Europe (1.55%). In the UK, approximately 850,000 people are estimated to be living with dementia, which is 1.6% of the population.

Research conducted within Mediterranean populations have found a decrease in adherence to the Mediterranean diet (Bonaccio et al., 2016; Di Guiseppe et al., 2008), with globalisation deeply influencing people's lifestyle choices, yielding a shift towards westernised eating habits. Western eating patterns are characterised by high saturated fat, refined grains, high sugar and reduced consumption of fruit and vegetables (Uranga et al., 2016), while the Med diet is characterised by a high intake of plant food (fruit, vegetables, cereals and legumes), olive oil as the main source of fat, a moderate intake of fish, a low to moderate intake of dairy products and alcohol, a low intake of saturated fats, meat and poultry (Burlingame et al., 2011). While Med diet adherence has been decreasing over the last two decades, those in midlife report a higher adherence to the Med diet than the younger population in Italy (Leone et al., 2017).

There have been several prospective and cross-sectional studies that have attempted to gain insight into the relationship between the Med diet (Panagiotakos et al.,2007), DASH diet (Sacks et al., 1999) and cognitive function. The DASH diet is similar to the Med diet and is characterised by high consumption of fruits, vegetables, wholegrains, fish, poultry, nuts, low fat dairy and low consumption of sweets, fats, and red meat. Compared to the Med diet, the DASH diet requires high intake of low-fat dairy (Berendsen et al., 2017). Prospective studies in the USA and Europe with both the Med and DASH diet over several years with older adults found an association with less cognitive decline (Galbete et al., 2015; Trichopoulou et al., 2015) specifically, improved episodic, semantic, and working memory (Tangney et al., 2014). Furthermore, several cross-sectional studies in Italy and NI with older adults, found that close adherence to the Med diet was associated with lower cognitive impairment (De Amicis et al., 2018; Tierney et al., 2019) and better cognitive function (McEvoy et al., 2018).

Prospective studies conducted in midlife over an extended 16-year period also showed a significant association with decreased risk of cognitive impairment (Bhushan et al., 2019) and improved psychomotor speed over a 4-month period in midlife (Smith et al., 2010). Research has found that a healthy diet in midlife is positively associated with cognitive function (Samieri et al., 2013). Moreover, research on both the DASH and Med diet has shown promising results in the protection against cardio risk factors for dementia (Kesse-Guyot et al., 2012). However, their dietary components may not specifically capture the levels and types of foods shown to optimize brain health (Morris et al., 2016). Therefore, the MIND diet (Morris et al., 2014) which is a hybrid of the Med diet and DASH diet, was designed to promote the specific components and servings linked to neuroprotection and dementia prevention (Morris et al., 2014).

The MIND diet promotes 10 healthy foods (Leafy greens, other veg, nuts, berries, fish, poultry, olive oil, beans, whole grains, red wine) and limits 5 other foods (red meat, butter, cheese, pastries and sweets, fried foods). While previous research shows that higher consumption of vegetables is associated with lower risk of cognitive decline (Chen et al., 2012; Nooyens et al., 2011), the strongest association is observed for higher intake of leafy greens (Morris et al., 2006; Morris et al., 2018). Previous research on cognitive function or dementia do not observe protective effects for overall fruit consumption (Morris et al., 2006; Morris et al., 2018). However, berries were shown to slow cognitive decline, particularly in global cognition and verbal memory in older adults (Devore et al., 2012).

There has been limited research to date investigating the effectiveness of the MIND diet. Morris et al. (2015) originally devised the MIND diet and found that the diet can slow cognitive decline over an average of 4.7 years in adults aged 58-98 years old (Morris et al., 2015). Interestingly, recent research found that the MIND diet and not the Mediterranean diet, protected against 12-year incidence of mild cognitive impairment and dementia in older adults (Hoskings et al., 2019). Also, a large observational study with older adults found that longer adherence to the MIND diet was associated with better verbal memory (Berendsen et al., 2018).

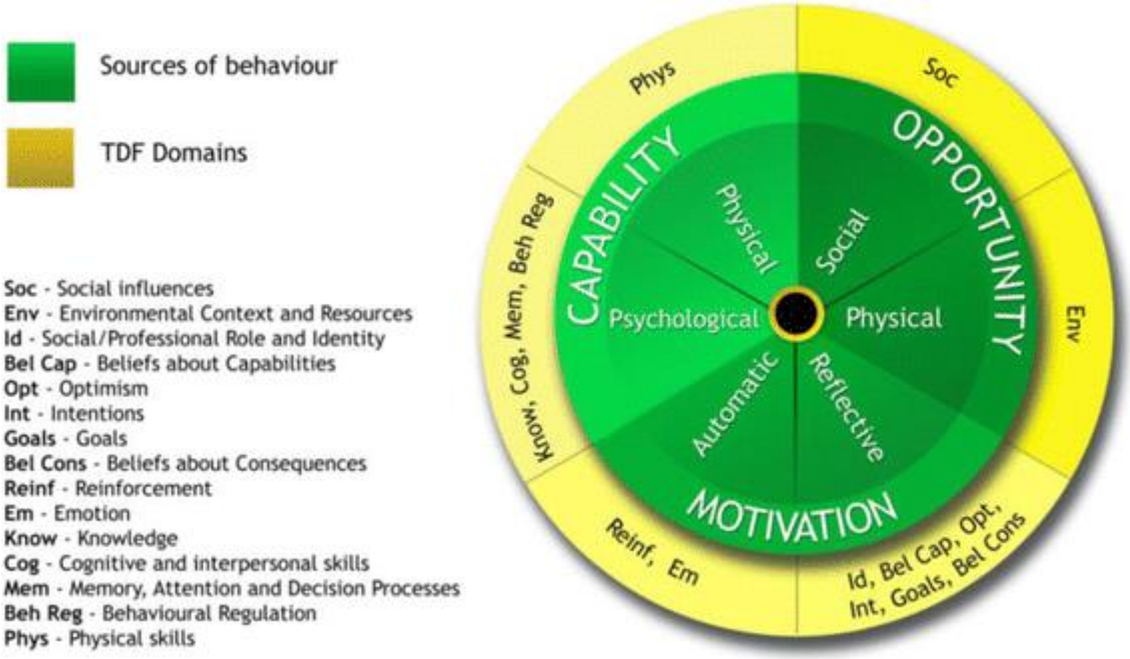
Social and cultural changes that have been shown to have contributed to reversal of dietary habits in Southern European countries, with previous research highlighting socio-economic variables associated with adherence to a Med diet (Bonaccio et al., 2012a; Bonaccio et al., 2012b; Lopez et al., 2018). As we are looking to promote healthy ageing, we are investigating modifiable risk factors in the prevention of cognitive decline. Research has found that a healthy diet in midlife is positively associated with cognitive function in later years (Samieri et al., 2013; Kesse-Guyot et al., 2012). Therefore, this study could add support to the dementia strategy research by exploring modifiable risk factors in the prevention of dementia, which could be applied globally.

5.2.1 Theoretical Framework

The theoretical framework underpinning this research is the COM-B model (Michie et al., 2014). Changing behaviour involves changing one or more of the components of the COM-B model, which stand for, capability, opportunity, motivation, and behaviour (see Figure 5.1). Capability can be either psychological (knowledge, psychological skills, or stamina) to perform the behaviour, or “physical” (having the physical skills, strength, or stamina) to perform the behaviour. Opportunity can be divided into “physical” (what the environment allows in terms of time, resources etc) or “social” (interpersonal influences, social cues, cultural norms). Motivation can be divided into “reflective” (self-conscious planning and evaluations, beliefs about what is good or bad) or “automated” (wants and needs, desires, impulse and reflex responses). The TDF facilitates understanding of health behaviours around evidence-based guidelines and provides a method to categorise behaviour (Cane et al., 2017). Use of the TDF to identify factors influencing MIND diet behaviour can then be mapped onto the COM-B model for designing interventions. The TDF has 14 domains that may influence behaviour change (Cane et al., 2014) (see Figure 5.1).

Figure 5.1

TDF domains and corresponding mapping onto the COM-B component



Michie et al.(2014) Cane et al.(2012).

The COM-B model is at the core of an overarching framework called the BCW (Michie et al., 2014), which is a three-stage approach to designing a behaviour change intervention. This framework includes 9 intervention functions (education, persuasion, incentivisation, coercion, training, restriction, environmental restructuring, modelling, and enablement linked to the COM-B model. These are how an intervention might change behaviour and are linked to BCTs (Michie et al., 2013). BCTs are considered the active component of the intervention designed to change behaviour, such as self-monitoring of behaviour and goal setting. The COM-B model and TDF have been used by several studies to explore barriers and facilitators to behaviour change in sexual health (Cassidy et al., 2018), physical activity in obese pregnant women (Bentley et al., 2019) and reducing sugar (Al Rawahi et al., 2018).

To our knowledge, this is the first study investigating adherence to the MIND diet at midlife (40-55 years old) in a Mediterranean and non-Mediterranean country. This study addresses this gap in the literature and highlights cross-cultural perceived barriers and facilitators to adhering to the MIND diet at midlife. The COM-B model is used to develop a “behavioural diagnosis” of what factors needs to change in order to change behaviour. The behavioural diagnosis is the assessment of influences on the participants behaviour. It includes consideration of individual, social, and environmental factors that may either impede or facilitate behaviour. It also considers what has influenced past behaviour, current potential and limitations of the individual, and context, leading to the development of effective interventions. Researchers have noted the importance of addressing cultural factors in designing behaviour change interventions (Banna et al., 2016) as the ideal diet may be conceptualised differently across diverse populations.

Previous research found differences is dietary patterns between Rome and NI, with N.I consuming more ready-made meals (Simpson et al., 2005), snacked between meals more often than Italians (Huseinovic et al., 2016) and consumed more takeaway food, sugary drinks and less fruits and vegetables that those living in other Mediterranean countries (Fitzpatrick et al., 2010) . Although the MIND diet is a hybrid of the Med diet, it is a new diet that specifies foods such as berries, leafy greens, and wholegrains, which are not part of a traditional Med diet. Therefore, comparing factors influencing MIND diet behaviour across a Mediterranean and non-Mediterranean country can reveal valuable findings that may promote awareness of diverse health beliefs and habits across culture, which may be particularly informative in the development of behaviour change interventions.

The aim of the study was to establish and compare components of the COM-B model that influence the uptake of the MIND diet in a 40-55-year old Italian and Northern Ireland (NI) sample, that will inform a dietary behaviour change intervention.

5.2.2 Specific objectives were:

- To determine participants perceived capability, opportunity, and motivation to the uptake of the MIND diet in 40-55-year olds in a Mediterranean (Italy) and non-Mediterranean (NI) country
- Compare barriers and facilitators to the MIND diet from a Mediterranean and non-Mediterranean country
- Identify intervention functions and BCTs that are likely to change MIND diet behaviour

5.3 Method

5.3.1 Participants and study design

Twenty-five participants from NI (female 60%, male 40%) and twenty-five participants from Rome, Italy (female 64%, male 36%) aged 40-55 years were recruited onto the study, to take part in either a focus group or an interview. Interview/focus groups took place in person (NI: 15 interviews, 2 focus group n=6, n=4; Italy 13 interviews, 2 focus group n=6 n=6). Ethical approval was obtained from a University Ethics Committee, which is in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki). Participants were approached by email, Facebook, and advertisement booklet. The invitation email/Facebook message contained some brief information about the study. Interested participants were asked to contact the researcher by email and sent a participant information sheet (PIS), consent form and information booklet on the MIND diet. Questions asked to participants were the same for both NI and Italian populations. Before the Italian interviews began, questions were translated from English to Italian by a fluent Italian speaker (BG). Questions were then back translated to English to ensure the interpretation of questions (Breslin, 1970). Most of the interviews were spoken in English and those that were not translated during the interviews by one of the Italian researchers (BG), to allow the English-speaking researcher (DT) to analyse data. Interviews were conducted at the participants workplace. In accordance with the COM-B framework, both focus groups and interviews were conducted (Michie et al., 2014), using semi-structured questions and lasting between 30-60 minutes each (see Table 5.1). The interview and focus group questions were based on guidance using the COM-B (Michie et al., 2014) model and TDF (Cane et al., 2012) (Table 5.1). The model and framework were used both in developing the interview schedule and informing the content analyses used. All participants were asked to complete a personal information form and consent form before the interview/focus group began. The information form contained questions on participants diet at baseline (see Table 5.2) and showed that those living in NI consumed more red meat, fried food, butter, and sugary foods than those living in Italy. Participants were informed that the study was voluntary and that they could withdraw at any time. They were assured of confidentiality regarding any personal information they supplied to the researcher. According to similar behaviour change theories, the ideal sample size for elicitation studies is 25 (Francis et al., 2010). Also, similar to other qualitative studies using the COM-B and TDF (Al Rawahi et al., 2018; Bentley et al., 2019), twenty-five NI and 25 Italian participants were recruited onto the study, to take part in either a focus group or an interview.

Table 5.1:

Interview/focus group questions asked to participants in accordance with the TDF and COM-B model.

COM-B	TDF	QUESTION
Psychological Capability	Knowledge.	What is your understanding of the MIND diet?
Psychological Capability	Memory, attention, and decision processes.	To what extent is eating MIND diet foods something you normally do? ➢ Prompt: Do you eat MIND diet foods each day
Psychological Capability	Behaviour regulation	To what extent do you monitor whether you are eating MIND die foods?
Physical Capability	Skills	To what extent are you confident in cooking/eating MIND diet foods?
Social Opportunity	Social influences	To what extent do/would your family or friends help or hinder you eating MIND diet foods? ➢ Prompt: Does/would your family support you in eating the MIND diet?
Physical Opportunity	Environmental context and resources.	Discuss anything in your work or/and home environment that might help or hinder you eating the MIND diet? E.g. budget, time
Reflective Motivation	Social/Professional role and identity	To what extent would eating the MIND diet be accepted by your friends and family? ➢ Prompt: Do you think your family/friends influences what you eat?
Reflective Motivation	Belief about capabilities	How difficult/easy would it be for you to eat the MIND diet? ➢ Prompt: What are the barriers to consuming the MIND diet? ➢ Prompt: What are the facilitators to consuming the MIND diet?
Reflective Motivation	Optimism	To what extent are you confident that any barriers you may have to eating the MIND diet can be solved?
Reflective Motivation	Intention	To what extent do you intend to follow the MIND diet to promote brain health?
Reflective Motivation	Goals	To what extent would you like to follow the MIND diet?
Reflective Motivation	Belief about consequences	What do you think will happen if you eat the MIND diet? ➢ Prompt: Discuss any benefits to eat the MIND diet?
Automatic Motivation	Reinforcement	To what extent are there any incentives for you to the MIND diet?
Automatic Motivation	Emotion	How do you feel about eating the MIND diet?

COM-B: Capability (C): Psychological or physical ability to enact behaviour; Opportunity (O): Physical and social environment that enables behaviour. Motivation (M): Reflective or automatic mechanisms that activate or inhibit behaviour; Behaviour (B). TDF: Theoretical Domains Framework.

Table 5.2

Percentage of participants food intake at baseline

	More than once a day		Daily		2-3 times a week		Once a week		Less than once a week	
	Italy	NI	Italy	NI	Italy	NI	Italy	NI	Italy	NI
Fruit & Vegetables %	44	44	26	36	20	20	8	0	4	0
Beans and legumes %	4	0	0	4	44	20	40	24	12	52
Fish %	0	0	0	4	32	28	48	40	20	32
Poultry %	0	4	0	4	36	60	36	34	28	8
Wholegrains %	12	0	16	40	20	16	16	16	36	28
Nuts %	4	0	16	4	12	20	20	32	40	44
Red meat %	0	0	0	8	28	64	40	12	32	16
Cheese %	0	0	12	24	48	48	24	20	8	8
Fried food %	0	0	0	0	4	40	12	24	84	32
Butter %	0	20	0	52	8	12	20	4	72	12
Sweets/pastries %	0	16	8	28	44	20	8	20	40	12

NI=Northern Ireland N=50, numbers are in percentages

5.3.2 Materials and procedure

A topic guide was developed using the TDF. An example of a question related to TDF knowledge was “what is your understanding of the MIND diet”. A further question exploring participants skills was “to what extent are you confident in cooking MIND diet foods”. The TDF consists of a comprehensive set of 14 domains into which all determinants of adherence to implementation of a behaviour can be organised (see Table 5.1). A booklet containing information on the elements of the MIND and the origins of the diet were given to participants. Before interview began, there was an in-depth discussion on the MIND diet and its components between participant and researcher to ensure participants understood what the diet entailed. Participants were informed of what foods to eat, how often to eat foods and portion sizes required. There was also discussion on dementia risk factors and prevalence in the UK and Italy. All interviews and focus groups were audio recorded.

5.3.3 Data Analyses

The data was transcribed verbatim and analysed using content analysis. The two main researchers (DT&BG) have extensive experience and training in thematic/content analysis employed within theory of behaviour change frameworks and to inform intervention design. DT is a trainee Health Psychologist with an array of skills and experience in qualitative research analysis and the use of behaviour change theories. The research team have a range of expertise in psychology and nutrition. Two researchers (DT&BG) independently read through the entire dataset and coded the data from each transcript and assigned initial “code names”. A reflective diary was kept ensuring a clear overview of the material. Each code was noted as either “barrier” or “facilitator”, depending on the context in which the code occurred. A deductive approach was applied in the form of existing constructs (e.g., capability) and theoretical domains (e.g., skills). However, there was scope to define subthemes which arose within each domain.

Initially, there was a 95% agreement of codes, demonstrating an acceptable level of agreement (Hartmann, 1977). Discussion between researchers resolved any differences within the coding process. After agreement on codes had been made, an additional step in analysis was taken by applying summative content analysis (Hsieh & Shannon, 2005), which involved two researchers searching the text for occurrences of codes and frequency counts for each identified code was calculated. Using a common approach (Bussieres et al.,2012; Lake et al., 2017), TDF domains were judged based on the frequency count of coding for each TDF domain, which had been aggregated from all the factors, beliefs or phrases mentioned that fell within that domain. For example, some participants reported that they believed the MIND diet would make them feel better generally. This belief statement is coded under the TDF domain “belief about consequences.” Domains were then rank ordered according to the frequency coding to identify which components and domains of the theoretical models were the main barriers and facilitators to the uptake of the MIND diet.

5.4 Results

Table 5.3 reports the characteristics of a total sample including 25 Italian and 25 NI participants. Transcripts provided data from 12 of the 14 domains of the TDF in the Italian sample, all 14 domains of the TDF in the NI sample and all components of the COM-B model for both samples (see Table 5.4 and 5.5). The most commonly reported barriers and facilitators fell into: environmental Context and Resources, Belief about Capabilities, Belief about Consequences, Social Influences, Skills and Knowledge. None of the data fell into, reinforcement and goals, which were the least reported domains in the NI study. (See Table 5.6 and 5.7 for quotes).

Table 5.3

Summary Characteristics of Interview/Focus Group Participants(n=50)

Characteristic		Northern Ireland (N=25)	Italy (N=25)
Mean age(sd)		44(4.9)	46(4.2)
40-44		60(15)	36(9)
45-49		16(4)	44(11)
50-55		24(6)	20(5)
Gender			
	Male	40(10)	36(9)
	Female	60(15)	64(16)
Occupation			
	Professional	44(11)	64(16)
	Skilled	16(4)	36(9)
	Unskilled	40(10)	0
Education			
	Higher education	36(9)	64(16)
	Further education	28(7)	36(9)
	No formal qualifications	36(9)	0
Marital status			
	Married	44(11)	44(11)
	Co-habiting	4(2)	4(2)
	Separated	4(2)	4(2)
	Single	32(8)	32(8)
	Widowed	4(2)	4(2)
Children	Yes	44(11)	72(18)
in household	No	56(14)	28(7)

Education: Level of education obtained within a discipline or profession. Higher education= undergraduate/postgraduate degree: Further education= any study after secondary school that does not include higher education, such as higher national diploma, higher national certificate, apprentices for industry such as hairdressing, plumbing. Sd=standard deviation N=50

Table 5.4: *Barriers in rank order of utterances in relation to MIND diet in 40-55-year olds in Rome and NI: COM-B and TDF domains*

Italy					Northern Ireland				
COM-B	TDF	Rank order	Frequency of Utterances	% of utterances.	COM-B	TDF	Rank order	Frequency of utterances	%of utterances
Physical opportunity	Environmental context	1	93	33	Physical opportunity	Environmental Context and resources	1	90	29
Social opportunity	Social Influence	2	43	15	Reflective motivation	Belief about capabilities	2	46	15
Reflective motivation	Belief about Capabilities	3	37	13	Psychological capability	Knowledge	3	37	12
Psychological capability	Behaviour regulation	4	29	10	Psychological capability	Memory, attention, Decision making	4	30	10
Psychological capability	Knowledge	5	29	10	Psychological capability	Behaviour regulation	5	24	7
Reflective motivation	Social, Professional and Identity	6	15	5	Physical capability	Physical skills	6	17	6
Reflective motivation	Belief about consequences	7	11	4	Social opportunity	Social Influence	7	15	5
Physical capability	Skills	8	9	3	Reflective motivation	Belief about consequences	8	12	4
Reflective motivation	Intention	9	9	3	Reflective motivation	Social professional and identity	9	12	4
Reflective motivation	Optimism	10	7	2	Reflective motivation	Intention	10	9	3
Automatic motivation	Emotion	11	4	2	Reflective motivation	Optimism	11	6	2
Automatic motivation	Reinforcement	0	0	0	Reflective motivation	Goals	12	5	2
Reflective motivation	Goals	0	0	0	Automatic motivation	Emotion	13	3	1
Psychological capability	Memory, attention	0	0	0	Automatic motivation	Reinforcement	14	1	0
			286	100				307	100

Information above the thick black line represents the top 6 reported domains of the TDF and corresponding COM-B components. Eighty percent of the data fell into the top 6 TDF domains; COM-B: Capability (C): Psychological or physical ability to enact behaviour; Opportunity (O): Physical and social environment that enables behaviour. Motivation (M): Reflective or automatic mechanisms that activate or inhibit behaviour; Behaviour (B). TDF: Theoretical Domains Framework.

Utterances: Spoken word/words in relation to themes/subthemes emerging from questions asked regarding MIND diet. n=50

Table 5.5

Facilitators in rank order of utterances in relation to MIND diet in 40-55-year olds in Rome and NI: COM-B and TDF domains

Italy					**Northern Ireland**				
FACILITATORS COM-B	TDF	Rank order	Frequency of utterances	% utterances	COM-B	TDF	Rank order	Frequency of utterances	% of utterances
Physical opportunity	Environment context	1	48	21	Reflective motivation	Belief about consequences	1	28	17
Reflective motivation	Belief about Capabilities	2	36	16	Reflective motivation	Belief about capabilities	2	27	16
Reflective motivation	Belief about consequences	3	32	14	Physical opportunity	Environmental Context and resources	3	22	13
Social opportunity	Social	4	28	12	Social Opportunity	Social influence	4	21	13
Physical capability	Skills	5	19	8	Physical capability	Skills	5	20	12
Reflective motivation	Identity	6	16	7	Automatic motivation	Emotion	6	15	9
Automatic motivation	Emotion	7	16	7	Automatic motivation	Reinforcement	7	10	6
Reflective motivation	Optimism	8	10	4	Reflective motivation	Intention	8	6	4
Reflective motivation	Intention	9	10	4	Psychological capability	Behaviour regulation	9	4	2
Automatic motivation	Reinforcement	10	7	3	Reflective motivation	Optimism	10	4	2
Psychological capability	Regulation	11	4	2	Reflective motivation	Social/Professional and identity	11	3	2
Psychological capability	Attention	12	3	1	Psychological capability	Knowledge	12	3	2
Psychological capability	Knowledge	13	2	1	Psychological capability	Memory	13	1	1
			231	100				164`	100

Information above the thick black line represents the top 6 reported domains of the TDF and corresponding COM-B components. Eighty percent of the data fell into the top 6 TDF domains; COM-B: Capability (C): Psychological or physical ability to enact behaviour; Opportunity (O): Physical and social environment that enables behaviour. Motivation (M): Reflective or automatic mechanisms that activate or inhibit behaviour; Behaviour (B). TDF: Theoretical Domains Framework. Utterances: Spoken word/words in relation to themes/subthemes emerging from questions asked regarding MIND diet. n=50

5.4.1 Capability

Psychological capability was a COM-B component identified as a barrier to adherence to the MIND diet. Twenty percent of the barriers in the Italian sample fell into the psychological component of the COM-B model compared to 29% in the NI study. These barriers fell into 2 of the TDF domains, behaviour regulation and knowledge. No Italian barriers fell into attention and decision process, unlike the NI study where 10% of barriers fell into this domain.

Knowledge: Similar to the NI study, all Italian participants reported having never previously heard of the MIND diet. Italian participants reported that they recognised that the MIND diet was similar to the Med diet and to their own diet.

Behaviour regulation: In terms of dietary patterns, behaviour regulations are the steps taken to ensure that food intake is remembered and conducted, and steps taken to break unhealthy habits. In both samples, most of the participants did not monitor their food intake. However, some participants reported that they used to record their food intake to monitor what and how much they ate but are now able to control their diet from memory.

Physical Capability: Skills: Physical skills are defined as the level of self-efficacy in cooking/eating with MIND diet foods. Skills were reported as a facilitator in both the NI (12%) and Rome study (8%). Skills were reported as a key barrier only in the NI study, with 6% of barriers falling into this domain. All participants in the Rome study reported being confident cooks, even if they didn't like or cook certain foods, whereas, in the NI study, it was reported that those who couldn't cook generally were married men and those participants who reported that they didn't like certain foods, were not confident in cooking them.

5.4.2 Opportunity

According to the COM-B model, for behaviour to occur, there must be a physical and social opportunity in the environment. Barriers relating to physical opportunity were the most commonly reported barriers in both the NI and Italian populations, with 29% of all utterances falling into this component in the NI sample and 33% in the Italian sample. The TDF domain related to this component is environmental context and resources. Social opportunity was reported as being a key barrier and facilitator in both NI and Italian samples, with 13% of all facilitators and 5% of barriers falling into this component from the NI sample and 15% of all barriers and 12% of facilitators from the Italian sample. The TDF domain related to this component is social influence.

Environmental context and resources*:* This domain are defined as any circumstance of a person's physical environment or situation that could support or hinder the development of skills and abilities. For example, budget, time, does not cook or shop, availability of quality foods. The work environment was reported as a barrier to eating the MIND diet foods by both NI and Italian samples. It was reported that canteen food can be unhealthy and that there is the temptation to eat more quantity of food. Several participants reported that if they did not have lunch with them, they would eat out in a café or buy lunch from a bakery which would be unhealthier. Time was a major barrier reported by both samples, particularly for those that were in employment, however, their reasons for *time* being a barrier differed. For the NI participants, it was more a matter of convenience that they had been working all day, having maybe taken children to after school activities, and did not have the *time* to cook with fresh foods. The Italian population reported *time* as barrier in the same manner, but also, the *time* to travel to access fresh food in the farmers markets in the country, especially for those living in the city.

Budget was also reported as a major barrier to buying several of the MIND diet foods such as fish, berries, and nuts in both populations. However, this was only the view of those participants in low paid jobs or unemployed in the NI sample. Several participants from the Italian sample, who are all professional or skilled workers, reported *budget* to be a barrier, especially with regards to fish and wholegrains.

Treats such as cakes and sweets in the home and workplace were reported as being a major barrier in adhering to the MIND diet in the NI sample. Participants reported that having *treats* in the house for guests and children would hinder them in adhering to the MIND diet as they often eat the *treats* themselves. Also, NI participants reported that *treats* in the workplace were common, that there were always biscuits available and that this would be a hindrance to adhering to the MIND diet. However, treats in the workplace were not reported by the Italian sample, in fact, when asked if biscuits were commonly found in the workplace, participants reported that it is only on occasion that biscuits or treats were offered at work, such as, someone's birthday.

A major barrier reported by the Italian sample and a key difference between both samples, was access and availability of certain foods of the MIND diet. Most Italian participants reported that the availability of berries out of season were scarce. One participant reported that, Italy provides so many different, tasty fruit, that why would they choose berries that are hard to find and expensive. Several participants also reported that wholegrains were expensive and hard to find. Italian participants also reported that access to fresh fruit, vegetables and fish may hinder them in adhering to the MIND diet, especially those that lived in the city of Rome. Participants reported that the fish and produce in the city is more expensive and poor quality than in the country and that they would consume less fruit and vegetables, and fish because of this. In contrast, the NI sample reported that the fruit and vegetables are more expensive and of poorer quality in the country and small towns, and that they would have to travel to the bigger stores to access cheaper better-quality food.

Another facilitator reported by both samples in order to help in adhering to the MIND diet was to bring their lunch to work. Participants reported, that in order to consume the MIND diet at work, they would need to bring their own lunch to prevent them from eating out. Many participants from the Italian sample already brought a healthy lunch to work, such as salad, which they perceived would help prevent barriers in adhering to the MIND diet, as they could take a lunch to work containing MIND diet foods.

Social Influence**:** This domain is described as the *“interpersonal processes that can cause individual to change their thoughts, feelings or behaviours, which may be due to social pressure, norms, social/family support or peer pressure”* (Cane et al., 2012)**.** A key barrier reported by both samples was visiting family/friends. Both samples reported that either going out to visit friends or family coming to visit resulted in eating unhealthier and more quantity. However, the NI sample reported eating more fast foods, while the Italian sample reported cooking more unhealthily, such as lasagne, cheese and pasties and more quantity. Family support/influence was reported as a key facilitator by both samples. Participants from NI sample reported that they felt their family would support them if they were to uptake the MIND diet. Another key barrier under this domain, which was only reported by the Italian sample, was *lack of family support/influence*. Participants often reported avoiding certain foods such as wholegrains or eating less healthy foods such as vegetables, as other family members did not like them. Also, several participants reported that their family would not support them in this diet, particularly those who originate from the South of Italy, where eating more food and more unhealthily is typical of their culture.

5.4.3 Motivation.

Motivation is a component of the COM-B model and there must be strong motivation for the behaviour to occur [34]. Participants reported reflective motivation to be a barrier to the uptake of the MIND diet and 18% of barriers fell into this component of the COM-B model, compared to 15% in the NI study. More facilitators were reported under this domain with 33% from the NI sample and 37% from the Rome sample.

***Belief about capabilities*: ** The extent to which the individual believes they are able to adhere to the MND diet. Taste preference was reported as a major barrier to the adherence of the MIND diet in both the NI and Italian populations. Participants reported not liking various elements of the diet such as fish, vegetables, and chicken. However, many of the participants in the Italian sample reported not liking wholegrains, in particular, wholegrain pasta or bread and even if they did like it, they would not buy it as their children did not eat it. Convenience was also reported as a barrier to the uptake of the MIND diet in both samples. Both samples reported cooking less healthy food to suit their children and eating it themselves rather than making two meals for *convenience*.

Mindset was reported by both samples as a barrier to the uptake of the MIND diet. The NI sample reported that being in the right mindset was important to change diet and to be determined to do so. However, the Italian sample reported the difficulty they perceived in reducing certain foods, such as cheese. Many Italian participants reported that they would not be able to do this. Belief about Capabilities was also reported as being a major facilitator in the uptake of the MIND diet with 16% of all barriers falling into this domain in both samples. While both samples reported that being organised and prepared when cooking meals or having lunch prepared for work was a facilitator, the Italian participants reported that the MIND diet seemed similar to their own diet and would be easy to follow. They also reported that the MIND diet allowed for simple meals such as pasta and vegetables which is quick and easy to make.

***Professional, Social and Identity*:** How the individual views the uptake/maintenance of the MIND diet relative to their identity (for example, parent, culture). Culture was reported as both a barrier (3%) and a facilitator (7%) under this domain from the Italian study only. Participants reported that the MIND diet was similar to their own diet and the Med diet. Participants reported that as they ate most of these foods, that this would help them adhere to the MIND diet. They also reported that butter is not part of their diet, they only use olive oil which further supports uptake of the MIND diet. However, most participants reported that not only were berries hard to find out of season, but they were not part of their culture. Some participants also reported that wholegrains were not part of their culture and it would not be acceptable to serve wholegrains to family and friends. It was also reported that cheese is a big part of the Italian culture and reducing cheese would be difficult to do.

Belief about consequences: This domain is described as, anticipated outcomes of not eating brain healthy foods, anticipated or experienced outcomes of eating brain healthy foods. (positive or negative). Belief about consequences was reported as a major facilitator in both samples with it being the most reported facilitator in the NI sample (17%). Both samples reported that if they adhered to the MIND diet, they believed it would be good for their overall health, less sleepy and improve mental health. However, some of the Italian participants recognised that with more fibre from the wholegrains and less cheese, that this would have a benefit for their bowels and cholesterol.

Emotion: Both samples reported that they would feel positive about following the MIND diet with 7% of facilitators falling into this domain in the Italian sample and 9% in the NI sample. However, similar to NI participants, even though participants felt positive about the MIND diet, this did not necessarily coincide with their intention to uptake the diet.

Table 5.6

Quotes from barriers regarding uptake of the MIND diet in rank order

Northern Ireland			*Rome*		
COM-B/TDF	SUB-THEME	QUOTE	COM-B/TDF	Subtheme	QUOTE
Physical opportunity: Environmental context	5. Time 6. Food environment at work/canteen 7. Budget 8. Treats in for kids.	"For me it is time, by the time you get home from work, and maybe have done overtime, you couldn't be bothered" "There is nothing healthy in a canteen"	Physical opportunity: Environmental context	1. Availability/ Access to food 2. Budget 3. Time 4. Season	"Finding berries and the cost of them are a barrier" "Berries are hard to find as they are seasonal, I only eat them in summer"
Reflective motivation: Belief about capabilities	4. Convenience 5. Taste preference 6. Mindset	"Kids don't want healthy stuff, so sometimes I have convenience stuff to make it easier for me" "I don't like fish; you know the strong smelling fish"	Social opportunity: Social influence	1. Family influence 2. Visiting family And friends	"The problem is my family; they only eat white pasta" "I would cook more unhealthily and quantity if family are visiting"
Psychological capability: Knowledge	2. Lack knowledge of MIND diet and foods	"If you don't know what is healthy for your brain, you won't eat that way"	Reflective motivation: Belief about capabilities	1. Taste preference 2. Convivence Mindset	I don't buy the brown pasta as it is more expensive, and it doesn't taste as nice as the white" "I don't eat vegetables, any kind of them" "I love cheese, I do not think I could eat less cheese"
Psychological capability: Memory, attention, and decision process	4. Alcohol 5. Tired 6. Holidays	"If I had a good drink at the weekend, it would take Tuesday or Wednesday to get over it, and I wouldn't want to eat this food"	Psychological capability: Behaviour regulation	1. Self-monitoring	"No, I don't monitor my food intake"
Psychological capability: Behaviour regulation	2. Lack monitoring of food consumption	"No, I don't, and sure, when I go to weight watchers, I don't even do it"	Psychological capability: Knowledge	1. Lack knowledge of MIND diet.	"I have never heard of the MIND diet"

Physical capability: Skills	2. Lack cooking skills	"I couldn't cook that, if you handed me all the ingredients, I would be like, what am I doing with it"	Social, professional and identity.	1. Culture	"My family eat lots of food, lots of white pasta and cheese, this is typical of Southern Italians to eat more and are more overweight" "Berries are not part of our culture"

COM-B: Capability, Opportunity, Motivation, Behaviour. TDF: Theoretical domains framework

Table 5.7

Quotes from participants regarding facilitators of uptake of the MIND diet.

Northern Ireland ***Rome***

COM-B/TDF	SUBTHEME	QUOTE	COM-B/TDF	SUBTHEME	QUOTE
Reflective motivation: Belief about consequences	4. Feel better generally 5. Improve psychological health 6. Improve memory	"I think the diet would just help you feel better generally" "And even help your head, less stress and worry"	Physical Opportunity: Environmental context and Resources	1. Bring lunch 2. Time	"Here I bring lunch every day, it is very simple for me to prepare my salads so not a barrier" "Having the time to travel to get better quality food would be a facilitator".
Reflective motivation: Belief about capabilities	2. Planning/ preparation/ organisation	"Organisation and preparation the night before, so having your berries and salad ready for work"	Reflective motivation: Belief about capabilities	1. Normal diet 2. Simple meals 3. Organisation 4. Motivation	"sometimes it is easier for all the family if you can cook it quickly, like pasta and veg" "If you were motivated enough, I think you could overcome your barriers". "I think you need to plan and be motivated".
Physical opportunity: Environmental context and resources	3. Accessibility fresh/frozen food 4. Bring lunch to work	"I would go to Lidl, because it is cheaper and better quality" "In my work, you need to be prepared and bring lunch with you"	Reflective motivation: Belief about consequences	1. Overall health 2. Cholesterol 3. Lose weight 4. Fiber/bowel	"I think this diet could help you gain more health" "I think my bowels would work better on this diet" "I think with eating less cheese would be good for your cholesterol" "I think you could lose weight on this diet"
Social opportunity: Social influence	2. Family support/influence	"My mum is always cutting out articles showing me	Social opportunity:	1. Family support/ influence	"Yes, my wife would support me if I wanted to do this diet"

		research on good and bad foods for your health.	Social influence		"yes, I think if I was out with family, there would be more alcohol, unhealthy foods and less veg"
Physical capability: Skills	2. Confident cook	"I am pretty confident cooking these foods"	Physical capability: Skills	1. Confident cook	"Yes, I cook generally the same legumes, I don't like beans very much, so I don't cook them often, but I am able to cook them"
Automatic motivation: Emotion	2. Positive	"I would be positive about it; I get excited trying new things"	Reflective motivation Professional, social and identity	1. Culture	"this is typical foods for me, this would not be difficult for me" "we don't eat butter, it is not in our culture, we use olive oil"
			Automatic motivation Emotion	1. Positive	"I would feel positive about doing this diet"

COM-B: Capability, Opportunity, Motivation, Behaviour. TDF: Theoretical domains framework

5.5 Discussion

This is the first study to describe a cross cultural theory-based qualitative approach exploring barriers and facilitators to the uptake of the MIND diet to inform an intervention. Results found that the main barriers and facilitators reported were; environmental context and resources, belief about capabilities, social influence, behaviour regulation, knowledge, skills, belief about consequences, emotion, memory, attention and decision making, and professional, social identity, which can be mapped onto the COM-B model (see Figure 1). This is the first study to use the COM-B model to code and analyse cross-cultural qualitative responses from individuals at midlife regarding MIND diet behaviour. The purpose of this was to ensure findings were grounded in theory and to efficiently identify the key components of an intervention which could create and sustain behaviour change.

Similar to the NI study, the Italian key barriers reported were: environmental context and resources, belief about capabilities, behaviour regulation and knowledge. However, skills, and memory, attention and decision processes were not reported as key barriers in the Rome population. Instead, social influence and social, professional and identity were reported as key barriers to the uptake of the MIND diet. Key facilitators reported were environmental context and resources, belief about capabilities, belief about consequences, social influences, skills, and emotion. The Italian population reported one further facilitator which was social, professional and identity. Our results confirmed previous research finding regarding commonly reported barriers and facilitators to adherence to healthy dietary change, including *budg*et

(Petroka et al.,2017), *time* and *taste preference* (De Mestral et al., 2016) and *family influence* (Pinho et al., 2018).

Similar to the NI population, the Italian sample reported having no knowledge of the MIND diet prior to the study and what constituted brain healthy food. Nicklas et al. (2013) found that lack of knowledge regarding dietary recommendations and health benefits were reported as a key barrier in meeting dietary recommendations, and lack of information on healthy food was also reported as a major barrier (Ashton et al., 2017).

Participants from both samples reported lack of monitoring their food intake which further highlights “capability” as a barrier to uptake of the MIND diet. Previous research found that behaviour regulation was associated with changes in dietary outcomes (Greaves et al.,2011) and more specifically, self-monitoring was associated with a positive change in diet (Lynch et al.,2018; Teasdale et al., 2018). Self-monitoring is shown to not only increase awareness of eating patterns (Chung et al., 2014; McGrice et al., 2015), but also allows professionals to identify food aversions/intolerances and poor food choices (McGrice et al., 2015).

Opportunity was highlighted as a key barrier to the uptake of the MIND diet. The main difference between the two samples is due to social influences being reported as a barrier in the Italian sample but not the NI sample. Environmental context and resource was a major theme to emerge with “Time” being a key factor in both samples, mainly reported by those who led busy lives. This finding supports previous research that found “Time” to be a barrier to eating a healthy diet (Hibbs-Shipp et al., 2015; Nicholls et al., 2017). Busy lifestyle was found to be associated with less home cooked meals (Aston et al., 2017) and poorer eating habits (Fernandes et al., 2013; Nahn et al., 2012).

“Budget” was also found to be a significant barrier in both samples, which was mainly due to the healthy elements of the MIND diet, such as fish, wholegrains, berries, and nuts. These findings support previous research that found the cost of food to be a significant factor in people’s choice of food and consumption (Kearney et al., 2000) and that higher adherence to a whole dietary pattern such as the Mediterranean diet, had higher cost associated with the healthy elements of the diet (fish, fruit, vegetables, nuts) and lower cost to the unhealthy elements of the diet (processed meat and sweet) (Ashton et al., 2017;Tong et al., 2018). These findings are further supported in Roa et al. (2013) that found unhealthy processed foods to be less expensive than fruit, vegetables, and nuts. However, Roa et al. (2013) explained that the higher cost could be offset by reducing the amount of unhealthy food consumption. Further support for this was found in Germani et al. (2014) who compared the cost of a 4-member family with the cost of the same family following the Mediterranean diet and found that the cost of the Mediterranean diet was slightly higher in the overall budget. However, following an increase in the budget for healthy foods such as fruit and vegetables and reducing the budget for unhealthy foods such as processed meat and sweets, the overall budget for both diets were similar. It was therefore concluded that low adherence to the Mediterranean diet was not associated with cost but rather a difference in allocating money to different food groups.

Access and availability of fresh food was reported as both a barrier and facilitator in both samples. However, the Italian sample reported it as a major barrier compared to the NI sample and for different reasons, mainly due to seasonal foods being unavailable and limited access to fresh foods reported by those living in the city.

One interesting difference between the two samples under this barrier is that in NI, there is cheaper, better quality food in the bigger stores and cities. However, it was reported that it is in the country markets in Rome that cheaper, fresher food is found. The literature generally supports that access to fresh cheaper foods is a barrier in rural areas. Previous research found that shops selling healthier food was a long distance from country communities (Maley et al., 2010; Neill et al., 2011) and that limited access to food resources led to poorer dietary habits (Carnahan et al., 2016).

However, in line with our findings with the Italian sample, previous research found that those who had access to farmers markets or grew their own food, was a facilitator to healthy eating [72]. However, the Italian sample further reported that farmers markets only open in the morning which did not suit those who worked. This finding is supported in Smith et al. (Smith et al., 2011), that found farmers markets to have inconvenient times and low frequency. Barnridge et al. (2015) found that participants reported eating the recommended daily fruit and vegetables when receiving nutrition education and access to a garden. However, those who received no nutrition education but access to the garden, did not report eating the recommended fruit and vegetable, suggesting that it is knowledge not access to the garden that was related to an increase in fruit and vegetable consumption.

Social influence was reported as a barrier to the uptake of the MIND diet by the Italian sample only, and as a facilitator by both samples. Family influence was reported as key barrier in the Italian sample. This may be due to the Italian sample being influenced by their children with 72% of the sample having children in the home compared to only 44% of the NI study. The Italian sample often reported that their children would not eat certain elements of the MIND diet such as wholegrains or vegetables, influencing their decision to buy or cook such foods. This finding is supported in the literature that the taste preference of family and friends is a barrier to healthy eating (Ashton et al., 2017). Furthermore, research found the preference of children and family to be an important barrier when adopting a healthier lifestyle, particularly with increasing consumption of healthy foods. However, family support and influence were also reported as a key facilitator in adhering to the MIND diet, which is consistent with previous research that found family support was associated with healthier foods (Pawlak et al., 2009; Walker et al., 2006).

Motivation was highlighted as a barrier and facilitator to the uptake of the MIND diet in both samples. A major barrier reported in both samples was belief about capabilities, with taste preference being a factor associated with adhering to the MIND diet. This finding is in line with previous research that found taste preference to be a barrier to healthy eating (Ashton et al., 2017). Morrow et al. (2017) found that men were more likely to eat healthily if they did not perceive taste to be a barrier. Many of the Italian participants reported that the MIND diet was very similar to their own diet and therefore, felt it would be quite easy to follow. Previous research found that level of education is associated with healthy eating (Chandola et al., 2006; Cutler et al., 2006; Thornton et al., 2014) and the Italian sample are all educated with 76% of the Italian sample with a higher qualification compared to 36% of the NI sample with a higher qualification and 36% with no formal qualifications. Research found that level of nutritional knowledge is associated with length of education and awareness of food related issues, leading individuals to be more interested in a balanced dietary pattern (Bonaccio et al., 2012a; Bonaccio et al., 2012b). However, the Italian sample perception of the MIND diet adherence ease may be attributable to their culture. The MIND diet is a Mediterranean style diet and many of the Italian participants reported following their cultural diet which is rich in fruit, vegetables, nuts, grains, and olive oil and that this in itself is a facilitator to adhering to the MIND diet. Research in the Mediterranean countries have found that the Mediterranean diet is progressively disappearing (Burlingame et al., 2011; Dernini et al., 2017). However, research estimating adherence to the Mediterranean Diet in the Mediterranean countries using secondary data, found that Italy had the best adherence to the Mediterranean Diet (Finardi et al., 2018). Even though Italians had the best adherence to the Mediterranean diet, it was still decreasing since the economic crisis (Benedetti et al., 2016).

Culture was also reported as a barrier to adhering to the MIND diet in the Italian sample only. Participants often reported that certain MIND diet foods were not typical of their culture and serving certain foods to family and friends were not acceptable, such as wholegrain pasta and bread. This finding is in support of previous research that found low consumption of wholegrains in a Spanish sample (Bautista et al., 2013; Ruiz-Cabello et al., 2015). Baruth et al. (2014), found family to be a barrier to healthy eating. It was reported in Baruth's study that women were pressurised to eat more and that they were not supported if they were trying to eat a healthy diet. Furthermore, the sample in Baruth's study was with African American women, and they may feel pressure to eat more, as food and the context of eating their traditional food is important to their cultural identity (Baruth et al., 2014).

The findings from this study are important to understand behaviour in the context in which it occurs. These findings not only highlight the components of the COM-B/TDF that need to change in order change behaviour, but the cultural differences in terms of important factors that need addressed in intervention design. The development of an appropriate intervention depends on the understanding of MIND diet behaviour in context, and the findings from this study provides us with the necessary knowledge of factors influencing behaviour that will inform an intervention. This is important, as an intervention to change MIND diet behaviour in Northern Ireland, may not address the needs of those living in Italy. The COM-B model is at the core of an overarching framework called the Behaviour Change Wheel (Michie et al., 2014) which is a 3-stage systematic approach to designing a behaviour change intervention. The research in this paper represents stage one, to understand behaviour in the context in which it occurs and identify what needs to change in order to change MIND diet behaviour.

5.5.1 Limitations

This study was undertaken in a small sample of Italian and Northern Irish men and women and our findings may be context based and, therefore, not generalisable to the whole population. However, generalisability was not the main aim of our study, rather to explore people's attitudes and perceptions towards the uptake and adherence to the MIND diet, with the aim to inform an intervention. Researcher subjectivity may be seen as a limitation to our study; however, codes and themes were identified by a second researcher which suggest that the themes drawn have credence beyond interpretation of the lead researcher. Focus groups run the risk of introducing bias (Harrison et al., 2015), resulting from an individual's desire to conform to social acceptability (Acocella et al., 2012). However, in this study, focus group participants were acquaintances, and therefore, may reduce the risk of social acceptability. Barriers and facilitators reported in this study are "perceived" and, therefore, may have limited value in predicting uptake of the MIND diet. A limitation of this study is that the two samples differ in terms of socio-economic status, with all the participants from the

Italian sample being of high socio-economic status and approximately one-third of the NI participants of low socio-economic status, which may make comparisons more difficult. Further research should include participants across different socioeconomic backgrounds. Furthermore, half of the Italian participants spoke in Italian and some of the richness of the data may have been lost in translation. However, the second researcher (Italian) translated, transcribed, and analysed the data to maximise interpretation and understanding of the data.

5.5.2 Strengths

To our knowledge, this is the first study to develop a “behavioural diagnosis” of factors influencing the uptake of the MIND diet in a Mediterranean and non-Mediterranean country. This was the first study to apply the TDF to explore people’s attitudes towards a whole dietary pattern and compare these attitudes between a Mediterranean and non-Mediterranean country. The COM-B model provides a more comprehensive explanation of adherence than existing models [33], making it easier to identify appropriate interventions. Moreover, this study used the COM-B model as an additional step in the thematic analysis, which increased the study’s efficiency and showed that the entire framework was adequate for purpose.

5.6 Conclusion

The COM-B and TDF makes a novel application to understanding what would influence the uptake of the MIND diet. This research identified that the main barriers to the uptake of the MIND diet were; time, work environment (opportunity), taste preference and convenience (motivation), with culture (motivation), seasonal foods and lack of family support (opportunity) to be a barrier to the Italian sample only. The main facilitators reported were; improved health, memory, planning and organisation (motivation) and access to good quality food (opportunity). Cooking skills, knowledge (capability) and heathy work lunch (opportunity) being a facilitator to the Italian sample only. Developing interventions that target these salient barriers to MIND diet uptake will have greater potential to change behaviour. Future research can use the insight from this paper to test the effectiveness of the intervention functions and BCTs outlined in these findings. Furthermore, understanding barriers and facilitators to towards uptake of the MIND diet may help health professionals working with individuals/communities to help prevent or reduce the risk of cognitive decline.

5.7 References

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Chapter 6

Thesis Methodology

Development of dietary intervention to promote adherence to the MIND diet in healthy adults at midlife.

6.1 Introduction

Cognitive skills are important for the daily functioning of older people. However, with age, some of these cognitive abilities decline, such as episodic memory, executive function, processing speed and problem solving (Zaninotto et al., 2018). Research shows that a healthy diet may reduce the risk of cognitive decline and dementia (van den Brink et al., 2018). The MIND diet is a hybrid of the Med and DASH diet and has been designed specifically to promote brain health (Morris et al., 2015). The MIND diet consists of 15 components, which includes 10 brain healthy foods (green leafy vegetables, other vegetables, whole grains, berries, beans, fish, poultry, nuts, olive oil and red wine). Also, there are 5 food groups that should be limited which include, red meat, butter, cheese, fried/fast food, and sweets/pastries. The MIND diet score has been shown to be more predictive of cognitive decline than either the Med or DASH diet and adhering to the MIND diet moderately has been shown to reduce the risk of dementia by 35% (Morris et al., 2015).

Adherence in general is a complex concept and not fully understood (Conn et al., 2017). It can be defined as "*the extent to which a person's behaviour, taking medication, following a diet, and/or executing lifestyle changes, corresponds with agreed recommendations from a health care provider*" (Chakrabarti et al., 2014). The term "adherence" replaced the term compliance, as compliance referred to a process by which patients complied with a clinician's decision regarding treatment (Chakrabarti et al., 2014). However, adherence refers to a process where the patient is involved in decision making regarding treatment (Chakrabarti et al., 2014). While the concept of adherence is often used in regard to medical treatment, it is also important for effective lifestyle behaviours change interventions (Cole et al., 2011). Furthermore, adherence/compliance should not be mistaken for concordance, which is not synonymous with either compliance or adherence. Concordance is referred to the interaction between the patient and professional, and the quality of the therapeutic relationship between the two (Win et al., 2015). Poor adherence is a widespread challenge in lifestyle interventions (Middleton et al., 2013). To increase adherence, its determinants need to be better understood. Leung et al. (2017) highlighted the need for more rigorous research methodology to increase knowledge of factors influencing adherence. Identifying factors related to adherence could have important implications for intervention improvement, specifically, how interventions could be improved to facilitate behaviour change (Leung et al., 2017). Research has found several factors that may influence adherence in dietary interventions such as, socio-demographic factors (Lemstra et al., 2016), with lower education and younger age being associated with poor adherence (Leung et al., 2017). Other factors found to be associated with adherence to dietary interventions were, poor health, program dissatisfaction, and depressed mood (Lemstra et al., 2016). Designing interventions that are more effective, sustainable, and scalable, researcher's need to understand, not only whether an intervention has an effect, but why and how an intervention has an effect, and which components had the greatest impact on outcomes. For this, a theory driven intervention design is needed (De Silva et al. 2014).

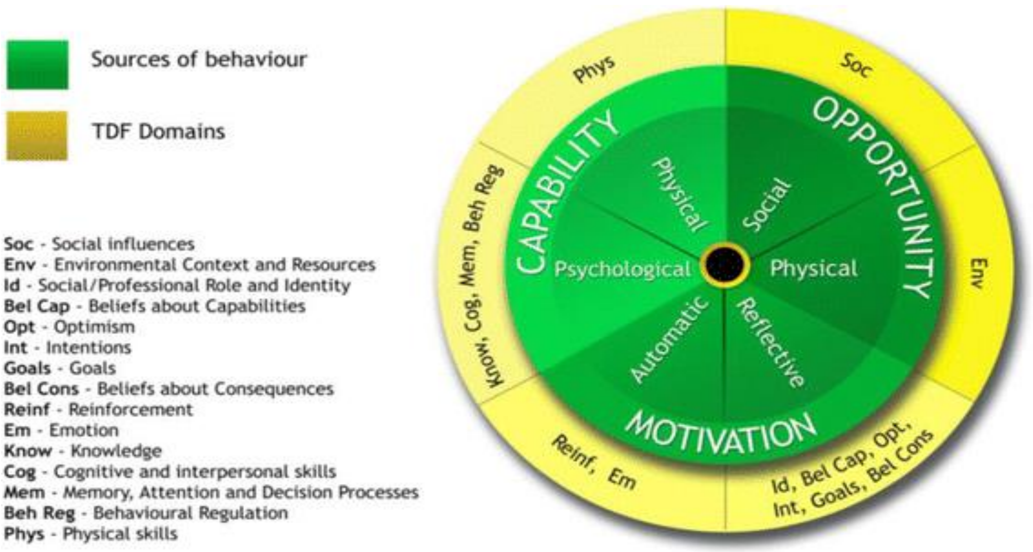
The BCW is a systematic approach to understand behaviour in the context in which is occurs and guides this transition by linking this behaviour to techniques known to change behaviour (Michie et al., 2014). The BCW is a synthesis of 19 behaviour change frameworks (Michie et al., 2011). At the BCW core is the COM-B model and stands for capability, opportunity, motivation, and behaviour (discussed in more detail in chapter 2). The COM-B model explains adherence more comprehensively than other existing models (Michie et al, 2014). Not only does it include automatic processes such as habit, it also includes factors at a systems level. Furthermore, specifying the components of the COM-B model and the relationship between them, allows for a precise description of the relationship between individual determinants and adherence, thus identifying interventions for behaviour change more clearly (Jackson et al., 2014).

The BCW has been used to design a range of dietary interventions such as to improve adoption of the Med diet (McEvoy et al., 2018), improve adherence to dietary guidelines in those with familial hypercholesterolemia (Kinnear et al., 2020) and developing text messages targeting healthy eating for children (Chai et l., 2018). To our knowledge, there are no dietary intervention studies implemented that have been developed using the BCW. However, Kerrison et al. (2018) conducted a RCT examining the effectiveness of self-referral reminders and theory based leaflet designed using the BCW to increase participation within the English Bowel Scope Screening program. It was found that uptake of the screening was significantly higher in those who received the referral reminder with the theory-based leaflet that those without the theory-based leaflet or control.

Using the COM-B model to analyse the target behaviour (behavioural diagnosis) is the first step of intervention design, to identify barriers and facilitators of the behaviour that the intervention is intended to change (Michie et al., 2014). The model argues that for any behaviour to occur, there must be the capability to do it. Capability can be either “physical” (having the strength, stamina), or “psychological” (knowledge, psychological skill) to perform the behaviour. There must be sufficient opportunity, which includes social opportunity (social norm, social/family influences) and physical opportunity (time, resources) to perform the behaviour. There also must be sufficient strong motivation to perform the behaviour which can be “reflective” (self-conscious planning and evaluations) or automatic (desires, impulses, want and needs). If a deeper understanding of behaviour is required, the COM-B components can be further elaborated by the TDF (Cane et al., 2012). The TDF consists of 14 domains, each of which can be mapped onto the COM-B model (see Figure 6.1)(further discussion on BCW in chapter 2). Once a “behavioural diagnosis” has been made using the COM-B model, the BCW guides the intervention process by recommending which intervention functions best serve to bring about change (education, training etc), and further guides the selection of which Behaviour Change Techniques (BCT: active ingredients that bring about change) that would best deliver the intervention functions (Connell et al., 2019; Michie et al., 2014)

Figure 6.1

TDF domains and corresponding mapping onto the COM-B component.



Michie et al. (2014), Cane et al. (2012).

According to the MRC, utilising theory and incremental stepped approaches are important when designing behaviour change interventions (Craig et al., 2008). The reason for selecting the BCW for this thesis is not only because it helps understand behaviour in the context in which it occurs, it also includes reflective processes involved in behaviour change and the provision of a clear and direct process in designing an appropriate intervention to foster change (McEvoy et al., 2018; Michie et al., 2014; Michie et al 2011).

To explore if a dietary intervention to promote adherence to the MIND diet is effective, systematically designed and theory driven, interventions that are clearly reported and rigorously assessed are warranted. Therefore, the aim of this study was to describe the development and rationale for a web-based behaviour change intervention to promote adherence to the MIND diet by applying the BCW.

6.2 Eight steps in designing the MIND diet intervention using the Behaviour Change Wheel.

The BCW and COM-B model was applied to define the target behaviours and select the most suitable intervention components and implementation approach, based on existing literature and formative work with the target population. There are 8 steps in the intervention development process, categorised into three stages recommended by the BCW (Michie et al., 2014) (see Figure 6.2). The methods employed in each of the eight steps of the BCW framework are described below. Policy categories which is step 6, was excluded as it was not relevant to this study.

Figure 6. 2

Stages involved in the development of an intervention using the Behaviour Change Wheel.

*COM-B= capability, opportunity, motivation & behaviour, TDF=theoretical domains framework, BCW= behaviour change wheel, BCTTv1: Behaviour change techniques taxonomy version 1

6.2.1 Step 1 & 2: Define the problem in behavioural terms and selecting target behaviour.

To understand dietary behaviour, there is a need to understand why behaviours are as they are and what needs to change for the desired behaviour to occur (Atkins et al., 2015). In order to do this, we reviewed the evidence in the literature (chapter 2) examining the MIND diet (Michie et al., 2015; Van de Brink et al., 2019) to define the MIND diet behaviours and inform the outcome assessment of MIND diet behaviour change (Morris et al., 2015). Previous research on “whole” dietary patterns found that the MIND diet score was more predictive of cognitive decline than either the Med diet or DASH diet (Morris et al., 2015). This study found a 53% lower risk for AD with high adherence to the MIND diet. Furthermore, a 35% lower risk of AD was shown for a moderate adherence to the MIND diet (Morris et al., 2015), whereas no significant association with AD was shown for the Med or DASH diet (Van Den Brink et al., 2019). While the Med diet has been shown to have strong evidence base for cardiovascular disease prevention (Martínez-González et al., 2019), and the DASH diet was designed to prevent hypertension (Siervo et al., 2015), the MIND diet was specifically designed to protect the brain (Morris et al., 2015).

6.2.2 Step 3: Specify the target behaviour.

When considering MIND diet behaviour, intervention designers should consider all other potential behaviours that may influence the behavioural problem, which can then be reduced by considering what impact these behaviours may have on the target behaviour. In this step, we considered behaviours such as, availability of healthy foods at work, who does the shopping and cooking, accessibility of MIND diet foods. According to the BCW, to understand behaviour, it is important to outline the new behaviour in terms of; who, what, when, where, how often, and with whom the behaviour will occur (See Table 6.1).

Table 6.1

MIND diet behaviour according to who needs to do what, when, where, how often and who with

Target behaviour	**MIND diet**
Who performs MIND diet	The male/female participants aged 40-55 years
What do they need to do to achieve MIND diet behaviour	Participants need to choose foods that enable them to meet the MIND diet daily and weekly target guidelines. The exact details of the MIND diet target are provided in chapter 6. In brief, participants are to consume; leafy greens, berries, fish, poultry, nuts, bens, olive oil, whole grains, vegetables, and limit foods seen as unhealthy for the brain (cheese, red met, sweet/pastries, butter and fried food.
When do they do it	Every day during mealtimes
Where do they do it	Anywhere, in their own homes, work, social events, homes of family and friends

How often do they do it	Every day, aiming to consume the target food and portions for that day.
Who do they do it with	Alone, with family, friends, or work colleagues

MIND= Mediterranean-DASH intervention for neurodegenerative delay diet

The MIND diet consists mainly of plant-based foods, with limited intake of saturated fat and animal products, with unique specification of berries and leafy greens (Morris et al., 2015), which are shown to have the strongest association observed for cognitive function (Morris et al., 2018), compared to fruit and vegetables as a whole (more information on this in Chapter 2). Therefore, there are a range of behaviours that constitute the MIND diet (see Table 6.2). Individual adherence to the MIND diet is determined using the MIND diet score (Morris et al., 2015), where the frequency of portions per food component was reported and computed cross all food groups to create an overall MIND diet score with maximum of 14 points (see Table 6.2). The MIND diet is a new behavioural pattern and participants had not heard of it before, therefore, an in depth discussion around the food groups, portion sizes and frequency of foods and who what when and where the behaviour would occur was conducted with participants to gain an understanding of what was required of them during the intervention to meet the MIND diet daily and weekly targets (see Table 6.2).

Table 6.2

MIND diet component servings and scoring

	Examples	0	0.5	1
Green Leafy Vegetables	Kale, spinach, cabbage	≤2 servings/wk	> 2 to <6/wk	≥6 servings/wk
Other Vegetables	Broccoli, carrots, potatoes, Tomatoes, onion,	<5 serving/wk	5 – <7 wk	≥1 serving/day
Berries	Blueberries, strawberries raspberries	<1 serving/wk	1 /wk	≥2 servings/wk
Nuts	Walnuts, almonds, brazil	<1/mo	1/mo – <5/wk	≥5 servings/wk
Olive Oil	Olive oil	Not primary oil		Primary oil used
Butter, Margarine	Butter, margarine	>2 T/d	1–2 /d	<1 T/d
Cheese	Cheddar,	7+ servings/wk	1–6 /wk	< 1 serving/wk
Whole Grains	Bread, pasta, rice, cereals	<1 serving/d	1–2 /d	≥3 servings/d
Fish (not fried)	Salmon, cod, tuna	Rarely	1–3 /mo	≥1 meals/wk
Beans	Kidney, butter, chickpea, black bean	<1 meal/wk	1–3/wk	>3 meals/wk
Poultry (not fried)	Chicken, turkey	<1 meal/wk	1 /wk	≥2 meals/wk
Red Meat and products	Red meat, bacon, sausages	7+ meals/wk	4–6 /wk	< 4 meals/wk
Fast Fried Foods	French fries, pizza, KFC	4+ times/wk	1–3 /wk	<1 time/wk
Pastries & Sweets	Cake, ice-cream, biscuits, chocolate	7+ servings/wk	5 −6 /wk	<5 servings/wk

Morris et al., (2015). Wk=week, mo=month, T=tablespoon, d=day

6.2.3 Step 4: Identify what needs to change

Intervention designers need to identify what needs to change, in order to change MIND diet behaviour. According to the BCW, data from different sources should be collected in order to understand behaviour (Michie et al., 2015). Therefore, interviews and focus groups were conducted with the target group. This behavioural diagnosis is an important step, to understand behaviour in the context in which MIND diet behaviour occurs by exploring participants capability, opportunity and motivation (COM-B) towards adoption of the MIND diet prior to intervention design, so these can be addressed in changing behaviour. Interviews and focus groups generate different information from participants. Research shows that while focus groups generate a wider range of ideas and views than that of interviews (Krueger et al., 2014), one to one interviews capture more detail than focus groups and offer more insight into participants personal thoughts and experiences (Kidd et al., 2000). This allows researchers to identify barriers and facilitators towards adoption of the MIND diet in order to address these in the design of an intervention.

The COM-B model, which is at the core of the BCW was used to understand behaviour in the context in which it occurs in the target group. The TDF (Cane et al., 2012) was used to elaborate the COM-B components, for a more detailed understanding of MIND diet behaviour. The TDF was originally developed using a consensus approach (Michie et al., 2005) and included 128 explanatory constructs derived from 33 psychological theories. From this, the TDF had 11 theoretical domains. However, subsequent development and validation (Cane et al., 2012) led to 14 domains, covering the spectrum of behavioral determinants and can be mapped onto the COM-B component and include constructs that align with other social cognition models (Michie et al., 2011). The TDF was developed to synthesis key theoretical constructs used in a range of theories (Abraham &Michie, 2008) that are relevant and helpful in implementation interventions. The comprehensive coverage of the TDF allows us to analyse the most important domains specific to the MIND diet behaviour allowing a crucial step in predicting, and ultimately changing MIND diet behaviour. By providing a wider range of behavioural determinants, we gain a deeper understanding of factors influencing MIND diet behaviour which are then addressed in the intervention development process.

In step 4, twenty-five male and female participants aged 40-55 years were recruited to take part in an interview or focus group to explore barriers and facilitators to capability, opportunity, and motivation towards adoption of the MIND diet. A COM-B "behavioural analysis" of the data was conducted to determine which COM-B components and theoretical domains needed to change to promote MIND diet adherence. Findings from the interviews and focus groups are reported in full in chapter 4. The COM-B behavioural analysis found that 80% of the barriers fell into 6 of the TDF (environmental context and resources, belief about capabilities, knowledge, behaviour regulation, memory/attention, physical skills), and 80% of the facilitators fell into 6 of the TDF (belief about capabilities, belief about consequences, emotion, skills, environmental context and resources, social influence), all of which can be mapped onto all three of the COM-B components. Therefore, this analysis identified barriers and facilitators to capability, opportunity, and motivation for achieving MIND diet behaviour change in the target population. These results informed the design of the MIND diet intervention.

6.2.4 Step 5: Identifying intervention functions most likely to bring about behaviour change towards MIND diet in target population.

Links between the COM-B analysis conducted in stage 1 and intervention functions suggest which functions are likely to be effective in facilitating change in MIND diet behaviour. There are nine functions to choose from: education, persuasion, incentivisation, coercion, training, restriction, environmental restructuring, modelling, and enablement (Michie et al, 2014) (see Table 6.3). These 9 functions were identified through the synthesis of 19 frameworks (Michie et al., 2011), and can be understood in term of broad categories in which an intervention can change behaviour (Michie et al., 2014). The BCW recommends evaluating intervention functions through the

APPEASE (Affordability, Practicability, Effectiveness and cost-effectiveness, Acceptability, Side-effects/safety, and Equity) criteria (Michie et al., 2014), to assist in the decision making regarding the intervention delivery and content, and to make judgements on what would be most appropriate for the intervention (see Table 6.3). This allowed for the identification of appropriate and suitable intervention functions within the context of this feasibility study in which the intervention was to be delivered.

Table 6.3:

Descritpion of 9 intervention functions and *6 APEASE criteri*a

Education	Increasing knowledge or understanding	Affordability	An intervention is affordable if within budget, it can be delivered to or accessed by all those it would be relevant
Persuasion	Using communication to induce positive or negative feelings or stimulate action	Practicality	An intervention is practical to the extent that it can be delivered as designed through the means intended to the target group
Incentivisation	Creating an expectation of reward	Effectiveness/cost effectiveness	The effect size of the intervention in relation to the desired objectives in a real-world context. Cost-effectiveness refers to the ratio of effect to cost.
Coercion	Creating an expectation of punishment or cost	Acceptability	The extent to which relevant stakeholders (public, professional, and political) judge an intervention appropriate.
Training	Imparting skills	Side effects	An intervention may be effective and practicable but have unwanted or unintended consequences. This needs to be taken into consideration when planning the intervention.
Restriction	Using rules to reduce the opportunity to engage in the target behaviour (or to increase the target behaviour by reducing the opportunity to engage in competing behaviours)	Equity	The extent to which an intervention may reduce or increase the disparities in standard of living, well-being, or health between different sectors of society.
Environmental restructuring	Changing the physical or social context	N/A	N/A
Modelling	Providing an example for people to aspire to or imitate	N/A	N/A
Enablement	Increasing means/reducing barriers to increase capability or opportunity (beyond environmental restructuring)	N/A	N/A

APEASE: Affordability, practicality, effectiveness/cost-effectiveness, acceptability, side effects, equity
Adapted from Michie et al. (2014)

As all COM-B components have been highlighted as potential to change behaviour, all intervention functions have potential for intervention design. However, after evaluation through the APPEASE criteria, we found that 6 of the 9 intervention functions mapped onto the COM-B model and TDF identified as most relevant to the COM-B analysis conducted in stage 1. These were: education (increasing knowledge), training (imparting skills), persuasion (influencing attitudes and actions), modelling (using examples to inspire people), environmental restructure (changing physical or social environment), enablement (providing support to overcome barriers). These intervention functions were considered most likely to be effective to change behaviour in the target population (see Table 6.4).

Recent research in the development of dietary interventions found similar intervention functions best suited to the development of their intervention to promote the Mediterranean Diet in adults with high cardiovascular disease (McEvoy et al., 2018), improve adherence to dietary guidelines with individuals with familial hypercholesterolaemia (FH) (Kinner et al., 2020), and in the development of an app to promote healthy eating in adolescents and young adults (Rhode et al., 2019). Recently, a systematic review found that the most commonly used intervention functions in digital behaviour change dietary interventions were; education, enablement and persuasion with coercion, restriction and incentivisation rarely used (Heiden et al., 2019) which in fact, were the three functions excluded in this study (see Table 6.4).

Table 6.4

Links between COM-B, TDF and intervention function.

COM-B	TDF	Intervention function
Psychological capability	Knowledge	Education
	Behaviour regulation	Education Training Modelling Enablement
	Memory, attention, and decision process	Training Environmental restructuring Enablement
Physical Capability	Skills	Training
Physical opportunity	Environmental Context and Resources	Training Environmental Restructuring Enablement
Reflective Motivation	Belief about Capabilities	Education Persuasion Modelling Enablement.

COM-B= capability, opportunity, motivation, behaviour; TDF theoretical domains framework

6.2.6 Step 6: Policy categories

Similar to other intervention design researchers, the policy categories were found to be less practical than other steps of the BCW in this context (Connell et al., 2015; McSharry et al., 2017).The identification of BCTs flowed logically from the behavioural analysis and intervention functions. No policy categories were identified at this stage of the intervention design. However, this is something that could be considered in future research, after the intervention has gone through feasibility testing.

6.2.7 Step 7: Identifying intervention content

Step 7 aimed to identify the intervention content in terms of which BCT's would best deliver the intervention functions and bring about change in the target behaviour. Examples include self-monitoring and social support. Two researchers used the behaviour change technique taxonomy (BCTTv1)(Michie et al., 2014) to identify the most likely BCTs to bring about behaviour change and mapped these onto the TDF identified from the COM-B analysis in stage 1 and the 6 selected intervention functions. Eighteen BCT's were identified for inclusion in the dietary intervention such as social support, self-monitoring, goal setting some of which have produced successful dietary change in previous dietary interventions (Ashton et al., 2019; Moore et al., 2019). Identifying BCT's for inclusion was also based on the APEASE criteria recommended by Michie et al. (2015) and the theory and techniques tool (Connell et al., 2019), which explores the link between BCT's and mechanisms of action (MO). This information is based on evidence of links made by authors in previous research (Crey et al., 2019; Johnston et al., 2018) and by expert consensus (Connell et al., 2019) to support intervention designers develop and evaluate theory-based interventions. This tool identified which BCT's has direct links to the TDF domains being addressed in the MIND diet intervention. For example, the tool showed that there was a link between TDF behaviour regulation and self-monitoring of behaviour, and a link between both TDF social influence and environmental context with BCT social support.

Therefore, capability to increase MIND diet adherence will be addressed by offering instruction on how to perform behaviour, self-monitoring and information on health consequences, opportunity to increase the theory and techniques tool (Connell et al., 2019), which explores the link between BCTs and MO. This information is based on evidence of links made by authors in previous research (Carey et al., 2019; Johnston et al., 2018) and by expert consensus (Connell et al., 2019) to support intervention designers develop and evaluate theory-based interventions. This tool identified which BCT's has direct links to the TDF domains being addressed in the

MIND diet intervention. For example, the tool showed that there was a link between TDF behaviour regulation and self-monitoring of behaviour, and a link between both TDF social influence and environmental context with BCT social support. MIND Diet adherence by engaging peer support along with restructuring the physical environment, prompts/cues and behaviour substitution and motivation to increase MIND diet adherence will be facilitated by positive self-talk, problem solving, self-monitoring and action planning.

A range of resources were developed to facilitate behaviour change in the target population and optimise delivery of the BCT which included written educational material on the MIND diet elements and the benefits of the diet, providing information on what the MIND diet entails and what participants will need to do to adhere to the MIND diet guidelines. Previous research found that lack of knowledge and poor awareness of dietary guidelines were main reasons for poor dietary adherence (Ayele et al., 2018), and that increased education and knowledge about dietary recommendations to improve adherence to dietary patterns (Abu-Janb et al., 2018). Online peer support was embedded in the intervention for participants to support each other though the intervention period. This was a chat room for participants to engage with each other and provide support if needed, which was moderated by the researcher. Peer support has been shown to be effective for improving dietary behaviour change compared to a control (Moore et al. 2019). Self-monitoring resources were provided to enable participants to monitor their MIND diet. This allowed participants to track if they are meeting the MIND diet daily and weekly targets. Research shows that interventions delivered remotely using self-monitoring techniques can be effective in changing dietary behaviours (Teasdale et al., 2018), or a mobile app may be effective in promoting dietary change (Ahn et al.,2019). Recently, a systematic review (Mandracchia et al., 2019) found that, out of the 6 included studies that used self-monitoring, 4 studies improved fruit and vegetable intake. A range of recipes were provided to participants to encourage and support MIND diet behaviour. Research has found that providing recipes and instruction on how to perform a behaviour may increase participants adherence to healthy eating (Cradock et al., 2017; Rita et al., 2018).

Also, text messages were sent on a weekly basis over the 12 weeks of the intervention to check in with participants progress, which has been found to be effective in promoting adherence to dietary guidelines over 6 months (Santo et al., 2018). Each week delivered tips and advice on how to adhere to the MIND diet in different situations such as the workplace, eating out and cooking for family and friends (See Table 6.5).

6.2.8 Step 8: Mode of delivery

We opted for a mixed mode of delivery. Mainly, the intervention was delivered online as this was deemed most practicable, acceptable, and affordable according the APEASE criteria. Online web-based dietary interventions are becoming more popular and widespread, with research showing a decrease in interest in receiving nutritional information in a traditional one to one format, and more interest in receiving nutritional information on an online platform (Bensley et al., 2014).

Web-based intervention programs are an effective way to reach diverse populations and can be as effective as face to face interventions to improve nutrition related behaviours (Neuenschwander et al., 2013). The use of the internet and smart phones have increased worldwide, facilitating web-based research including dietary interventions. Statistics show that 91% of those living in the UK use the internet, with

78% using a smartphone to access the internet, and that technology use is not limited by socio-economic status (Rossiter-Base, 2019). Interventions delivered online can potentially overcome barriers of traditional face to face participation, such as flexibility for busy people, improve access, easier access for those living in rural areas, reduce travel time and cost of attending face to face appointments (Burrows et al., 2015). One of the most widely searched information on the internet is for health information, with diet and nutrition universally popular (Young et al., 2019). Online dietary interventions are particularly useful as they can be integrated into everyday life (Rogers et al., 2017), such as accessing the content of the intervention while dining, or shopping for groceries, which could increase adherence (Michie et al., 2017).

Research found that an online platform to deliver a dietary intervention improved dietary knowledge, attitude and behaviour over a 6-month period among those with type 2 diabetes (Ramada et al., 2018), increase vegetable intake over a 5 week period in middle aged adults (Nakamura et al., 2017), improve dietary quality over a 12 week period in children (Chai et al., 2019), and increased adherence to the Mediterranean diet over a 6 month intervention period (Papadaki et al., 2005).

However, web-based, or smart phone interventions report high attrition rates, limiting the ability of online interventions to engage and retain participants (Geraghty et al., 2013). Another major limitation is the time commitment required for digital interventions to be effective. Individuals need to use digital behaviour change interventions for a minimum amount of time to have any meaningful effect on behaviour, and users need to remain motivated during that time. As with any behavioural change, there is an opportune (teachable) moment when the user is most amenable to make behavioural changes or is at risk of a setback. Digital interventions are unable to identify and act appropriately on these moments, which decreases their efficacy.

However, Webb et al. (2010), found that personal contact such as text messages to participants alongside the web-based intervention, enhanced behaviour change. Also, O'Brien et al. (2016), found that a web-based intervention promoting healthy dietary behaviours in a sample of students, were more effective when combined with text messages. Therefore, text messages will be delivered to participants in this thesis to provide motivation to change their diet and promote healthier eating (Keely et al., 2019).

Table 6.5

Links between COM-B analysis, TDF, intervention functions and BCT's for 12-week intervention design

	Research findings	Source of behaviour	TDF	Intervention function	Intervention proposal	BCT
Front page	Key barrier 1. Lack knowledge 2. Lack monitoring 3. Lack cooking skills	Psychological capability Physical capability	Knowledge Behaviour regulation Skills	• Education • Training • Enablement • Modelling	Provide information on the MIND diet foods, their servings, benefits for health. Provide quick and easy recipes. Provide self-monitoring of behaviour forms to complete	5.3 Information on health consequences 2.3 Self-monitoring of behaviour 4.1 instruction on how to perform behaviour 11.3 conserving mental resources
Week 1	Key Facilitator 1. Feel better generally 2. Better memory 3. Improve psychological health	Reflective Motivation	Belief about consequences	• Education • Persuasion • enablement	Provide information on dementia statistics and risk factors. Provide information on health benefits of MIND diet and brain healthy foods Deirdre's diary Action plan Did you know? Fresh vs frozen food MIND diet reviews	5.3 information on health consequences 5.2 Salience of consequences 6.2 social comparison 9.2 pros and cons(task) 5.3 Information about environmental consequences
Week 2	Key barrier 1. Work enviro Key facilitator 1. Bring lunch	Physical opportunity	Environmental context and resources	• Persuasion • Environmental restructure	Deirdre's diary Action plan for the week Did you know? Provide information on how to overcome workplace diet traps	15.1 Verbal persuasion about capability 6.2 Social comparison 11.3 conserving mental resources 12.3avoidance/reducing exposure for behaviour

						12.4 adding objects to the environment (lunch/snack) 7.5 Remove aversive stimulus (unhealthy food from workdesk)
Week 3&4	Key barrier 1. Time 2. Budget 3. Convenience 4. Taste preference Key facilitator 1. Availability/access food 2. Prep/plan	Physical opportunity Reflective motivation	Environmental context and resources Belief about capabilities	• Persuasion • Environmental restructure • Education	Provide information on overcoming key barriers and using key facilitators to encourage change. Encourage positive attitude towards dietary change Deirdre's diary Action plan Did you know? Provide advice on plan meals ahead of time to encourage adherence to the MIND diet	11.3 conserving mental resources 15.4 Self talk 15.3 Focus on past success 12.1 Restructuring physical environment 5.1 Information on health consequences 5.3 Information on social/environmental consequences
Week 5&6	Family support Peer pressure	Social opportunity	Social influence	• Persuasion • Environmental restructure	Provide information on peer pressure and how to overcome it, with diet friendly socialising tips. Provide advice on how to get family involved with supporting dietary behaviour change	3.2 Social support 12.1 Restructuring physical environment 11.3 conserving mental resources
Week 7&8	Eating out	Environmental and social opportunity	Environmental context, social influence	• Enablement • Education • Environmental restructure	Provide information and advice on adhering to the MIND diet when eating out. Provide advice on dealing	11.3 conserving mental resources 1.2 problem solving 8.2 behaviour substitution

					with food cravings, including alternative healthy snack food swaps	12.3 avoid reduce exposure to cues for behaviour
Week 9&10	Distractions to healthy eating. Comfort eating, stress	Psychological capability	Memory, attention, decision making	• Environmental restructure • Enablement • Education	Provide information on comfort eating and advice on how to recognise and deal with comfort eating. Provide information on the practice of and benefits of mindful eating	12.4 adding objects to the environment 1.2 problem solving 12.3 Avoid/reduce exposure to cues for behaviour
Week 11&12	Weight management/ maintenance/relapse prevention	Capability Opportunity Motivation	Knowledge Skills Belief about capabilities Social influence Belief about consequences Memory, attention&decision making	• Education • Environmental restructure • Enablement • Education	Provide information on weight management, maintenance, and relapse prevention	7.1 Prompts and cues 12.2 Restructuring physical environment 12.2 Restructuring social environment 1.2 problem solving 2.3 Self-monitoring

COM-B=capability opportunity motivation and behaviour; TDF= theoretical domains framework; BCT= behaviour change techniques

6.3 Discussion

This paper describes the process to developing a theory-based intervention promoting the MIND diet in adults at midlife. The BCW was a valuable tool to guide the theoretical basis of the intervention and tailor the format and content to the target population. The main aim of this paper was the analysis of the qualitative data to highlight what aspects of the BCW could be used to design an intervention tailored to the needs of adults in midlife. Findings from a systematic review recommended that researchers need to use a framework such as the BCW (Michie et al., 2014) to conduct detailed “behaviour analysis” to understand behaviour prior to intervention design. Also, to align BCTs with MO and intervention functions as different BCTs may be more appropriate for certain individuals, behaviour, and mode of delivery (Cradock et al., 2017).

This research describes the systematic approach of designing an intervention, firstly, by applying the COM-B/TDF model to highlight the barriers and facilitators to capability, opportunity and motivation towards adoption of the MIND diet, linking to intervention functions within the BCW, and finally identifying and linking to behaviour change techniques that would bring about behaviour change when developing an intervention.

In this study, all components of the COM-B model were identified as potential targets for MIND diet behaviour change. Furthermore, the results from the behavioural diagnosis with participants suggested that environmental resources and context, belief about abilities, belief about consequences, emotion, memory/attention, knowledge, skills, behaviour regulation and social influence were important TDF domains to target in intervention design. Consequently, 6 intervention functions were identified as relevant for a dietary intervention. These results are in line with previous research that found the most common intervention function of the BCW in dietary interventions were; education, training and enablement (Evangelidis et al., 2019), with environmental restructure and modelling used in nearly 50% of dietary studies, and restriction, coercion and incentivisation rarely used (Beard et al., 2019).

Roset-Salla et al. (2016) evaluated the effectiveness of an educational intervention aimed at improving adherence to the Med diet of parents with small children. This study found that educational workshops with parents on increasing knowledge of the Med diet and developing dietary skills significantly improved adherence to the Mediterranean diet compared to a control. It is important to note, that while education is a common approach in intervention delivery, it is often not sufficient for behaviour change (Beard et al, 2019). To address the knowledge-behaviour gap, further support is needed such as enablement. This may involve encouraging problem solving and action planning, which is one of the most commonly reported BCT clusters (Gollwitzer et al., 2006). Action planning has been shown to be effective in changing dietary behaviour in previous systematic reviews (Ashton et al., 2019; Cradock et al., 2017). Constructs from BCT action planning highlight the importance of self-regulatory process in behaviour change (Vohs et al., 2016), and are seen in other behaviour change theories such as the HBM (Rosenstock et al., 1988).

Overall, 18 BCTs were identified for inclusion in the intervention design, to restructure the environment for implementation, and to educate, train, persuade, model, and enable participants to adopt the MIND diet. From the COM-B behavioural analysis in stage 1, participants reported lack of knowledge of the MIND diet and lack of self- monitoring. To address this, the BCW recommended the use of BCTs such as self-monitoring, instruction on how to perform a behaviour, demonstration of behaviour and goal setting, all of which were selected for inclusion in the development of this intervention. Goal setting (Samdal et al., 2017) and self-monitoring of behaviour (Bull et al., 2018) have been found to be an effective BCT in dietary interventions. Instruction on how to perform a behaviour and demonstration of behaviour have been shown to have a positive impact on diet (Hartmann et al., 2014).

Finally, other BCTs in this study involved restructuring the environment, which included, adding objects to the environment (e.g. fruit basket) restructuring physical environment and add/reduce exposure to cues. Previous research found these BCT's commonly used in dietary interventions (Soltani et al., 2016). One meta-analysis found that, adding objects to the environment was effective in 70% of the studies examined (Ashton et al., 2019). With adopting a whole dietary pattern, there are many behaviours to consider. The next phase of the BCW process will evaluate the extent to which MIND diet adoption is feasible and acceptable in this non-Mediterranean country. This will allow further tailoring of the intervention to meet the needs of the target population.

A potential limitation of the 12-week online intervention is that it does not target other lifestyle behaviours such as physical activity, which are important modifiable behaviours for cognitive function (Fernandes et al., 2017). Furthermore, despite a clear, well directed framework, the process is lengthy and time consuming, in particular, the coding of the BCTs and analysing qualitative data within the COM-B and TDF framework. However, the systematic approach applied to developing the dietary intervention is a major strength and provides a strong coherent basis for intervention evaluation. The strength of the BCW itself is strengthened from the synthesis of 19 frameworks, instead of just one theory (Michie et al., 2014). Multiple theories allow for the use of different strategies or BCTs thereby offering greater opportunity for inducing change (Webb et al., 2010).

6.4 Conclusion

The BCW provided a systematic approach to designing a 12-week dietary intervention to promote MIND diet behaviour in male and females at midlife. This study identified potential intervention components towards adoption of the MIND diet. Eighteen BCTs have been identified as active ingredients for targeting the key determinants (capability, opportunity, motivation) of MIND diet behaviour in adults at midlife. The next step is to test the feasibility and acceptability of the 12-week dietary intervention which is presented in the next chapter, to ultimately inform the design of a larger scale RCT testing the effectiveness of the theory driven intervention on health outcomes.

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Chapter 7

The MIND diet, cognitive function, and well-being among healthy adults at midlife. A randomised feasibility trial.

7.1 Abstract

Background**:** The Mediterranean and DASH diets have been shown to slow cognitive decline, however, neither diet is specific to the nutrition literature on dementia prevention. Therefore, the MIND diet was designed specifically to promote brain health. The aim of this research was to test the effectiveness of the MIND diet on cognitive function and assess the feasibility and acceptability of a behaviour change intervention using the BCW.

Methods: An online feasibility and acceptability randomised control trial was conducted. Participants were both male and female aged 40-55 years old. Forty-one participants were randomised into a MIND diet with support group (n=15), MIND diet group with no support (n=14) or control group (n=12) for 12 weeks. Baseline and follow-up measures of cognitive function, mood, quality of life, MIND diet score was assessed in each group. Capability, opportunity, and motivation (COM-B) was also assessed pre and post intervention. Six participants from each of the intervention groups, took part in an interview post intervention.

Results: Qualitative findings suggest that self-monitoring, education, and goal setting, was sufficient to adhere to the MIND diet. A repeated measures factorial Analysis of Variance showed that in comparison to the control group, both intervention groups significantly improved positive affect, physical quality of life, MIND diet score and all COM-B components at follow-up ($p<0.05$).

Conclusion: The findings from this study show that the BCW is an acceptable framework to design and deliver effective interventions to increase capability, opportunity, and motivation to adhere to the MIND diet. Future interventions with longer duration are needed to establish an association with MIND diet and cognitive function in adults at midlife. This study recommends using less BCTs with a focus on

self-monitoring, goal setting and education on diet as an effective strategy for promoting adherence to the MIND diet.

7.2 Introduction

Maintaining healthy brain function is important for health, however, as we age, cognitive skills (e.g., memory, attention, processing speed) decline as a normal part of the ageing process (Dumas et al., 2015; Harada et al., 2013). There is an increasing ageing population both in the UK and globally, and cognitive impairment is a major public health issue (Moore et al., 2018). Cognitive decline heralds the development of dementia and MCI, which in turn can lead to an increased risk of AD. While it is difficult to estimate the prevalence rate for cognitive impairment due to differing diagnostic criteria, the prevalence rate is currently between 3-42% in adults over 65 years old (Petersen et al., 2016). With no pharmacological treatments effective to treat or prevent age related cognitive decline, recent opinion is emerging, that for an intervention to be beneficial, it would need to start in the preclinical stage (Flanagan et al., 2020). The brain develops neurologically until approximately 30 years (Lebel and Beaulieu et al., 2011), before it starts to decline slowly, with signs of neurodegeneration generally not occurring until older age. This slow process gives an opportunity for preventative measures or intervention strategies to take place (Flanagan et al., 2020).

Diet is regarded as having an important role in facilitating healthy brain function (Chen et al., 2019; McEvoy et al., 2019). Specifically, several studies have found oily fish (Butler et al., 2017; Quin et al.,2014),fruits and vegetables (Mottaghi et al., 2018;

Yuan et al., 2019) B-vitamins and antioxidants (Cao et al., 2016; Kim et al., 2013) to have a positive effect on cognitive function. In contrast, components of the diet such as saturated fat and refined carbohydrates may impair cognitive function (Martinez et al., 2018; Solfrizzi et al., 2017). The omega 3 polyunsaturated fatty acids (PUFA's) and eicosapentaenoic acid (EPA) found in fish have been found to be beneficial to the brain by reducing inflammation and increasing neurite outgrowth and synaptogenesis (Dyall et al., 2015). Fruit and vegetables have been shown to be important in maintaining a healthy brain, by lessening cognitive deterioration (Larsson, Virtamo & Wolk 2013), particularly vegetables containing carotenoid lutein, such as leafy greens, which are shown to improve verbal skills in older adults (Johnson et al, 2012). (see literature review for further information). However, recent research has taken a different approach by focusing on whole dietary patterns to address potential synergism between food groups and nutrients (Solfrizzi et al., 2017; Mumme et al., 2019).

There is a growing body of prospective studies that have attempted to gain insight into the relationship between dietary patterns and cognitive function. These dietary patterns include the Med Diet (Panagiotakos et al., 2007), the DASH diet (Sacks et al., 1999), and MIND diet (Morris et al., 2015). All three diets have been associated with less cognitive decline among adults over 65 years (Galbete et al., 2015; Trichopoulou et al., 2015), as well as better cognitive function (Shannon et al., 2019), better verbal memory (Berendsen et al., 2018) and reduced risk of AD (Morris et a., 2015). Furthermore, the MIND diet score was found to be more predictive of cognitive decline than either the Med or the DASH diet, and adhering to the MIND diet moderately reduced the risk of dementia (Morris et al., 2015) (see further information in literature review, chapter 2). The MIND diet score (Morris et al., 2015) is calculated based on 15 dietary components ranging from 0-15 points with 15 being the maximum adherence. Based on pre-defined cut-offs, a value of 0,0.5 or 1 is assigned to participants for intake of berries, leafy greens, nuts, poultry, fish, whole grains, beans, vegetables and olive oil, with 1 being assigned to those with the highest intake. A value of 1 is assigned to those with the lowest intake for fast food, red meat, butter, cheese, and sweets/pastries.

While RCTs are considered the “gold standard” to measure the effectiveness of an intervention, there are very few RCTs examining the effectiveness of the Med diet (Valls-Pedret et al., 2015; Knight et al., 2016; Martinez-Lapiscina et al., 2013) or the DASH diet (Smith et al., 2010) and to date, no RCT’s have tested the effectiveness of the MIND diet on cognitive function.

Martinez-Lapiscina et al. (2013) (thePREDIMED study: Spain) included adults aged 55-80 years and involved two intervention arms: the Med diet (supplemented with extra virgin oil (EVO) or mixed nuts) versus a low fat ‘usual’ diet control group. Results showed that over a 6-year period, scores on the MMSE and CDT were significantly higher in those who took part in the two intervention arms (Med diet +extra virgin oil/Med diet +mixed nuts) than those in the control, showing that the Med diet improved global cognition. Support for these findings are seen in Valls-Pedret et al. (2015), who carried out a 5 year RCT with cognitively healthy adults over 60 years old. Similar to Matinez-Lapiscina et al. (2013), participants were randomised into either one of two interventions (Med diet +EVO or Med diet + nuts) or a control group. Results from a battery of cognitive tests which included global cognitive function, episodic verbal memory, semantic fluency, immediate and working memory, attention, visuomotor speed and cognitive fluency, found that those allocated to the Med diet+nuts intervention arm displayed improvement in the memory composite scores compared to those in the control group. Those in the Med diet + EVO displayed improved frontal function and global cognitive composite scores compared to the control group.

In contrast, Knight et al. (2016) found no beneficial effects on cognitive function following a Med diet intervention in a cohort of healthy adults over 65 years old in Australia. The latter study used a battery of 11 tests to measure executive function, working memory, short term and episodic memory, speed processing and visual spatial memory. However, given that the intervention was conducted over a relatively short period of 6 months and had a smaller sample size compared to other RCTs, the study may have lacked statistical power to detect a significant effect on cognitive function.

Smith et al. (2010), conducted a 4-month study to assess cognitive performance in the domains of psychomotor speed and EFML using a battery of cognitive tests. An improvement in psychomotor speed and EFML with DASH adherence in middle age men was observed. However, in Berendsen et al. (2017), a positive association was found between long-term adherence to the DASH diet and better cognitive function in adults aged over 70 years, but no association was found for slower cognitive decline over a 6 year period. However, in the Women' Health Initiative Memory Study, with older American women, it was reported that DASH score was not associated with incidence of mild cognitive impairment or dementia (Haring et a., 2016).

Previous research on the Med and DASH diets, has demonstrated protective effects on cardiovascular conditions that can adversely affect brain health. Specifically, combined nutrients from a whole diet are thought to bring about additive, synergistic and interactive effects in the brain that influence neuronal and cell signalling pathways at a molecular level known to play a key role in the development and maintenance of cognitive function (Jacobs et al., 2009). However, it has been suggested that the dietary components of both diets may not specifically capture the levels and types of foods shown to optimize brain health (Morris et al., 2014). As such, the MIND diet was developed to emphasize the dietary components and servings linked to neuroprotection and dementia prevention (Morris et al., 2014).

In brief, the MIND diet encourages the consumption of 10 foods (leafy greens, other veg, nuts, berries, fish, poultry, olive oil, beans, whole grains, red wine) and the limitation of 5 other foods types (red meat, butter, cheese, pastries and sweets, fried foods). The MIND diet specifies the consumption of leafy greens and berries rather than fruit and vegetables as a whole (Dash and Med Diet), high dairy (DASH) or potatoes (Med Diet). While previous research shows that higher consumption of vegetables is associated with cognitive decline (Chen et al., 2012; Nooyens et al., 2011), the strongest association is observed for leafy greens (Kang et al., 2005; Morris et al., 2006) (further discussion in Chapter 2).

Previous research on cognitive function or dementia did not observe protective effects for overall fruit consumption (Chen et al., 2012; Nooyens et al., 2011). However, berries were shown to improve memory and learning in animal models (Willis et al., 2009), and improved executive function in young adults (Whyte et al., 2019). In this study, participants drank a berry smoothie and set to complete cognitive tests at baseline, and again 2, 4 and 6 hours later. The smoothie was consumed after baseline measures. Compared to a control, those in the intervention group showed quicker response time on the Modified Attention Network Task (Fan et al., 2002) at 2 and 4 hours and the Task Switching Task (Rogers et al., 1995) at 6 hours, demonstrating the effectiveness of berries in improving cognitive performance throughout a 6 hour day (further discussion in chapter 2).

There has been limited research investigating the MIND diet, however, recent observational research with older adults, has found that the MIND diet can slow cognitive decline over an average of 4.7 years (Morris et al., 2015). This study found that the MIND diet score was more predictive of cognitive decline than either the Med Diet or DASH diet, and that adhering to the MIND diet moderately, reduced the risk of dementia. Also, it was found that longer adherence to the MIND diet was associated with better verbal memory (Berendsen et al., 2018), and lower risk of cognitive decline (Adjibade et al., 2019; Hosking et al, 2018; Shakersian et al., 2018). One RCT examined the MIND diet effectiveness on cognitive function, and found improvements in working memory, verbal recognition memory and attention compared with the control group (Arjmand et al., 2020).

Psychological theory-based interventions are considered an ideal approach to effective behaviour change (Ramadas et al., 2018). A recent systematic review found that theory-based interventions were more successful in improving diet than studies not using theory (Avery et al., 2013). According to the Medical Research Council's (MRC) framework for complex interventions (De Silva et al., 2014), designing interventions that are likely to be more effective, sustainable and scalable, researchers need to understand which components of the intervention impact the outcomes most positively. For this reason, intervention design and evaluation based on a theoretical framework is required (De Silva et al., 2014).

Previous research shows that the traditional one to one setting with a healthcare professional providing nutritional information has decreased, with a growing interest in receiving information in an online format (Bensley et al., 2014). Also, web based nutritional education has been found to be an effective way to promote behaviour change (Bensley et al., 2014; Schwarzer et al., 2017; Nakamura et al., 2017). Furthermore, previous research suggests that web-based intervention effectiveness is associated with extensive use of theory and multiple behaviour change techniques (Webb et al., 2010). However, intervention's that are explicitly theory informed are limited (Hysong et al., 2009).

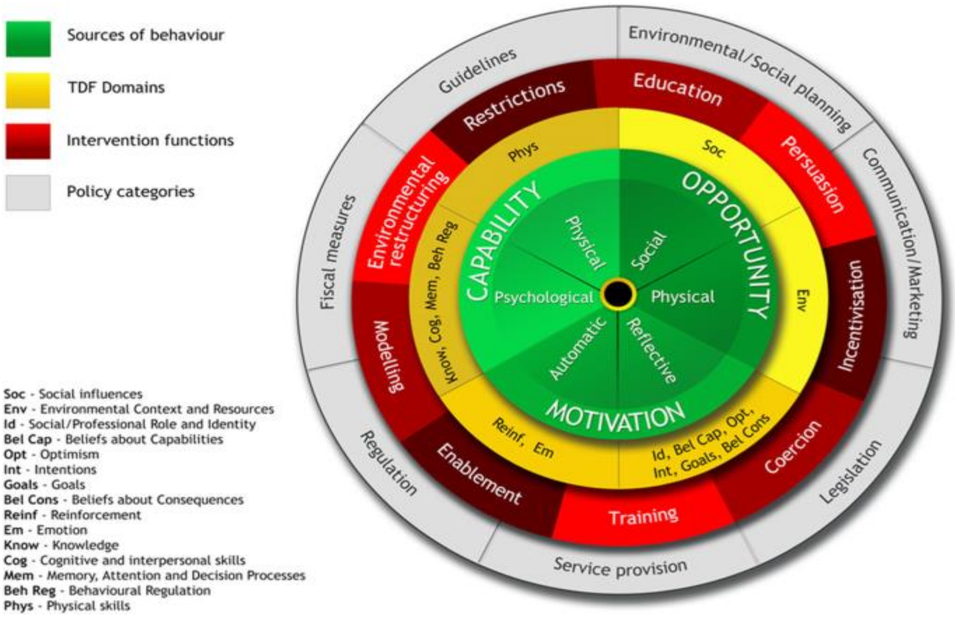
There are many theoretical frameworks in which behaviour change interventions can be based, however, it is unclear which one is the most comprehensive. The BCW aims to overcome this challenge by synthesising 19 different behaviour change frameworks (Michie et al., 2011).

7.2.1 Theoretical Framework

The BCW is an eight-step/3 stage guide to designing interventions using a theoretical approach (Michie et al, 2014). The first stage helps researchers understand, select, and specify the target behaviour. This stage also helps identity what needs to change in the person or environment in order to achieve the desired behaviour by analyzing interview/focus group data using the COM-B mode and the TDF. The TDF comprises 14 theoretical domains with each domain relating to a COM-B component and representing a range of possible theory-based facilitators and barriers to behaviour change (Michie et al, 2014). Stage 2 identifies the best intervention functions that are most likely to be effective in changing the target behaviour in context (see Chapter 6 for further information) (see Figure 7.1).

Figure 7.1

TDF domains and corresponding mapping onto the COM-B component



Michie et al. (2014)

The third stage helps identify content of the intervention by selecting the most appropriate behaviour change techniques which best serve the intervention function, such as social support and/or problem solving and identify mode of delivery such as face to face or online platform (see Methods Chapter 6 for in-depth intervention design).

The COM-B model has been used in the design of a weight management smartphone “app” for parents of overweight children. Curtis (2015) found that change was identified for “psychological capability” in that parents reported a lack of knowledge and monitoring of appropriate food portion size as well as a difficulty in the comprehension of food packaging portion guidelines and measurements of food portions. (Curtis, 2015). COM-B model was also used to develop a smart phone-based attentive eating intervention. The following COM-B components were identified as being relevant to the target behaviour; psychological capability, physical opportunity and automatic motivation. The intervention designers then used the COM-B model to design an intervention suitable delivery as a smartphone app. The intervention designers demonstrated how the COM-B model's use can be used to analyse behaviour in context as the basis for designing a smart phone app to deliver the intervention. (Robinson et al., 2013).

This intervention is informed by phase 2 behavioural diagnosis (phase 2, chapter 4), exploring barriers and facilitators to the uptake of the MIND diet. Phase 2 found that the most common barriers and facilitators to the MIND diet fell under 9 of the TDF domains (knowledge, behaviour regulation, skills, memory, attention and decision processes, environmental context and resources, social influence, belief about capabilities belief about consequences and emotion. Using the guide of the BCW (Michie et al., 2014), these TDF domains were then mapped onto intervention functions and BCTs best suited to change behaviour. These BCT's were then embedded into an online 12-week dietary intervention programme. Based on previous nutritional intervention studies, 12 weeks was shown to be adequate duration to detect change in cognitive performance (Brickman et al., 2014; Calapai et al., 2017; Krikorian et al., 2010).

According to the MRC, the first stage of an evaluation is to assess the feasibility and acceptability of an intervention. The initial stage of evaluation is important in understanding the feasibility of the intervention and enhancing its design (Moore et al., 2015). Furthermore, it is suggested that the first stage of evaluation is vital to the future effectiveness and therefore, should be conducted prior to an extended study (Sekhon

& Cartright., 2017). Process evaluation can be carried out alongside outcome evaluation using a qualitative approach to explain the outcomes (Moore et al., 2015), which can provide important insights into the fidelity of implementation of an intervention alongside the drivers of different facets of an intervention and the experiences of participants (Moore et al., 2015; Munro&Bloor, 2010). Given the aims of this chapter, it is important that an intervention designed using the BCW to promote adherence to the MIND diet is implemented, and the feasibility and acceptability explored. Furthermore, by introducing a novel diet, it is important to understand how this would impact on general quality of life and well-being. For that reason, secondary measures of mood and quality of life were included in this study. The MIND diet has previously evaluated the MIND diet and Med diet with risk of depression (Fresan et al., 2019). This study found that the Med diet and not the MIND diet, reduced the risk of clinical depression. However, Salari-Moghaddam et al. (2019) cross-sectional study, found that adherence to the MIND diet was significantly associated with a reduced risk of depression and psychological distress. The current study used measures of everyday mood (positive and negative affect) as opposed to depressive symptoms, as this study is looking at a community sample with no underlying psychiatric problems. Affect describes both the positive and negative facets of subjective well-being and has been shown to be independent of mental illness (Diener et al., 2003). Dietary patterns such as the Med diet are associated with improved mood states, improved self-reported functional health and quality of life and less depression in some studies (Beezhold et al., 2010; Govindaraja et al., 2018; Lassale et al., 2019).

7.2.2 Aim: This study aims to assess the COM-B model effectiveness to plan and implement an intervention to facilitate adherence to the MIND diet.

7.2.3 Objectives:

- To assess the effectiveness of a 12-week dietary intervention designed to promote adherence to the MIND diet in 40-55-year old's
- To assess the usefulness of a 12-week dietary intervention to increase capability, opportunity, and motivation in the uptake of the MIND diet in 40-55-year old's
- To assess the effectiveness of the MIND on the cognitive function, everyday mood, and quality of life
- To assess feasibility and acceptability of the intervention

7.3 Method

7.3.1 Design. This study employed mixed methods (Creswell & Clarke., 2003) and as such included two stages of research. In stage 1, structured interviews were used to explore the feasibility and acceptability of the intervention. The second stage was a randomised controlled prospective follow up study, employing a 3 (control Vs intervention) x 2 (baseline Vs follow up) factorial design. Outcome measures for COM-B, cognitive function, everyday mood, and quality of life were recorded for both the intervention and control groups.

7.3.2 Stage 1: Feasibility and acceptability of intervention

Outcome evaluation was achieved by determining if the MIND diet had a beneficial effect on cognitive function, everyday mood, and quality of life. This information is presented in the results section. Process evaluation looks at acceptability of the intervention to the participants and this was established by conducting individual interviews with participants, following completion of the intervention. The use of process evaluation has served to increase focus on the evaluation of the specific intervention processes and not only the outcomes. The MRC identifies the value in conducting process evaluations, and the use of interviews have been extensively used to understand the context of intervention outcomes (Aust et al., 2010).

Participants

On completion of the intervention, 6 participants from the intervention with support and 6 participants from the intervention with no support took part in interviews. Therefore, a total of 12 participants aged 40-55 years took part in post-intervention interviews.

Measures: Interviews

The interviews were guided by an interview schedule using open ended questions lasting approximately 30 mins. Interviews were recorded using a handheld recorder. The interview schedule is presented in Table 7.3, and explores participants views on the acceptability of the intervention. Questions also tapped into participants capability, opportunity and motivation in adhering to the MIND diet. These components were addressed within the intervention.

Table 7.1

Interview schedule for evaluation of intervention

Interview schedule
Capability
Knowledge:
1. To what extend did the intervention increase your knowledge of the MIND diet.
2. What is the main thing you learned for the intervention?
Skills:
1. To what extend did the intervention improve your skills in cooking eating the MIND diet foods
Behaviour regulation:
1. To what extend did monitoring your food benefit you
Memory and attention:
1. To what extend did the intervention help you develop a greater capacity to maintain mental effort regarding eating MIND diet foods:
2. To develop greater resilience against cravings
Opportunity
Environmental context and resources
1. Describe how you found doing the MIND diet programme? easy/hard?
2. Has the intervention impacted on your everyday eating habits?
3. To what extend did the intervention help you create better tools and opportunities to support you in consuming the MIND diet e.g. budget, time
4. To what extent did the intervention help you create family support in adhering to the MIND diet
Motivation
Belief about capabilities
1. To what extend did the intervention help you develop better plans for following the MIND diet guidelines
2. To what extend did the intervention motivate you to adhere to the MIND diet
Belief about consequences
1. How did eating MIND diet foods make you feel?
2. Would you continue with the MIND diet?
3. Do you feel any changes physically or mentally since following the MIND diet?
4. Any negative consequences from eating MIND diet foods
Emotion
1. To what extend did you enjoy following the MIND diet
OTHER
1. What did you like about the online platform for intervention delivery?
2. What did you not like about the online platform for intervention delivery?
3. Is there anything you would like to see included in the online system?

7.3.3 Data analyses

The data was transcribed verbatim and analysed using content analyses. Two researchers read through all the transcripts independently to identify initial codes which were then refined. All codes and relevant data extracted for the transcripts were allocated to the pre-defined themes of capability, opportunity, motivation, and acceptability of website. The analysis continued until no new themes emerged for the data. Discussion between researchers resolved any differences within the coding process.

7.3.4 Stage 2: Randomised controlled trial

Participants, recruitment and randomisation: The software program G*Power 3 (Faul et al., 2009) was used to conduct a power analysis to determine whether the sample size was sufficient to detect a difference between groups. The effect size chosen was small 0.28 and based on previous research on nutrition education and dietary intake (Shahril et al., 2013). With power set at .80, and alpha = .05, G*Power indicated that a sample size of 36 would be required. Forty-one participants took part in the study. Participants were healthy males and females aged between 40-55 years old living in Northern Ireland. An advertisement was posted around the local communities for interested people to contact the researcher. Also, a notice was posted on social media and Ulster university global email. Booklets were handed out in GAA community Centre's, over 50s club, schools, community activities such as dance classes and library. All interested participants were asked to contact the researcher by email and dates and times were arranged for baseline data collection at participant's home. Participants were emailed a participant information sheet (PIS) to gain further information on the study. All participants were asked for consent to be contacted by text for the duration of the study, for reminders to complete food charts and diaries. Participants were randomised into one of three groups (MIND diet with support, MDWS; MIND diet with no support, MDNS; control) by a random number allocation conducted by a researcher outside of the research team.

Inclusion criteria: Healthy male and female aged 40-55 living in NI

Exclusion criteria: Anyone following a specific dietary pattern (veganism, vegetarian, Atkins). Anyone on a specific diet recommended by their GP (eating disorder), specific illnesses such as high cholesterol, diabetes, heart disease, dementia.

7.3.5 Design and content of intervention

Intervention group one: MIND diet with support

This intervention was informed by the phase 2 behavioural diagnosis exploring barriers and facilitators to the uptake of the MIND diet. Phase 2 found that the most common barriers and facilitators to the MIND diet fell under 9 of the TDF domains (Knowledge, behaviour regulation, skills, memory, attention and decision processes, environmental context and resources, social influence, belief about capabilities belief about consequences and emotion. Using the guide of the BCW (Michie et al., 2014), these TDF domains were then mapped onto 6 intervention functions (education, training, modelling, enablement, environmental restructure, and restriction) and 18 BCTs best suited to change behaviour (information on health consequences, self-monitoring, instruction on how to perform behaviour, conserving mental resources, salience of consequences, social comparison, pros and cons, information on social/environmental consequences, verbal persuasion about capability, avoidance/reducing exposure for behaviour, adding objects to the environment, remove aversive stimulus, self-talk, focus on past success, social support, reward, problem solving, behaviour substitution, prompts and cues, restructuring physical environment). These BCTs were then embedded into an online 12-week dietary intervention programme. A range of resources were developed to facilitate behaviour change in the target population and optimise delivery of the BCTs which included written educational material on the MIND diet elements and the benefits of the diet, alongside recipes, self-monitoring resource and peer support. Over the 12 weeks of the intervention, each week delivered tips and advice on how to adhere to the MIND diet in different situations such as the workplace, eating out and cooking for family and friends (see Methods paper, chapter 6 for more information). Participants also received a self-monitoring chart to track their daily consumption of the MIND diet (see Appendix 17 for more detailed content of the intervention with support).

Intervention group two: MIND diet without support

Participants in the second group of the intervention did not have access to the website. Participants received information on the MIND diet elements such as, what foods to eat, how often and portion sizes. Participants also received a self-monitoring chart to track their daily consumption of the MIND diet. The self-monitoring chart and basic information containing food frequency and portion sizes for both intervention groups were in paper form. It was suggested by the researcher that the MIND diet chart be placed in a prominent place to facilitate use, for example the participants refrigerator.

Intervention: There were two intervention groups: MIND diet with support (with 12-week online support MDWS) and MIND diet no support (MDNS) and control group. Eighteen BCTs were employed in the intervention with support (see intervention map) and 2 BCT's employed in the intervention with no support, including self-monitoring and instruction on how to perform behaviour. Participants in both groups met with the researcher twice. Once at baseline to take measures and to complete a personal information form and gain body height and weight measurements, and again at follow up (12 weeks) to take final measures. Participants in the online support group were introduced to the website at baseline and asked to engage in each week of the intervention which provides advice and information on adhering to the MIND diet. To allow participants to engage and interact with each other and the researcher in the online environment, a chat room/forum was on the website for participants to log onto and the researcher to engage and monitor participants throughout the intervention period. This chat room was for social support which is one of the BCTs identified by the BCW as possibly effective for behaviour change. The MIND diet without support group were asked to follow the MIND diet for 12 weeks without the 12-week web-based support and given only the MIND diet food guidelines, portion sizes and self-monitoring resource. All participants in both intervention groups were asked to monitor their food intake by means of a food diary (7 days) in week 1 and 12 and to record their MIND diet foods daily on a chart provided. Participants received a weekly text message to remind them to complete the food chart. Twelve participants from the intervention groups took part in interviews one week after the intervention ended to evaluate the intervention and allow participants to discuss in more depth their experience of the 12-week dietary programme, what they liked and didn't like about the programme and for the researcher to better understand their experience, any difficulties participants faced and any improvements for future research.

Control group: The control group (n=12) were asked to follow their usual diet without any support but received basic information on general government dietary guidelines as set out in the ‘Eat Well Guide’ (UK Department of Health, 2016). The group were asked to complete all the same measures as the intervention group at baseline and follow up and asked to record their food intake at week 1 and 12.

7.3.6 Materials.

Cognitive function was measured using Cambridge Neuropsychological Test Automated Battery (CANTAB), which is a validated cognitive research computer software (Morris et al., 1986). The tests have brain-to-behaviour reliability (Luciana & Nelson, 2002). Recent research has applied CANTAB tests to older adults and found adequate test-retest reliability (Goncalves et al., 2016a; Goncalves et al., 2016b). Construct validity has been obtained from studies with both Alzheimer's disease and without neuropsychiatric diagnosis (Goncalves et al., 2018). CANTAB tests have demonstrated sensitivity to ageing and neurodegeneration, and include tests of working memory, learning and executive function; visual, verbal and episodic memory; attention, information processing and reaction time; social and emotion recognition, decision making and response control. Tests used for this study were spatial working memory (SWM), spatial span (SSP), pattern recognition memory (PRM) and reaction time (RTI). Responses were logged via touch screen and the average administration time was 25 minutes. Each task contained a practice component to allow participants to familiarise themselves with the CANTAB tablet.

PANAS-20 (Watson, Clark and Tellegen (1988) . Everyday mood was measured in this study with the use of the Positive and Negative Affect Schedule (PANAS), (Watson, Clark and Tellegen (1988) This scale developed to measure levels of negative affect (e.g. feelings of distress, guilt, displeasure) and positive affect (e.g. levels of enthusiasm and alertness), has been found to show good reliability and validity, (Crawford & Henry, 2004). Cronbachs alpha for positive affect range from 0-86-0.90 and for negative affect 0.84-0.87, showing high reliability. The PANAS scale was administered 4 times a day (on rising in the morning, lunch time, dinner time and before bed) for 4 days a week (2 weekdays and 2 weekend days) at baseline and at follow up, to measure mood overtime.

COM-B questionnaire: Designed by the researcher based on the most common barriers and facilitators derived from phase 1 qualitative study. The questionnaire is based on the COM-B Self-Evaluation Questionnaire V1 (Michie et al., 2014). This questionnaire is recommended to use for the intervention development process of the BCW and is applicable to a range of health behaviours and populations. The questionnaire presented 22 prespecified statements and asked participants to rate the extent they agreed with each statement (1=strongly disagree; 5=strongly agree) (table2). Cronbach's Alpha was calculated for each of the COM-B components with multiple questions. Items that affected Cronbach's alpha negatively were deleted resulting in Cronbach alpha for Capability (.657), opportunity (.527) and motivation (.630). Similar Cronbachs Alpha for COM-B components were seen in Horsch et al. (2017) and Templeton et al. (2015).

QOL: WHOQOL BREF: (Whoqol.group) assesses measure of quality of life. It consists of 24 items to assess perception of quality of life in four domains, including physical health, psychological, social relationships, and environment. Cronbach's alpha values were 0.91 for the overall scale. All values were above 0.70, and thus showed adequate internal consistency. The WHOQOL-BREF is suitable for use in New Zealand with samples from the general population (Krageloh et al., 2013)

MIND diet chart: designed by the researcher to allow participants to record their MIND diet foods daily (see Table 7.1).

Table 7. 2
Weekly food chart for self-monitoring MIND diet consumption

Date:	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Leafy greens (6/wk): Tick the box if you have eaten at least one portion=1/2 cup							
Other vegetables (1/d): Tick the box if you have eaten at least one portion ½ cup							
Berries (2/wk). Have you eaten berries today? Tick the box if you have= 1 portion=handful							
Beans and legumes (3/wk). If you have eaten a portion of beans today, tick the box. 1 portion ½ cup							
Fish (1/wk). If you have eaten a portion of fish today, tick the box							
Poultry (2/wk) If you have eaten a portion of poultry today, tick the box							
Nuts and seeds (5/wk) If you have eaten a portion of nuts today, tick the box 1 portion handful							
Whole grains (3/d) If you have eaten a portion of wholegrains today, tick the box: brown bread/rice/pasta/cereal etc.							
Olive oil as main oil: If your main cooking oil is olive oil, please tick the box each day							
Red meat (max 4/wk). Have you eaten red meat today? If so, tick the box, includes pork							
Cheese (max 1/wk). Have you eaten a portion of full fat cheese today? If so, tick the box 1 portion 1 thumb size							
Fast/fried food (max 1/wk); Tick box if you have eaten a portion of fast/fried food. If you have eaten 2 portion, tick box twice. Takeaways, deep fat fried foods, crisps etc.							
Sweets/pastries (max 5/wk). Tick box if you have eaten a portion of sweets/pastries. If you have eaten 2 portion, tick box twice.							
Butter (max 1tbsp/d). Tick the box if you have eaten none or less than a tbsp of butter. If you have eaten more than a tbsp mark with an X							

d=day, wk=week

Food diary: All participants were asked to record their food intake for a seven-day period at both baseline and week 12. Type of food as well as brand names were recorded, and portion sizes consumed were estimated using general household measures. Total energy, macronutrient and micronutrient intakes at baseline and week 12 were analysed using the dietary analysis software programme Nutritics (Nutritics, 2020). The food diary information was also used to validate the scores recorded on the MIND food chart.

MIND diet score

MIND diet score was computed from the 7-day food diaries recorded on Nutritics (Nutritics, 2020). The MIND diet has 15 dietary components including 10 food groups heathy for the brain, (green leafy vegetables, other vegetables, nuts, berries, beans, whole grains, fish, poultry, olive oil and wine) and 5 food groups unhealthy for the brain (red meats, butter and margarine, cheese, pastries and sweets, and fried/fast food). Participants received 1 point if oil was identified as their main cooking oil. For all other dietary components, each food group was assigned a score depending on the frequency of consumption (0, 0.5, 1). The total MIND diet score was calculated by summing all the 15 components. (see Table 7.3 for dietary components and scoring).

Table 7.3

MIND diet component servings and scoring

	Examples	0	0.5	1
Green Leafy Vegetables	Kale, spinach, cabbage	≤2 servings/wk	> 2 to <6/wk	≥6 servings/wk
Other Vegetables	Broccoli, carrots, potatoes, Tomatoes, onion,	<5 serving/wk	5 – <7 wk	≥1 serving/day
Berries	Blueberries, strawberries raspberries	<1 serving/wk	1 /wk	≥2 servings/wk
Nuts	Walnuts, almonds, brazil	<1/mo	1/mo – <5/wk	≥5 servings/wk
Olive Oil	Olive oil	Not primary oil		Primary oil used
Butter, Margarine	Butter, margarine	>2 T/d	1–2 /d	<1 T/d
Cheese	Cheddar,	7+ servings/wk	1–6 /wk	< 1 serving/wk
Whole Grains	Bread, pasta, rice, cereals	<1 serving/d	1–2 /d	≥3 servings/d
Fish (not fried)	Salmon, cod, tuna	Rarely	1–3 /mo	≥1 meals/wk
Beans	Kidney, butter, chickpea, black bean	<1 meal/wk	1–3/wk	>3 meals/wk
Poultry (not fried)	Chicken, turkey	<1 meal/wk	1 /wk	≥2 meals/wk
Red Meat and products	Red meat, bacon, sausages	7+ meals/wk	4–6 /wk	< 4 meals/wk
Fast Fried Foods	French fries, pizza, KFC	4+ times/wk	1–3 /wk	<1 time/wk
Pastries & Sweets	Cake, ice-cream, biscuits, chocolate	7+ servings/wk	5 −6 /wk	<5 servings/wk

Morris et al., (2015). Wk=week, mo=month, T=tablespoon, d=day

7.3.7 Procedure: Following ethical approval, participants were approached by research staff, student e-mail, social media and face to face. The invitation email/social media message contained some brief information about the study. Participants approached face to face were given a recruitment booklet on the MIND diet. All Interested participants were asked to contact the researcher by email and sent a participant information sheet (PIS) and consent form. Date and time were arranged for data collection at participant's home. Prior to week 1 of the study, all participants were asked to complete a 7-day food dairy and a 4-day mood diary (PANAS). The researcher visited each participant prior to week 1 to complete baseline measures of

CANTAB tests, QOL and COM-B questionnaire, personal information sheet, consent form and weight and height measurements. Those in the intervention groups were given written information on the MIND diet elements and portion sizes and a self-monitoring resource to (weekly chart) to monitor intake of MIND diet foods daily. The intervention with support were guided through the website with an in-depth discussion on the MIND diet, the website and what was required of them (access the website regularly to access hints and tips on how to adhere to MIND diet). The researcher sent weekly text messages to the intervention group with support only, over the 12-week intervention to remind participants to complete daily food charts and access website. The control group were given information on the eat well plate and recommended national dietary guidelines. On week 12, all participants were asked to complete food and mood dairies (PANAS) again. In the 2 weeks following the intervention, the researcher visited each participant home to collect follow-up data on QOL, COM-B, CANTAB tests and weight measurements. On this visit, 6 participants from each of the intervention groups took part in an interview to evaluate the intervention and give their views and opinions on the website and the MIND diet.

7.3.8 Data Analyses. All statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) with significance set at $P < 0.05$ throughout (IBM SPSS Statistics for Windows, version 24.0, IBM Corp, Armok NY). Prior to analyses, the data was checked for normality by first examining statistics for skewness, kurtosis and to check that the scores are normally distributed. Skewed variables (TDF: behaviour regulation; TDF: emotion; free sugars; riboflavin; folates B6) were log transformed to attain a normal distribution prior to analyses, which is common in nutrition studies (An et al., 2019; Belenchia, et al., 2013). A series of one-way

ANOVA’s were conducted to look at baseline differences in cognitive function, mood, QOL, MIND diet score, capability, opportunity, and motivation. In order to determine the effect of the 12-week dietary intervention on outcome measure, a 3(group: intervention with support vs intervention with no support vs control) X 2 (time: baseline and follow up) repeated measures ANOVA was use. Sphericity was checked and if it was supported, sphericity assumed was reported and if Box's M was significant, Greenhouse Geisser was reported (Tabachnick and Fiddell, 2007). In case of any significant between-group differences, the ANOVA was followed by pairwise between-group comparisons using the Bonferroni post hoc test to appropriately control for multiple comparisons.

7.4 Results

The results were analysed with a view to determining the participants characteristics and, the feasibility and acceptability of the dietary intervention. Stage 1 presents information the feasibility and acceptability of the intervention. Participants characteristics and outcomes variables for pre and post intervention are reported in stage 2 to explore the impact of the dietary intervention cognitive function, mood, QOL, MIND diet adherence and COM-B.

7.4.1 Results: stage 1

7.4.1.1 Participants characteristics

Twelve participants from the intervention took part in post intervention interviews. Six participants from the MIND diet with support group and six participants from the MIND diet with no support group. There were 10 females and 2 males aged between 40-55 years.

7.4.1.2 Acceptability of the intervention

Interview transcripts were analysed with a view to explore participants capability, opportunity, and motivation to adhere to the MIND diet, and to explore the acceptability of the intervention.

7.4.1.3 Capability

Knowledge

All participants reported that the intervention increased their knowledge of the MIND diet.

“ Well, I think I fully understand the Mind diet and the benefits of the MIND diet”(P22)

“I think I am very well acquainted now, certainly with the food to avoid as well as the food you should eat too” (P4)

“Well, you know what is healthy for your brain” (P26)

Not only did participants learn about the diet, they also reported increasing their knowledge of the potential benefits of the diet.

“It gave me a good education about what was health for your brain and health in general” (P48)

“ the intervention made me take more notice of dementia and diet” (P37)

Cooking skills

Many of the participants reported improving their cooking skills.

“I had to get new recipes; I definitely did learn to cook new dishes” (33)

“Well, it has improved my cooking, because I looked up recipes and then I actually tried to follow the recipe. Sometimes, I am not always great at following recipes, but I tried, and it did make me think more about what I was eating and cooking healthier” (P19)

For some participants, it was not a case of improving cooking skills, more improving diet quality.

“Well it didn’t improve my cooking, but I had to cook more, and with fresh food” (20)

“I wasn’t a bad cook to start with, but I had to cook more fresh cooking, and plan ahead” (P26)

“I would cook more from scratch, less processed stuff really, staying away from chicken goujons and doing more fresh meats” (P48)

Participants felt that adhering to the MIND diet was a matter of adding the foods into their diet and trying new foods that they would not normally eat.

“I just add more vegetables into my diet, which we eat a lot of anyway, but just adding in things like spinach, nuts, seeds, things that I probably wouldn’t have done before” (P37)

“I always thought that eating spinach would be a chore, but actually it really improved the flavour of my meals” (P22)

“So, I’ve introduced different things, like chickpeas, so I have tried different things, that I wouldn’t have only for this diet” (P20)

Self-monitoring

Self-monitoring was reported as been key to adhering to the MIND diet.

"Keeping track of the diet, well I could see written down what I was eating, it kept me aware, just mindful of what I was doing" (P4)

"It makes you mindful of what you are eating, and if you see that you are overeating, you can pull back, and also if you are making unhealthy choices, you can look at the list of foods given and the guidance and see what foods you could add in" (P48)

Participants reported that self-monitoring helped keep them on target in terms of portion sizes and frequency of foods for each week.

"Well, I suppose it just keeps you in mind about what you have eaten, what you should be eating and if you have left anything out, that you should be eating, so it was very helpful" (P48)

"It keeps you right, because I could go back and see what I hadn't had or what I needed to have" (P23)

"It keeps you on target, if you are trying to do something you need to keep reviewing, and that's what I did" (P4)

Some participants felt that self-monitoring their food made them accountable and in turn helped them adhere to the diet better.

"definitely kept me on track, cause if I am accountable for something, the I will stick to it more than if I was trying to do it myself, so I felt that having to keep a diary made me more behaved" (P23)

"I found that it was, even the fact that I was writing things down and being accountable kind of made me think twice; do I really want that biscuit?" (P22)

Participants felt that their want to meet the MIND diet food frequency target for the day or week by ticking the box on the self-monitoring form motivated them to adhere to the MIND diet.

“The temptation to have a takeaway, but I knew I was going to have to tick that box” (P22)

“The tracking, yeah, it was a case of, right you have had your bit of that, or the leafy greens, cause it was there and I wanted to tick the box, I ate it” (P20)

7.4.1.4 Opportunity

Easy diet

Most of the participants reported that the diet was relatively easy to do.

“Yes, I did find it easy, there wasn’t anything on the list I didn’t like” (P23)

“I found it manageable, I didn’t find it you know, in any way difficult” (P19)

Some participants found that some aspects of the diet were harder than others, such as reducing the unhealthy foods.

“I think the biggest problem I had was cutting out the foods I should not have been eating, I was good at adding in and I liked everything, it was more dinnertime, making a healthy dinner” (P22)

Many participants felt that their eating habits had changed.

“Before the diet, I was heavily reliant on snacking. Now I am eating breakfast which cuts out the mid-morning biscuits” (P22)

“ I do have the odd day off, but generally, my diet has completely changed” (P48)

“Whenever we went out for something to eat, instead of getting a full cooked breakfast, I got poached egg on brown toast” (P23)

Participants particularly spoke about their ability to avoid unhealthy foods for their brain.

“I stopped eating sugary foods at work, that was the main thing” (P37)

“I would have had cheese on everything, and I don’t even entertain it now” (P23)

Healthy snacks/food cravings

Participants reported that the intervention helped them swap out unhealthy snacks such as biscuits for healthier snacks such as nuts or fruit.

“I had a cup of tea with a few nuts instead of biscuits, and it was quite filling too” (P19)

“Yeah, in the evenings after my dinner, I didn’t eat a load of rubbish, I was eating some fruit instead” (P22)

Many participants felt that the foods in the MIND diet were very filling and satisfying which lead to less cravings of unhealthy food.

“We don’t be as prone to snacking or eating rubbish as the MIND diet foods are very filling, you are fuller and because of the slow energy release you don’t have the sugar cravings” (P29)

“I definitely felt less hungry and less cravings for food, I think it was because I cut out a lot of sugar” (P48)

“When I was following the diet very well, I didn’t have any cravings. I was full and satisfied, I really reduced my sugar and salt, it was really interesting” (P33)

Social/family Influence

There were mixed reports on family influence depending on family circumstances. Some of the participants were single or had adult children so family influence was not a major factor. However, those with smaller children also reported mixed results, with one participant reporting that the whole family changed their diet with tremendous results.

"all our children have considerably lost weight, they've cut out white bread, they're eating what I am eating, nobody is getting sweet stuff, my boys' acne has improved"

However, another participant felt that children were a hindrance to adhering to the MIND diet as the children wouldn't eat MIND diet foods and the participants had to make two meals and was tempted by the more convenience food in the cupboard for the kids.

"I always had to make a separate meal. If it were just me living on my own, it would have been easy, because I would have the temptation with everybody's food in the cupboard"

Interestingly, social influence was the only COM-B component that did not significantly improve in the intervention, and the chat room set up in the website for participant peer support was not accessed at all by any of the participants. Some participants felt that discussing information on a chat room was not for them.

"I am not a big sharer that takes the time to discuss hints and tips, I tend to just work away myself"

"I think some people are chatty and others aren't. For me, I am not going to say, hey, guys, I am having trouble with my tomato, or whatever"

Generally, participants reported that they would have preferred more support directly from the researcher, whether that was though texts or WhatsApp.

"I forgot about it; I think people need a lot of support through making lifestyle changes. This may have been better through a WhatsApp group messages or weekly emails highlighted the chat soon and other aspects of the website"

"I would have preferred more contact with the researcher through a WhatsApp group, I am not familiar with chat rooms"

7.4.1.5 Motivation

Plan/prepare

Participants reported that planning and preparation were key factors in adhering to the MIND diet.

"If you want to eat healthy, you have to plan" (P29)

"I knew if I wasn't going to have enough time the next day, I would make overnight oats instead of fresh oats, so it's about planning" (P22)

Participants often reported that they knew what foods they had to eat, so making sure those foods were in the house, was another key factor in adhering to the MIND diet.

"You can't come home, open the cupboard and nothing there, you have to plan when you are doing your shopping, to make sure you have your nuts, your healthy meats and stuff" (P31)

" You have to be prepared and have the foods in the house" (P26)

"In your shopping, you had to make sure you are having the MIND diet foods in, so that is obviously a good help" (P37)

Physical health

There were a range of health benefits reported by participants after consuming the MIND diet for 12 weeks. Many participants reported sleeping better and feeling less sluggish.

“I have been sleeping much better, sleeping like a log” (P33)

“If I was eating very clean, and eating very much towards the MIND diet, I felt much less sluggish” (P22)

“I track my sleep with a Fitbit, and since doing the diet, I am getting more deep sleep, I wake up feeling like I had a good night sleep”(P20)

Several participants reported that they had suffered with irritable bowel syndrome (IBS) for many years and consuming the MIND diet has drastically reduced or even eliminated IBS symptoms.

“I suffer with IBS, but I have seen a huge improvement in my digestion, like with in the first week I noticed a difference. (P31)

“I had IBS for about 5 years, this diet has completely taken it away” (P22)

This was attributed to the increase in fibre in the diet.

“I upped my wholegrains by having bread everyday along with more nuts and seeds, so this may have helped my IBS” (P31)

Some of the female participants reported that their menopausal symptoms had reduced.

“My menopausal symptoms are not nearly as bad, my hot sweats aren’t as bad, but if I eat rubbish or fried foods, I am suffering the next day” (P31)

Menopausal participants particularly noticed that their dry skin had improved significantly.

"From the menopause, my skin would be very dry, but I am just thinking, my skin is not nearly as dry now" (P31)

"From being on HRT, my skin has been terribly dry, legs, arms, everywhere. But, since doing the MIND diet, it has totally changed" (P33)

Several participants reported that following the MIND diet helped them lose weight.

"I have 2 and half stone off. I used to feel so sluggish, but that has completely changed, and I started exercising as I had more energy" (P48)

"I have lost weight, I have nearly a stone and half off" (P33)

"I have over the stone off, so I am happy" (P26)

However, most interestingly, some participants reported improvements on more serious health conditions. One participant stated that she suffers with inflammation and joint pain, and that after reducing sugar intake suggested by the MIND diet, she felt much better.

"Cutting out the sugar has definitely helped me feel better, because I had a bulging disk and was getting stiff in the joints, and I notice now after eating sugary foods, my joints are sore" (P26)

Another participant said she had high blood pressure (BP) and was waiting to go on medication. She decided to try this diet and see if it helped first. Results from her Doctor after 12 weeks found an improvement in her BP.

"*So, remember I said my BP was high, I got it checked the other day and it was lower. I don't need to go on medication at the moment, but continue to be checked"(P23)*

Another participant avoided medication for stomach issues due to the beneficial effects of the MIND diet.

"I will definitely continue the MIND diet, as I have found a solution, because before, Doctors were recommending medications for my stomach. I always kind of thought I would try this food and that, but since doing the MIND diet, that is it, that's the answer" (P22)

Enjoyable/sustainable diet

Most participants reported that they really enjoyed following the diet and that they would continue with the diet.

"I am so pleased with the changes I have had; I feel like I can continue with the diet, it's more like a lifestyle" (P20)

"I will definitely continue with the diet, especially porridge every morning and all the greens and generally not eating processed food" (P22)

Other participants reported that they would continue the diet with some modifications.

"I will absolutely continue the diet, I might adapt it a little, I may eat a little redder meat but not much" (P33)

Some participants, particularly those in their 50's, felt motivated to continue the diet as it is associated with a healthy brain and healthy ageing was important to them.

"I think knowing that you are doing something that could actually help your brain stay healthy is important, especially at our age" (P31)

"I am more inclined to think of my health now, I am terrified of getting dementia, I am very conscious of it" (P33)

Acceptability of intervention/website

In order to evaluate the intervention and assess the acceptability of the website, participants were asked what they liked about the liked and disliked about the online platform for intervention delivery. Most participants reported that it was very accessible, simple, and clearly laid out.

"I liked the way it was laid out; it was clear, and the explanation was at a level that anybody could understand, I found it helpful" (P20)

"I liked the online platform; it was very accessible" (P48)

"It was well planned out, the layout was great, it was easy to access" (P20)

When asked if they followed each week's hints and tips over the 12-week intervention period, some participants said they did not, that they mainly went on the website for initial information on the MIND diet, portion sizes and recipes.

"You know, I got the general idea of what I needed, and all the recipes and I suppose I didn't really go into it much after that" (P22)

"I just went on the face of the website, to look at recipes and stuff, I didn't go into the weekly hints"(P19)

Other participants briefly read information on the weeks tips or read over the first few weeks, but no-one read the information on all the weeks as the intervention progressed.

“I went into the weeks, and had a wee look, and looked at recipes and stuff like that, but I suppose I could have delved into it abit more” (P26)

“I did go into the weeks at the start, but I was just looking for recipes which was for motivation, after a couple of weeks I knew what I had to do” (P37)

However, some participants in both intervention groups felt that with all the knowledge and guidelines of the MIND diet, having that target of portion sizes and frequency of foods, along with the self-monitoring tool, was enough to adhere to the MIND diet.

“For me personally, the self-monitoring was enough, if I am accountable to someone, I will stick to it. I don’t think extra support would have made a difference” (P23)

“Yea I think the monitoring chart and MIND diet guidelines was enough for me, I am not a big motivational person anyway” (P22)

Although, participants reported that they liked the contact with the researcher and more reminders about the website or links to the specific aspects of the website via text may have been helpful.

“I really liked getting a wee text from you asking how I was getting on, that was lovely” (P8)

“you know you could have a link on WhatsApp, and it would direct people to information you want them to see that week” (P20)

Generally, participants were happy with the website, but suggested that something that is quick and easy to read would be helpful.

“Sometimes you are just so busy, I like pictorials, like pop ups, something quick and easy”(P26)

"I think if something only took a few minutes, you are more inclined to do it" (P37)

7.4.2 Stage 2: Participants characteristics

Sample characteristics are presented in Table 7.4. The mean age of participants was 45.5 years. There were more women than men recruited onto the study (62.5%). A large percentage of the participants were professional (58.5%), married (70%), with a higher education (56%), and earning over £50,000 a year (32%).

Table 7.4

Participants characteristics by group

Demographic information	Intervention 1 N=15	Intervention 2 N=14	Control N=12
Age (M)	46	45.5	42.5
Gender %			
Male	14	50	50
Female	86	50	50
Occupation%			
Professional	46	60	20
Skilled	27	12	7
Unskilled	27	14	2
Retired	0	14	0
Unemployed	0	0	0
Income%			
Under £10,000	6	15	0
£10-20,000	0	0	17
£20-30, 000	19	20	17
£30-40,000	33	15	41
£40-50,000	14	6	0
Over £50,000	28	44	25
Marital status %			
Married	83	67	83
Co-habit	0	6	0
Separated	0	6	0
Widowed	0	15	0
single	17	6	17
Education %			
Primary	6	15	34
Secondary	6	21	0
Further education	20	6	24
Higher education	68	58	42

Note: descriptive information on age, occupation, income, marital status, and education were computed to identify participants characteristics. M=mean, %= percentage, n=number (n=41)

7.4.3 Exploring group differences at baseline

A series of one-way ANOVA's were conducted to compare baseline differences for all groups for mood, QOL, cognitive function, TDF and COM-B components, and MIND diet score. The groups did not differ on any of the measures except for TDF domain belief about capabilities (p=0.006), showing a higher mean score for the intervention without support group (see Table 7.5).

A series of one-way ANOVA's were conducted to compare baseline differences for all groups for all nutrients (energyKCal, energy (kj), carbohydrates, protein, fat, fibre, sugar, free sugar, saturated fat, poly-saturated fat, omega 3, omega 6, sodium, calcium, iron, zinc, iodine, vitamin A, vitamin D, vitamin B12, vitamin C, riboflavin, vitamin B6, folates B9). The groups did not differ in any measures except for fibre (p=0.033), showing a higher mean score for the intervention with support group (see Table 7.6).

Table 7.5

Mean scores and standard deviations for mood, quality of life, MIND diet score and COM-B components for control and intervention (MIND diet with support/MIND diet no support) groups at baseline for 40-55-year olds

Variable	Min score	Max score	Intervention with support	Intervention without support	Control	f	DF	P
PA	10	50	23.42 (4.92)	25.05 (5.27)	25.01 (4.98)	.487	2,38	.618
NA	10	50	11.45 (1.52)	2,29 (2.98)	11.04 (1.36)	1.217	2,38	.307
QOL: Environment	8	40	32.73 (3.88)	32.00 (5.05)	31.14 (4.43)	.226	2,38	.798
QOL: Physical	7	35	27.26 (3.63)	29.07 (4.58)	30.58 (2.71)	2.622	2,38	.086
QOL: Psychological	6	30	20.80 (2.95)	22.28 (3.49)	22.33 (2.99)	1.594	2,38	.216
QOL: Social	3	15	10.53 (2.29)	11.50 (2.02)	11.83 (1.46)	1.082	2,38	.349
MIND score	0	14	6.46 (1.15)	6.71 (2.18)	7.16 (1.60)	.577	2,38	.566
TDF: Knowledge	2	10	2.80 (0.94)	3.28 (1.20)	2.58 (1.08)	1.478	2,38	.241
TDF: Behaviour regulation	2	10	4.26(2.18)	4.00(2.148)	3.833(.717)	.187	2,38	.831
TDF: Memory/attention	2	10	5.53 (1.92)	6.28 (1.32)	5.50 (1.38)	1.080	2.38	.350
TDF: Skills	2	10	7.26 (1.94)	7.92 (2.26)	7.83 (1.69)	.463	2.38	.633
TDF: Resources &context	4	20	11.13 (2.50)	12.92 (3.12)	11.75 (2.89)	1.478	2,38	.241
TDF: Social influence	2	10	4.13 (1.92)	4.92 (2.58)	3.66 (2.26)	1.043	2,38	.362

TDF: Belief about capability	4	20	10.80 (1.56)	11.92 (2.36)	9.50 (1.16)	5.919	2,38	**.006**
TDF: Belief about consequences	4	20	11.46 (1.35)	12.28 (1.85)	11.50 (2.23)	.903	2,38	.414 .
TDF: Emotion	2	10	6.20(0.77)	6.42(1.08)	6.16(0.38)	.413	2,38	665
PRMMCLI	n/a	n/a	1602.07 (254.87)	1467.19 (182.19)	1521.39 (303.62)	1.078	2,38	.351
SSPFSL	n/a	n/a	6.06 (1.43)	6.21(0.89)	6.25(1.71)	.070	2,38	.932
SWMTE468	n/a	n/a	10.73 (8.20)	11.21(10.44)	16.58(12.39)	1.264	2,38	.294
RTIFMRT	n/a	n/a	405.68(39.30)	403.19(48.72)	400.64(39.37)	.046	2,38	.955

PA=positive affect, NA=negative affect, QOL=quality of life, PRMMCLI=Pattern Recognition Memory: Mean Correct Latency, SSPFSL=Spatial Span: Forward Span Length, SWMTE468=Spatial Working Memory: Total Errors, RTIFMRT=Reaction Time Task: Mean Five Choice Reaction Time. Significant results are presented in bold, n=41

Table 7.6

Mean scores and standard deviations for all nutrients for control and intervention (MIND diet with support/MIND diet no support) groups at baseline for 40-55-year olds

Variable	Intervention with support	Intervention no support	Control	f	DF	P
Energy/Kcal	1682(399)	1552(352)	1537(318)	.680	2,38	.513
Energy (Kj)	7057(1683)	6522(1478)	6449(1332)	.676	2,38	.515
Carbohydrate(g)	183(52)	175(49)	152(40)	1.406	2,38	.258
Protein (g)	76(21)	73(49)	75(14)	.098	2,38	.906
Fat(g)	67(16)	57(14)	61(18)	1.376	2,38	.265
Fibre(g)	18(5)	15(4)	13(3)	3.748	2,38	**.033**
Sugars(g)	64(25)	68(26)	48(23)	2.166	2,38	.129
Free sugars*(g)	22(11)	28(16)	22(22)	.623	2,38	.542
Saturated fat (g)	22(6)	21(7)	21(6)	.289	2,38	.751
Poly-unsaturated fat	10(3)	8(4)	9(3)	1.399	2,38	.259
Omega n3(mg)	0.9(0.4)	0.9(0.5)	0.6(0.3)	1.320	2,38	.279
Omega 6(g)	5.2(2.3)	3.6(2.8)	3.1(1.6)	3.015	2,38	.061
Sodium(mg)	1863(556)	1768(535)	1756(453)	.178	2,38	.838
Calcium(mg)	629(211)	676(233)	695(241)	.302	2,38	.741
Iron 9mg)	9(3.5)	9(3.5)	7(2)	2.581	2,38	.089
Zinc(mg)	7.6(2.3)	7.5(2.3)	7.3(2.3)	.091	2,38	.913
Iodine(mcg)	108(60)	115(37)	116(45)	.118	2,38	.889
Vitamin A(ug)	694(484)	602(333)	542(310)	.519	2,38	.600
Vitamin D*(ug)	2.3(1.9)	2.7(1.3)	2.6(1.4)	.274	2,38	.762
Riboflavin B2* (mg)	1.4(0.5)	1.4(0.4)	1.3(0.5)	.197	2,38	.822
Vitamin B6(mg)	1.7(0.5)	1.7(0.3)	1.3(0.3)	2.974	2,38	.063

Folates B9*(ug)	223(73)	233(59)	179(56)	2.040	2,38	.144
Vitamin B12(ug)	3.7(2.3)	4.2(1.7)	4.1(1.5)	.233	2,38	.793
Vitamin C(mg)	70(49)	71(38)	42(32)	2.009	2,38	.148

N=41

7.4.4 Intervention effects on outcome variables

In order to determine if there is a significant difference on mean scores on cognitive function, mood, QOL, MIND diet score and nutritional information over time (baseline to follow up), between the control and intervention groups, and interactions between group and time, a 3 (control Vs intervention (MIND diet with support) Vs intervention (MIND diet no support) x 2 (baseline Vs follow up) repeated measures factorial analysis of variance was conducted (see Table 7.7 and 7.8). A series of graphs were plotted to show the time by group interaction for positive affect (see Figure 7.2) physical quality of life (see Figure 7.3) MIND diet score, TDF knowledge, memory/attention, behaviour regulation, belief about capabilities, belief about consequences, skills, environmental context and resources and emotion (see Figure 7.4 A-I). A further series of graphs were plotted to show either time or group effects for carbohydrates, sugar, free sugar, and saturated fat and vitamin A (see Figure 7.5 A-E, vitamin b6, 9, and iron (see Figure 7.6 A-C), and vitamin C, fibre, and omega 6 (see Figure 7.7 A-C).

7.4.4.1 Time effects (differences in mean scores overtime for all groups)

There is an increase in mean scores over time (baseline to post intervention) across all 3 group for positive effect, MIND diet score, all TDF components, fibre, NSP, omega 6, vitamin A and vitamin C ($p<0.05$) (see Table 7.7 and 7.8). There was a decrease in mean scores over time across all 3 groups for spatial working memory, carbohydrate, sugars, free sugar, and saturated fat (p<0.05). (See Table 7.7 and 7.8)

7.4.4.2 Group effects (differences in mean scores between groups)

There was a difference in mean scores between groups for MIND diet score and all TDF components: Knowledge, behaviour regulation, memory and attention, environmental context and resources, belief about capabilities, belief about consequences and emotion (p<.05). Post hoc tests showed that for all the above variables, there was a significant difference in mean scores between both intervention groups and the control group, with mean scores being higher in the intervention groups than the control group (p<0.05). However, no significant difference was shown between the two intervention groups. (see Table 7.7)

There was a difference in mean scores between groups for fibre, NSP, omega 6, iron, vitamin B6, folates B9 and vitamin C (p<0.05). Post hoc tests show that there was a significant difference between MIND diet with support group and the control group for fibre, NSP, omega 3, vitamin B6 and vitamin C, with mean scores being higher in the MIND diet with support group (p<0.05). No significant difference was shown between the two intervention groups for these nutrients.

Post hoc tests also showed a mean difference in scores between both intervention groups and the control group for iron and folates B9, with mean score being higher in the intervention groups than the control group (p<0.05). No significant difference shown between the two intervention grou0s and the control group. (see Table 7.8).

7.4.4.3 Time by group interaction

There are significant interaction effects for PA, physical quality of life, MIND diet scores and all the TDF components except for Social Influences ($p<0.05$). This shows that compared to the control group, the intervention groups at completion of the dietary intervention showed an increase in mean scores for PA, physical quality of life, MIND diet consumption and increase capability, opportunity and motivation towards adherence to the MIND diet (See Table 7.7). There were no significant interaction effects for time by group for any of the individual nutrients.

Table 7.7 *Pre and post mean scores and standard deviations for intervention groups and control group mood, QOL, MIND diet score and COM-B components*

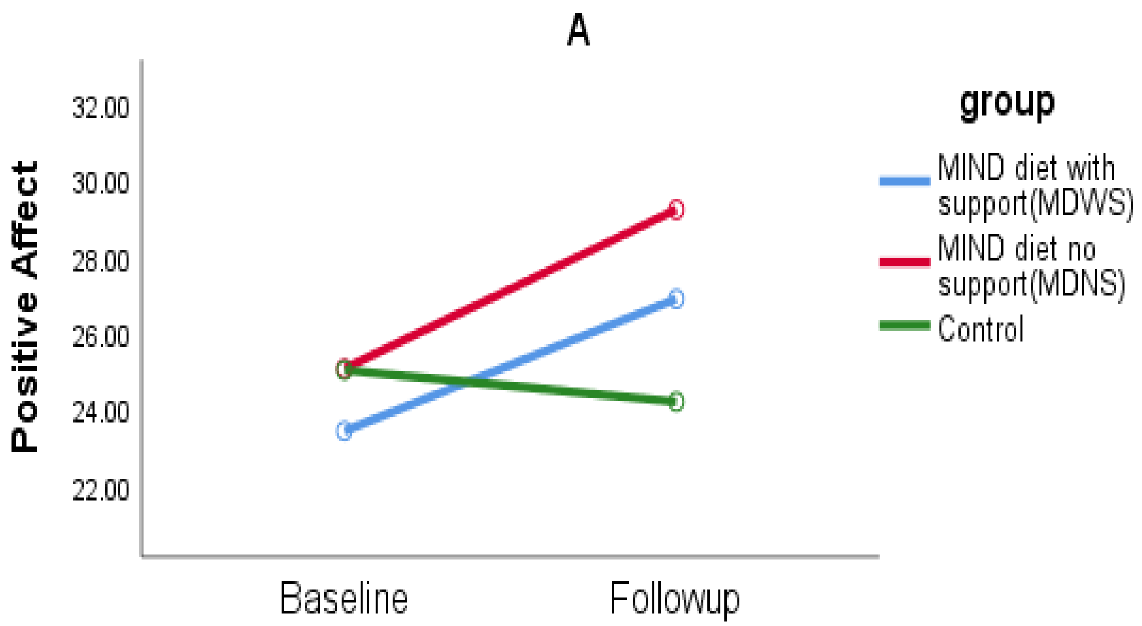
Variable	Baseline Mean(sd)			Follow-up Mean (sd)			Time	Group	TimexGroup Interaction
	MDWS	MDNS	CONTROL	MDWS	MDNS	CONTROL			
PA	23.42 (4.92)	25.05 (5.27)	25.01 (4.98)	26.88 (5.63)	29.22 (6.48)	24.18 (4.40)	F $^{(2,38)}$ =7.488, p=**0.009**, n_p^2 =1.66	F(2,38)= 1.109, p=0.340, n_p^2 = 0.55	F(2,38)=3.326, p=**0.047**, n_p^2 = 1.49
NA	11.45 (1.52)	12.29 (2.98)	11.04 (1.36)	11.58 (2.20)	12.40 (3.26)	11.36 (1.91)	F$^{(2,38}$)=.191, p= .665, n_p^2 = .005	F$^{(2,38}$)= 1.283, p=.289, n_p^2 = .001	F$^{(2,38}$)=.023, p=.977, n_p^2 =.001
QOL: Environment	32.73 (3.88)	32.00 (5.05)	31.14 (4.43)	33.20 (4.14)	32.00 (4.70)	32.16 (4.24)	F$^{(2,38}$)=.477, P=.494, n_p^2 =.012	F$^{(2,38}$)= .297, p=.745, n_p^2 = .015	F$^{(2,38}$)= .885, p=.885, n_p^2 =.006
QOL: Physical	27.26 (3.63)	29.07 (4.58)	30.58 (2.71)	29.20 (2.45)	29.57 (2.40)	29.58 (3.62)	F$^{(2,38)}$)=1.354, P=.252, n_p^2 =.034	F$^{(2,38}$)=1.250, p=.298, n_p^2 =.062	F$^{(2,38}$)=4.196, p**=.023**, n_p^2 =.181
QOL: Psychological	20.80 (2.95)	22.28 (3.49)	22.33 (2.99)	22.46 (2.97)	23.35 (3.05)	22.25 (2.89)	F$^{(2,38}$)=6.261, P=.17, n_p^2 =.141	F$^{(2,38}$)=.630, p=.538, n_p^2= .032	F$^{(2,38}$)=2.038, p=.144, n_p^2 =.097
QOL: Social	10.53 (2.29)	11.50 (2.02)	11.83 (1.46)	11.53 (2.26)	11.57 (2.27)	11.83 (1.89)	F$^{(2,38}$)=2.629, p=.113, n_p^2= .065	F$^{(2,38}$)=.581, p=.564, n_p^2=.030	F$^{(2,38}$)=2.238, p=.121, n_p^2=.105
MIND score	6.46 (1.15)	6.71 (2.18)	7.16 (1.60)	11.50 (1.62)	10.42 (1.85)	6.66 (1.73)	F$^{(2,38}$)=90.081, p**< .001,** n_p^2 =.703	F$^{(2,38}$)=7.368, p=**.002**, n_p^2 =.279	F$^{(2,38}$)=31.684, p**< .001**, n_p^2 =.625
TDF: Knowledge	2.80 (0.94)	3.28 (1.20)	2.58 (1.08)	10.00 (0.00)	10.00 (0.00)	3.41 (2.35)	F$^{(2,38}$)=410.50, p< .**001,** n_p^2 =.915	F$^{(2,38)}$=67.188, p<.**001,** n_p^2 =.780	F$^{(2,38)}$=67.06, p<.**001**, n_p^2 =.779
TDF: behaviour regulation*	4.26 (2.18)	4.00 (2.14)	3.83 (.717)	9.93 (.25)	9.57 (1.34)	4.16 (2.03)	F$^{(2,38)}$)=77.16, p<.**001**, n_p^2 =.670	F$^{(2,38)}$=14.001, P<.**001**, n_p^2 =.425	F$^{(2,38)}$=17.100, p< .**001**, n_p^2=.474
TDF: Memory/attention	5.53 (1.92)	6.28 (1.32)	5.50 (1.38)	8.93 (1.22)	8.28 (1.20)	6.25 (1.65)	F$^{(2,38)}$=49.229,p<.**001**, n_p^2=.564	F$^{(2,38)}$=6.20, p=.**005**, $n^{p}{}_{2}$=.246	F$^{(2,38)}$=6.812, p=.**003**, n_p^2=.264
TDF: Skills	7.26 (1.94)	7.92 (2.26)	7.83 (1.69)	9.66 (0.89)	9.14 (1.70)	7.66 (1.77)	F$^{(2,38)}$)=24.39, p<.**001**, n_p^2=.391	F$^{(2,38)}$=.945, P=0.398, n_p^2=.047	F$^{(2,38)}$=9.98, p<**.001**, n_p^2=.344
TDF: Resources/context	11.13 (2.50)	12.92 (3.12)	11.75 (2.89)	17.33 (2.49)	17.85 (2.03)	12.91 (3.31)	F$^{(2,38)}$=70.69, p< .**001**, n_p^2=.650	F$^{(2,38)}$=6.024, p=.**005**, n_p^2=.241	F$^{(2,38)}$=9.189, p=.**001**, n_p^2=.326

TDF: Social influence	2.13 (1.24) 2.07 (1.26) 1.58 (0.99)	3.46 (1.30) 2.85 (1.23) 2.16 (1.46)	$F(^{2,38})$=9.89, p=.**003**, $n_p{}^2$=.207	$F(^{2,38})$=3.81, p=.**031**, $n_p{}^2$=.167	$F(^{2,38})$=.626, p=.540, $n_p{}^2$=.032
TDF: Belief about capability	6.33 (1.63) 7.28 (2.61) 6.25 (1.42)	12.60 (2.16) 12.21 (3.01) 7.08 (2.84)	$F(^{2,38})$=50.51, p<.**001**, $n_p{}^2$= .571	$F(^{2,38})$=15.97, p< .**001**, $n_p{}^2$=.457	$F(^{2,38})$=8.021, p=.**001**, $n_p{}^2$=.297
TDF: Belief about consequences	11.46 (1.35) 12.28 (1.85) 11.50 (2.23)	18.33 (2.28) 18.14 (1.70) 12.91 (3.42)	$F(^{2,38})$=116.572, p<.**001**, $n_p{}^2$=.754	$F(^{2,38})$=12.066, p<.**001**, $n_p{}^2$=.388	$F(^{2,38})$=13.969, p<.**001**, $n_p{}^2$=.424
TDF: EMOTION*	6.20 (.77) 6.42 (1.08) 6.16 (.389)	9.66 (1.04) 9.85 (.363) 6.66 (1.55)	$F(^{2,38})$=62.05, p<.**001,** $N_p{}^2$=.620	$F(^{2,38})$=9.801, p<**.001** $N_p{}^2$=.340	$F(^{2,38})$=4.85, p=.**013** $N_p{}^2$=.203
PRMMCLI	1602.07 (254.87) 1467.19 (182.99) 1521.39 (303.62)	1514.10 (222.47) 1452.10 (249.88) 1654.08 (317.07)	$F(^{2,38})$=.048, P=.828, $n_p{}^2$=.001	$F(^{2,38})$=1.348, p=.272, $n_p{}^2$=.066	$F(^{2,38})$=1.984, p=.151, $n_p{}^2$=.095
SSPFSL	6.06 (1.43) 6.21 (.89) 6.25 (1.71)	5.86 (.83) 6.42 (1.28) 6.25 (1.71)	$F(^{2,38})$=.001, p=.980, $n_p{}^2$=.000	$F(^{2,38})$=.363, p=.698, $n_p{}^2$=.019	$F(^{2,38})$=.41, p=.63, $n_p{}^2$=.02
SWMTE468	10.73 (8.20) 11.21 (10.44) 16.58 (12.39)	8.13 (7.98) 8.07 (8.63) 10.33 (11.08)	$F(^{2,38})$=8.51, p=.**006**, $n_p{}^2$=.183	$F(^{2,38})$=.856, p=.433, $n_p{}^2$=.043	$F(^{2,38})$=.653, p=.526, $n_p{}^2$=.033
RTIFMRT	405.68 (39.30) 403.19 (48.72) 400.64 (39.37)	413.27 (51.09) 419.04 (56.79) 404.52 (26.86)	$F(^{2,38})$=1.629, p=.210, $n_p{}^2$=.041	$F(^{2,38})$=.170, p=.845, $n_p{}^2$=.009	$F(^{2,38})$=.240, p=.788, $n_p{}^2$=.012

PA=positive affect, NA=negative affect, QOL=quality of life, PRMMCLI=Pattern Recognition Memory: Mean Correct Latency, SSPFSL=Spatial Span: Forward Span Length, SWMTE468=Spatial Working Memory: Total Errors, RTIFMRT=Reaction Time Task: Mean Five Choice Reaction Time. Significant results are presented in bold. *=log transformed.

Figure 7.2

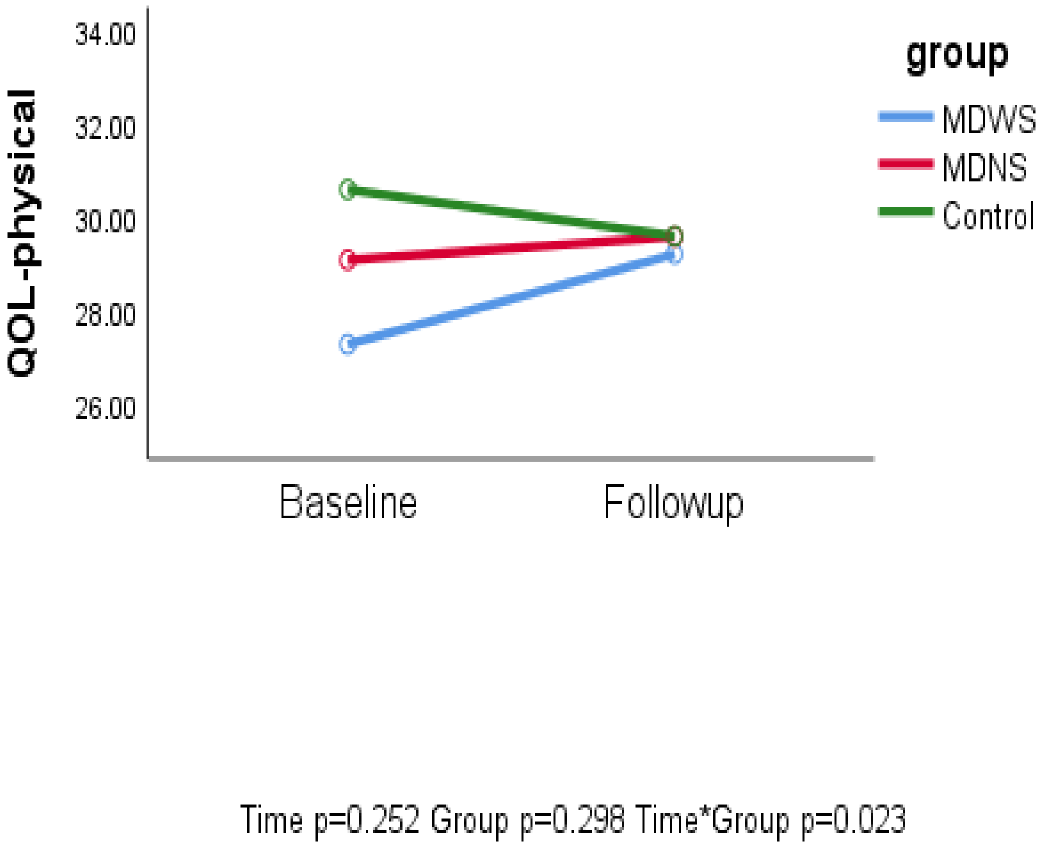
Interaction for time and group for positive affect showing that there is an increase in mean scores for both intervention groups and no change in the control group over 12 weeks. Group 1=MIND diet with support, Group 2=MIND diet no support, Group 3= Control group.



Time p=0.009 Group p=0.340 Time*Group p=0.047

Figure 7.3

Interaction for time and group for physical quality of life, showing significant improvement for MIND diet with support group (MDWS) n=15, but not for MIND diet with no support (MDNS)n=14 or control n=12 over 12 weeks.



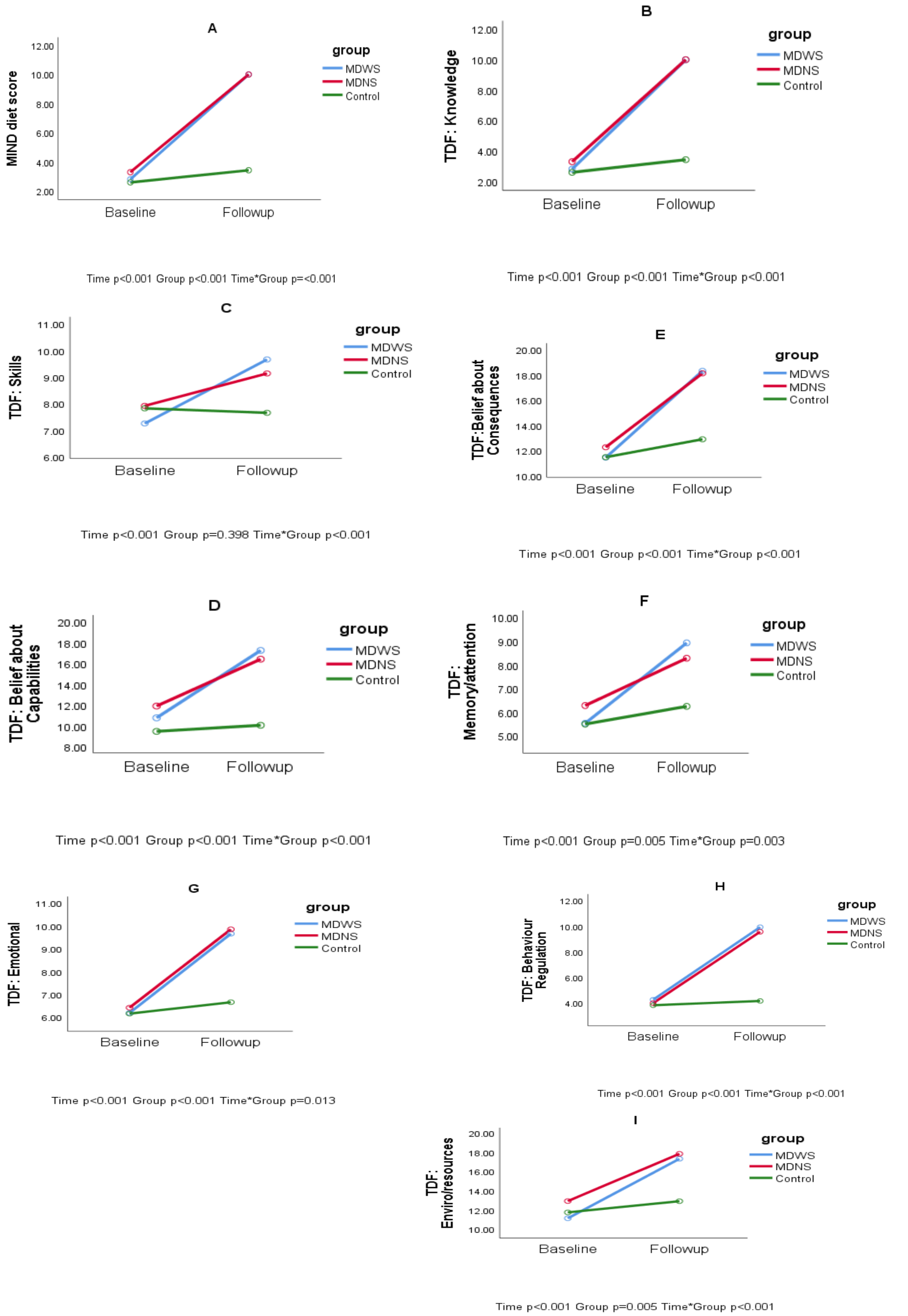


Figure 7.4 A-I: Interaction for time and group for TDF components and MIND diet score A-I shows that there is a significant improvement in the above variables for both intervention groups but no change in the control group. No significant difference between intervention groups. MIND diet with support n=15(MDWS), MIND diet no support n=14(MDNS) control n=12

Table 7.8 *Pre and post mean scores and standard deviations for intervention groups and control group for micro/macro nutrients*

Variable	Baseline Mean(SD)			Follow-up Mean (SD)			Time	Group	TimexGroup Interaction
	MDWS	MDNS	Control	MDWS	MDNS	Control			
EnergyKcal	1682 (399)	1552 (352)	1537 (318)	1504 (326)	1440 (417)	1495 (437)	F (^{2,38}) =3.939,p=0.054, n_p^2 =.094	F(^{2,38})= 0.339, p=0.714, n_P^2 = 0.018	F(^{2,38})=0.484, p=0.620, n_p^2 = 0.025
Energy (Kj)	7057 (1683)	6522 (1478)	6449 (1332)	6313 (1372)	6050 (1745)	6276 (1831)	F (^{2,38}) =3.908,p=0.055, n_p^2 =.093	F(^{2,38})= 0.333, p=0.719, n_P^2 = 0.017	F(^{2,38})=0.487, p=0.618, n_p^2 = 0.025
Carbohydrate(g) **-as %energy**	183(52) 44(5.5)	175(49) 45(5)	152(40) 40(6)	149(46) 39(7)	158(43) 44(7)	56(52) 42(4)	F (^{2,38}) =5.010 ,p=**0.031**, n_p^2 =0.116	F(^{2,38})= 0.342, p=0.713, n_P^2 = 0.017	F(^{2,38})=2.317, p=0.112, n_p^2 = 0.018
Protein (g) **- as %energy**	76(21) 18(3)	73(16) 19(4)	75(14) 20(4.5)	83(25) 22(5)	74(20) 21.5(7)	73(14) 20(3.5)	F (^{2,38}) =0.464 ,p=**0.500,** n_p^2 =0.012	F(^{2,38})=0.521, p=0.598, 00 n_p^2 = 0.027	F(^{2,38})=0.773, p=0.469, n_p^2 = 0.039
Fat(g) **- as %energy**	67(16) 36.5(5)	57(14) 33(5)	61(18) 35.5(5.5)	62(16) 37.5(7)	54(21) 33(5.5)	60(21) 35.5(5)	F(^{2,38})=1.311, p=0.259, n_p^2 = 0.033	F(^{2,38})=1.192, p=0.315, n_p^2 = 0.059	F(^{2,38})=0.115, p=0.892, n_p^2 = 0.006
Fibre(g)	18(5)	15(4)	13(3)	21(5)	18(6)	13(3)	F(^{2,38})=4.939, p=**0.032**, n_p^2 = 0.115	F(^{2,38})=7.765, p=**0.001**, n_p^2 = 0.290	F(^{2,38})=1.008, p=0.374, n_p^2 = 0.050
Sugars(g)	64(25)	68(26)	48(23)	55(26)	53(20)	48(25)	F(^{2,38})=6.193, p=**0.017**, n_p^2 = 0.140	F(^{2,38})=1.286, p=0.288, n_p^2 = 0.063	F(^{2,38})=1.366, p=0.267, n_p^2 = 0.067
Free sugars*(g)	22(11)	28 (16)	22(22)	13(9)	17(12)	23(24)	F(^{2,38})=9.146, p=**0.004**, n_p^2 = 0.194	F(^{2,38})=0.618, p=0.545, n_p^2 =.031	F(^{2,38})=2.893, p=0.068, n_p^2 = .132
Saturated fat **(g)**	22(6)	21(7)	21(6)	18(6)	18(7)	19(8)	F(^{2,38})=6.758, p=**0.013**, n_p^2 = 0.151	F(^{2,38})=0.103, p=0.903, n_p^2 = 0.005	F(^{2,38})=0.488, p=0.618, n_p^2 = 0.025
Poly- **unsaturated fat**	10(3)	8(4)	9(3)	12(5)	9(4)	9(3)	F(^{2,38})=1.274, p=0.266, n_p^2 = 0.032	F(^{2,38})=2.879, p=0.069, n_p^2 = 0.132	F(^{2,38})=0.413, p=0.664, n_p^2 = 0.021
Omega n3(mg)	0.9(0.4)	0.9(0.4)	0.6(0.3)	1.3(1.4)	1(0.7)	0.6(0.2)	F(^{2,38})=1.29, p=0.264, n_p^2 = 0.033	F(^{2,38})=2.328, p=0.111, n_p^2 = 0.109	F(^{2,38})=0.588, p=0.577, n_p^2 = 0.029
Omega 6(g)	5.2(2.3)	3.6(2.8)	3.1(1.6)	7.2(4.6)	4.6(3.3)	4.0(1.7)	F(^{2,38})=5.709, p=**0.022**, n_p^2 = 0.131	F(^{2,38})=4.315, p=**0.020**, n_p^2 = 0.185	F(^{2,38})=0.412, p=0.665, n_p^2 = 0.021
Sodium(mg)	1863 (556)	1768 (535)	1756 (453)	1618 (466)	1608 (539)	1731 (451)	F(^{2,38})=2.492, p=0.123, n_p^2 = 0.062	F(^{2,38})=078, p=0.925, n_p^2 = 0.004	F(^{2,38})=0.481, p=0.622, n_p^2 = 0.025
Calcium(mg)	629(211)	676(233)	695(241)	643(233)	653(208)	671(319)	F(^{2,38})=0.065, p=0.801, n_p^2 = 0.002	F(^{2,38})=0.198, p=0.821 ,n_p^2 = 0.010	F(^{2,38})=0.084, p=0920., n_p^2 = 0.004

Iron 9mg)	9(3.5)	9(3.5)	7(2)	10(2,4)	10 (2.2)	7(2.6)	$F(^{2,38})$=1.025, p=0.318, n_p^2 = 0.026	$F(^{2,38})$=4.771, p**=0.014**, n_p^2 = 0.201	$F(^{2,38})$=0.468, p=0.630, n_p^2 = 0.024
Zinc(mg)	7.6(2.3)	7.5(2.3)	7.3(2.3)	7.8(2)	8.4(2.2)	7.5(2.4)	$F(^{2,38})$=1.630, p=0.209, n_p^2 = 0.041	$F(^{2,38})$=0.335, p=0.718, n_p^2 = 0.017	$F(^{2,38})$=0.397, p=0.675, n_p^2 = 0.020
Iodine(mcg)	108(60)	115(37)	116(45)	98(31)	114(46)	103(61)	$F(^{2,38})$=0.772, p=0.385, n_p^2 = 0.020	$F(^{2,38})$=0.339, p=0.717, n_p^2 = 0.018	$F(^{2,38})$=0.156, p=0.856, n_p^2 = 0.008
Vitamin A(ug)	694(484)	602(333)	542(310)	891(245)	790(351)	683(388)	$F(^{2,38})$=8.032, p=**0.007**, n_p^2 = 0.174	$F(^{2,38})$=1.195, p=0.314, n_p^2 = 0.059	$F(^{2,38})$=0.079, p=0.925, n_p^2 = 0.004
Vitamin D*(ug)	2.3(1.9)	2.7(1.3)	2.6(1.4)	3(2.8)	2.8(1.2)	2.6(1.7)	$F(^{2,38})$=.953, p= .335, n_p^2 = .024	$F(^{2,38})$=.831, p= .443, n_p^2 = .042	$F(^{2,38})$= 1.283, p=.289, n_p^2 = .063
Riboflavin B2* (mg)	1.4(0.5)	1.4(0.4)	1.3(0.5)	2.3(3.9)	1.3 (0.3)	1.2(0.4)	$F(^{2,38})$= .048, p= .828, n_p^2 = 0.001	$F(^{2,38})$=1.161, p=.324, n_p^2 = .058	$F(^{2,38})$= .918, p=.408 , n_p^2 = .046
Vitamin B6(mg)	1.7(0.5)	1.7(0.3)	1.3(0.3)	1.8(0.6)	1.5(0.3)	1.3(0.3)	$F(^{2,38})$=0.080, p=0.779, n_p^2 = 0.002	$F(^{2,38})$=4.55, p=**0.017**, n_p^2 = 0.193	$F(^{2,38})$=0.526, p=0.595 ,n_p^2 = 0.027
Folates B9*(ug)	223(73)	233(59)	179(56)	251(71)	246(67)	169(53)	$F(^{2,38})$= 1.351, p=.252, n_p^2 = .034	$F(^{2,38})$=5.056, p=**.011**, n_p^2 = .210	$F(^{2,38})$= .911, p=.411, n_p^2 = .046
Vitamin B12(ug)	3.7(2.3)	4.2(1.7)	4.1(1.5)	3.5(1.6)	4.2(1.8)	4.1(2.1)	$F(^{2,38})$=0.030, p=0.864, n_p^2 = 0.001	$F(^{2,38})$=0.545, p=0.584, n_p^2 = 0.028	$F(^{2,38})$=0.037, p=0.964, n_p^2 = 0.002
Vitamin C(mg)	70(49)	71(38)	42(32)	113(61)	83(55)	48(26)	$F(^{2,38})$=9.616, p=**0.004** ,n_p^2 = 0.202	$F(^{2,38})$=4.160, p=**0.023** ,n_p^2 = 0.180	$F(^{2,38})$=3.017, p=0.061, n_p^2 = 0.137

Significant results are presented in bold. *=log transformed

Figure 7.5

A-E shows significant mean difference for Time for carbohydrate, sugars, free sugars, saturated fat, and vitamin A from baseline to follow-up (12 weeks). MIND diet with support n=15 (MDWS), MIND diet no support n=14 (MDNS), control n=12

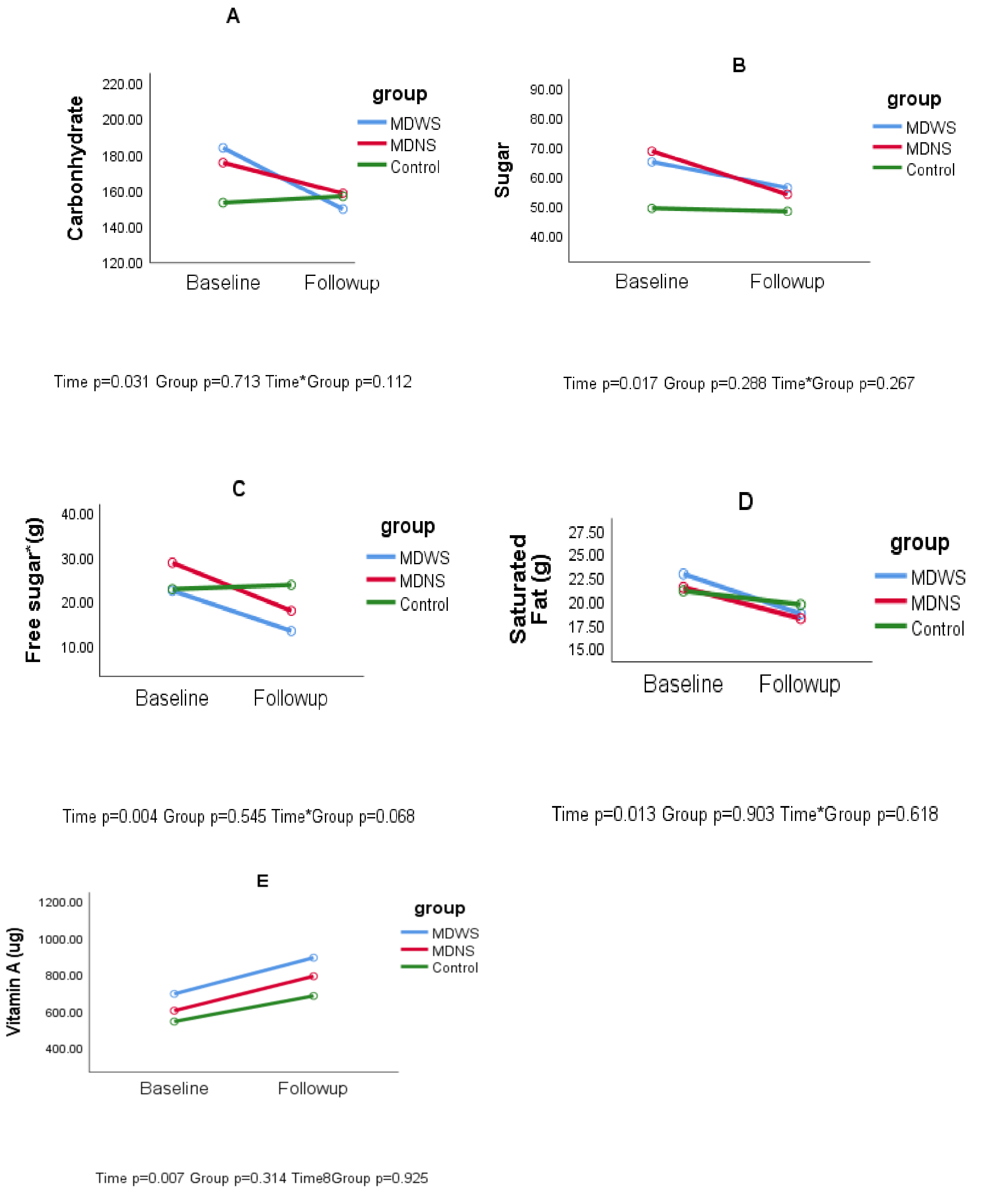


Figure 7.6

A-C shows significant mean difference for Group for iron, vitamin B6 and folates B9 from baseline to follow-up (12 weeks). MIND diet with support n=15 (MDWS), MIND diet no support n=14 (MDNS), control n=12

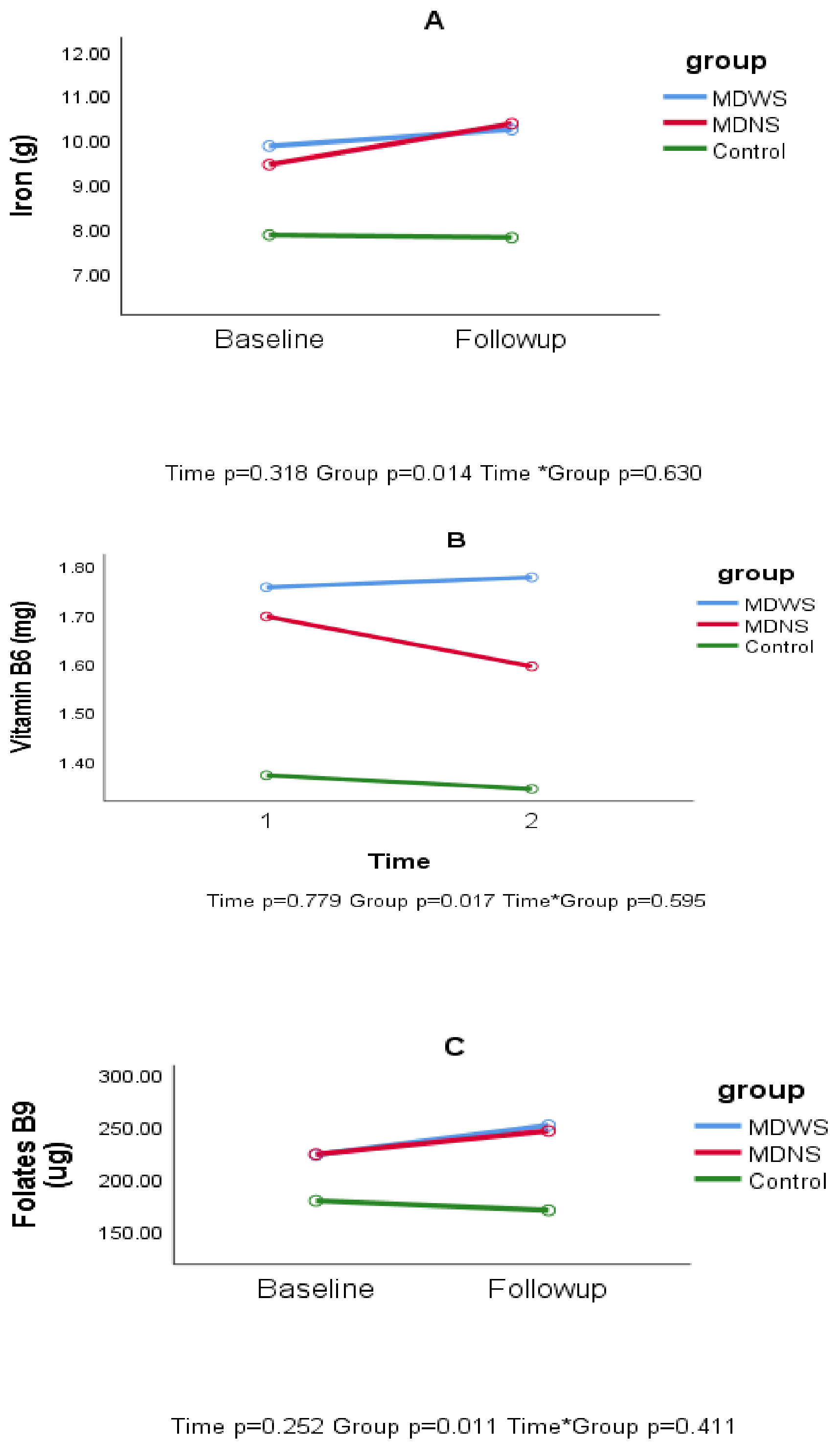
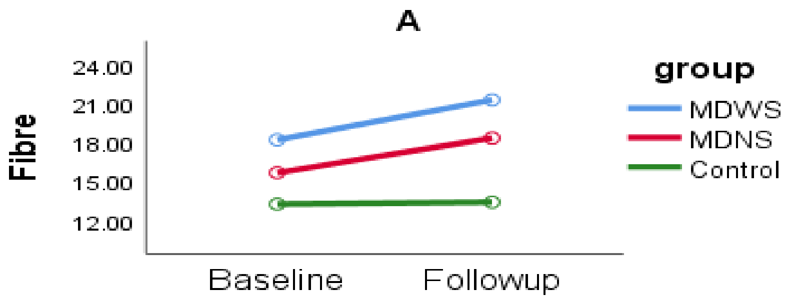
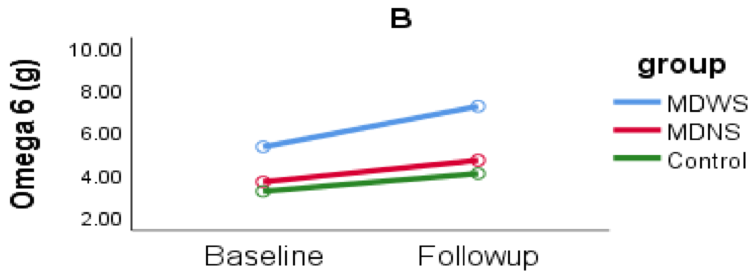


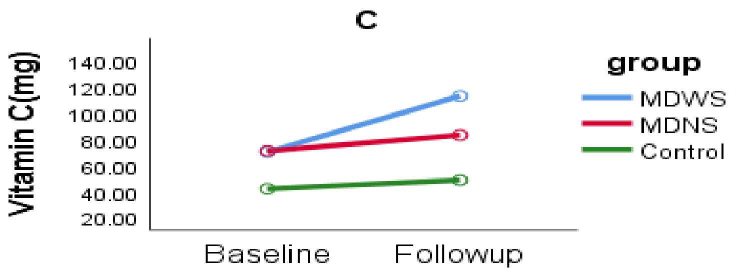
Figure 7.7 A-C
Significant difference in mean scores for Time and Group for fibre, omega 6 and vitamin C from baseline to follow up (12 weeks). MIND diet with support n=15 (MDWS), MIND diet no support n=14 (MDNS), control n=12



Time p=0.032 Group p<0.001 Time*Group p=0.374



Time p=0.022 Group p=0.020 Time*Group p=0.665



Time p=0.004 Group p=0.023 Time*Group p=0.061

7.5 Discussion

To our knowledge, this is the first RCT evaluating the effects of the MIND diet on cognitive function, mood, QOL, and capability, opportunity, and motivation towards adherence to the MIND diet in apparently healthy 40-55 year olds. The BCW was used to design the 12-week dietary intervention and select intervention functions and BCTs best suited to bring about change in our target behaviour (MIND diet). While there is a growing body of research using the BCW in designing interventions for a range of behaviours including enhancing self-care adherence in patients with heart failure (Herber et al., 2018), improving hearing aid use (Barker et al., 2016) and improving early detection of atrial fibrillation (Jatau et al., 2019), to our knowledge, this is the first study to evaluate the intervention and test the effectiveness and feasibility of the intervention based on the BCW design.

The 12-week dietary intervention significantly improved PA, physical QOL, MIND diet score and components of the COM-B model, that of capability, opportunity, motivation, and behaviour. It was also found that consumption of the MIND diet improved over time and/or between groups for various nutrients, including fibre, NSP, omega 6, vitamin A,C,B6, iron, folates B9, carbohydrate, protein, sugar, free sugar and saturated fat. This shows that adherence to the MIND diet not only improves nutrients associated with brain health, such as folates B9, iron and vitamin C, but improves overall nutrient intake which may have implications for overall general health including mood, which was found in the current study.

The current study found no association between higher MIND diet adherence and cognitive function. While there are no other studies evaluating the effectiveness of the MIND diet, previous observational studies found no association with MIND diet adherence and cognitive decline (Berendsen et al., 2018), or with older adults with cognitive impairment (Calil et al., 2018). The findings from the current study are also very similar to other dietary patterns such as the Med diet that did not find an association with higher adherence to diet and executive function, memory, processing speed and visual-spatial memory over a short 6 month RCT in adults aged over 65 years (Knight et al., 2016). The findings from the current study contrast with a range of cross-sectional and longitudinal studies that found that higher adherence to the MIND diet was associated with reduced risk of cognitive decline (Cherian et al., 2019; Hosking et al., 2019; Morris et al., 2015) and better cognitive function (McEvoy et al., 2017). Our findings are also in contrast to research evaluating other similar dietary patterns such as the Med diet, that found those following the Med diet improved cognitive performance (Martínez-Lapiscina et al., 2013; Valls-Pedret et al., 2015). However, a possible explanation for the difference in outcome compared to previous research on the MIND and Med diet, is that the current RCT analysed a sample of 41 participants conducted over 12 weeks, while the previous two RCT's and observational studies analysed much larger samples and conducted over several years with older adults. It is possible that the current study's length and small sample size lacked statistical power to detect an effect of the MIND diet intervention on cognitive function. In addition, the previous studies used different cognitive tests measuring some different cognitive domains, such as visuospatial ability and perpetual orientation. Furthermore, these previous studies are based on older populations, and it is possible that some associations between diet and cognitive function do not show during midlife (Nooyens et al., 2011).

The current study is in line with previous research that found a whole dietary pattern such as the Med diet and MIND diet to improve aspects of mood, such as contentment, alertness and reduction on depressive symptoms (Dinan et al., 2019; Lee et al., 2015; Moreno-Agostino., 2019). Chan et al. (2015) found that health behaviours can be associated with mood in everyday life. In particular, this study found that eating fruits and vegetables was related to better mood. In contrast, Wade et al. (2019), found that an 8-week Med diet intervention did not improve mood. However, in Wade's study, the Profile of Moods States (POMS), was used to measure mood, in which participants were asked to reflect on their perceptions of mood over the previous month. The current study used the PANAS scale to measure mood four times a day over four days at baseline and follow-up. It is possible, that measuring mood overtime has given a more accurate response to mood over the intervention period. Furthermore, the POMS scale only measures 6 distinct mood states, and it is possible a dietary intervention could influence components of mood not measured by POMs but measured by PANAS such as alertness (Ekkekakis et al., 2012). One study measuring daily fluctuations in mood, found that a dietary supplement improved alertness over 4 weeks (Scholey et al., 2010). Furthermore, in contrast to our findings, O'Conner et al. (2018) did not find an improvement in mood scores over a 16-week Med diet intervention. However, participants in this study scored low in depressive mood states at baseline, leaving little room for improvement in mood outcome.

The literature on quality of life shows that in general, dietary patterns are associated with quality of life and well-being (Toumpanakis et al., 2018; Carson et al., 2014), with adherence to specific dietary patterns such as the Med diet leading to a better quality of life (Zaragoza-Martí et al., 2018). Similar to previous research, the findings from this study found that the intervention significantly improved physical quality of life (Godos et al., 2019) but with no improvement in the psychological, social or environment components (Godos et al., 2019). Considering the growing population of older people around the globe, and the imperative to maintain QoL in older age, these findings are important , as they highlight that changes in diet promote aspects of well-being. This is also in line with other research that did not find an association with diet and the psychological component of quality of life (Perez-Tasigchana et al., 2016). In contrast to the current findings, recent research found that higher adherence to the Mediterranean diet was associated with better physical and psychological quality of life (Veronese et al., 2016; Zaragoza-Martí et al., 2018). However, both these studies were conducted in older adults and quality of life was assessed with the Short Form Health Survey (SF-12), which research has shown to measure different QOL constructs, with the SF-12 measuring health related quality of life and WHOQOL measuring global QOL (Huang et al., 2006).

The current study used the BCW/COM-B model to identify which intervention functions and BCT's best suited to deliver the 12-week online intervention. All the COM-B/TDF domain scores significantly improved at the end of the intervention except for social influence, showing that the intervention groups improved their capability, opportunity, and motivation to adhere to the MIND diet. This showed that the BCW was an effective framework for designing an intervention promote to uptake of the MIND diet. There were 2 intervention groups, one group followed the MIND diet with self-monitoring resource and access to a website where 18 BCT's and 6 intervention functions to deliver the intervention over a 12-week period. The second group only received the self-monitoring chart and basic information on the MIND diet elements, portion sizes and frequency of foods per week. However, both intervention groups significantly improved their MIND diet score at the end of the intervention, with no significant difference between the two groups. These finding suggest that self-monitoring, education, and goal setting, given that participants goal was to meet the MIND diet food target per week, was sufficient to adhere to the MIND diet. A systematic review found that, dietary interventions that use BCT's to deliver the interventions, found that goal setting, self-monitoring, increasing knowledge were the most utilised in app based mobile interventions and reported positive effects (Villinger et al., 2019), and that BCT'S that self-regulate behaviour such as self-monitoring and goal setting, explain intervention effects (Samdal et al., 2017).

7.5.1 Evaluation

In recent years, guidance on the design and evaluation of interventions, have placed emphasis on the acceptability of interventions, with the number of studies growing significantly in recent years (Blarigan et al., 2020; Estrada Del Campo et al., 2019; Sahota et al., 2019). The current study found that participants considered the COM-B driven intervention to be accessible, easy to use and simply laid out suggesting that the intervention components were acceptable to the target population. However, participants did not follow the intervention as intended. All participants accessed the website to gain all the information on the MIND diet, and how to fully adhere to the diets weekly target, and access recipes. Only a few participants accessed the weekly information on how to adhere to the diet in different situations such as the workplace and eating out and at that, those participants only briefly looked at the first couple of weeks. However, participants felt that self-monitoring, information on the MIND diet and having their target set for the week was enough to adhere to the MIND diet.

This finding supports Control Theory (Carver & Scheier, 1982), which attempts to explain the underlying processes of behaviour change. According to Control Theory, the key BCTs to bring about behaviour change are; self-monitoring, goal setting and feedback, and interventions using more BCTs from Control Theory were more effective that those using less (Michie et al., 2009; Prestwich et al., 2016). One systematic review also found that using self-monitoring along with at least one other BCT from Control Theory was significantly more efficient that other studies in the review (Michie et al., 2009). Participants in the current study reported that self-monitoring and goal setting was key to adhering to the MIND diet. Knowing their target and being able to see from the self-monitoring chart what foods they needed to add or reduce for that week was pivotal to their success. This is in line with previous research that found those BCTs that facilitate self-regulation of behaviour such as goal setting and self-monitoring explained intervention effects (Samdal et al., 2017; Semper et al., 2016). Furthermore, participants in the current study tracked their MIND dietary intake daily, knowing the frequency of foods and portion sizes, which led participants to a high adherence rate. This finding is in line with previous research that found comprehensiveness of self-monitoring records promoted behaviour change (Peterson et al., 2014).

Overall, our results suggest that including more BCTs are not more effective in changing behaviour. This is in line with systematic review that found more BCTs were not necessarily more efficacious (Ashton et al., 2019), and that interventions with fewer BCTs were most effective (Dombrowski et al., 2012; Michie et al., 2009). In contrast, Webb et al. (2010), found that web interventions incorporating more BCTs tended to have larger intervention effects than those with fewer techniques. The same review

(Webb et al., 2010), found that personal contact such as text messages to participants alongside the web-based intervention, enhanced behaviour change. This is similar to our findings that text messages from the researcher promoted motivation and engagement in the intervention. Furthermore, participants in the current study reported that a chat room was not acceptable and that more direct contact with the researcher and more engagement from the researcher through text messages with links to specific information would enhance engagement. This finding is similar to research that found text messages provided motivation to change their diet and promote healthier eating (Keely et al., 2019), that participants may engage with text messages rather than a study website (Van Blarigan et al., 2020), and internet peer support was the least preferred (Erwin et al., 2018). Furthermore, while text messages are short and targeted, which may increase the likelihood of participants reading and use of information, they are also convenient, have high adherence and promote behaviour change (Herring et al., 2014; Mhurchu et al., 2014; Steinberg et al., 2013).

Finally, a major finding of our study was the various health benefits of the MIND diet reported by the participants, and that this was a motivating factor to continue the MIND diet. This finding is in line with previous research that found; improving overall health (Vega-Soto et al., 2019; Zou et al., 2019), and increased energy important reasons to eating a healthier diet (Ashton et al., 2017). In contrast, Shepherd et al. (2006) systematic review found that body image rather than overall health was a key facilitator to eating a healthy diet. However, this systematic review was conducted with young people (11-16 years old), and body image may be more important to young people than general health.

7.5.2 Strengths and limitations

A major strength of the study is the design (RCT) and the inclusion of a theory driven intervention. This study also used CANTAB for measuring cognitive function, which is a highly sensitive battery of tests recognised as the gold standard cognitive assessment and data collection. Furthermore, CANTAB tests are sensitive to subtle changes with age and neurodegeneration. A further strength of the study is the use of food diaries and food charts, which minimises reliance on memory assessing usual food intake (Berendsen et al., 2014). Importantly, the high completion rates in the intervention group point to the acceptability of the dietary intervention. Furthermore, the fact that participants were able to increase their MIND diet score suggests adherence is achievable in healthy adults at midlife.

However, there are several limitations of the study which include the inability to track participants engagement on the website and their interaction with the website materials. However, weekly text messages were sent to those in the intervention with support group to remind them to engage with the website. Future research should use an analytical software programme that can assess engagement on the website (Dewan et al., 2019). In addition, the researcher responsible for delivering the intervention, also conducted the evaluation. It is possible that participants provided socially desirable responses (Acocella et al., 2012), however, to reduce this, participants were encouraged to discuss both positive and negative aspects of the intervention. Another limitation of the study is the small sample size, although within power, more research with larger samples is needed to determine if the results can be replicated. However, the current RCT in this thesis is a feasibility study and not a full-scale RCT. According to the MRC, preparatory work prior to embarking on a full scale RCT is important to assess the feasibility and acceptability of complex health interventions. Assessing feasibility and acceptability is crucial in uncovering potential issues related to acceptability, compliance, recruitment, retention, and delivery of the intervention (Saracutu et al., 2018). Furthermore, assessing the effectiveness of a 12-week dietary intervention on cognitive function outcomes may be insufficient to detect a significant improvement in cognitive function. Future RCT's examining the effectiveness of the MIND diet over a longer duration is warranted.

7.6 Conclusion and Recommendations

This is the first RCT to test the effectiveness of the MIND diet on cognitive function, mood, and quality of life. It is also the first RCT to use the BCW/COM-B model to design and deliver a dietary intervention using a whole dietary pattern. The findings from this study show that the BCW is an acceptable framework to design and deliver effective interventions to increase capability, opportunity, and motivation to adhere to the MIND diet. Our study showed that increased adherence to the MIND diet improved mood, quality of life and diet quality. Future interventions with longer duration are needed to establish an association with MIND diet and cognitive function in adults at midlife. This study recommends emphasising self-monitoring, goal setting and education on diet as an effective strategy for promoting adherence to the MIND diet. This study also recommends using less BCT's with a less complex intervention focussing on a well-structured text messaging service with more contact and advice directly from the researcher. These findings may be of interest to health professionals wanting to find effective ways to design lifestyle interventions and promote health and well-being in individuals and communities.

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Chapter 8

General Discussion

8.1 Introduction

In the final chapter of this thesis, the main findings from all the research chapters (i.e. Chapters two, three, four, five six and seven) will be presented. Firstly, this chapter will give a reminder of the purpose of this work, including findings from the literature review (chapter 2), followed by a brief discussion of the main findings, including what each chapter adds to the literature. Finally, an overview of the limitations and strengths of this work are presented, with a general conclusion and recommendations.

8.2 Purpose of this work

Age is the biggest risk factor for AD and mainly affects people over 65 years old. Above this age, a person's risk of developing AD doubles about every five years, with one in six people over 80 years having dementia. There is currently no cure or treatment to slow the progression of dementia. However, modifiable improvements on dietary intake seem to hold a crucial role in preventing cognitive impairment in recent literature. This thesis focuses on the importance of diet and nutrition as a strategy in preventing or delaying cognitive decline in older adults. Therefore, for an intervention to be beneficial, it would need to start in the preclinical stage (Flanagan et al., 2020). This thesis focuses on healthy adults at midlife (40-55 years old).

Research discussed in the literature review (Chapter 2) reported that theory-based interventions were more successful in improving diet than studies not using theory (Avery et al., 2013). According to the MRC framework for complex interventions (De Silva et al., 2014), designing interventions that are likely to be more effective, sustainable, and scalable, researchers need to understand which components of the intervention impact the outcomes most positively. The COM-B is at the core of a wider framework called the BCW , which is an eight-step systematic approach in designing a behaviour change intervention. The BCW guides the selection of BCTs. BCTs provide a means of characterising intervention content to facilitate the implementation, delivery, and evaluation of behaviour change interventions. The BCW links theoretical constructs to BCTs, addressing some of the issues in previous studies that have applied theory poorly, such as only loosely referring to theory, or only targeting a few of the constructs (Prestwich et al., 2014). Therefore, the BCW was used as a novel application in this thesis.

8.3 The main findings of this work

8.3.1 Chapter 3: Systematic review

The systematic review (Chapter 3) was the first phase of the research process and provided a comprehensive and systematic assessment of the effectiveness and use of social cognition models in dietary interventions that promote “whole dietary patterns”. The findings from this research phase provided a better understanding of the effectiveness of theory driven dietary interventions and the extent to which theory is used to design interventions. The main findings highlighted that fidelity of treatment is poorly reported and could potentially be the cause of ineffective or mixed intervention effects.

The findings in the systematic review (Chapter 3) highlighted weaknesses in studies theoretical implementation, with few studies using theory to tailor the intervention techniques to recipients, using theory to select recipients, results used to refine theory, but most notably, only half of the studies linking all BCTs to theoretical constructs. Furthermore, the findings highlight that while these dietary interventions focus on the design of the intervention, such as recruitment and randomisation, and on behavioural and dietary outcomes, less attention is focussed on mechanisms of action, intervention content responsible for behaviour change (Prestwich et al., 2014; Prestwich et al., 2015), and limitations in the extent and precise reporting of theory in intervention design and implementation. This presents challenges to researchers aiming to identify links between theory and content of the intervention (Bohlen et al., 2019), and limits the possibility of evidence accumulation and of studies to experimentally evaluate specific theories and therefore to refine them based on evidence (Prestwich, 2014). Furthermore, this provides little information on how behavioural interventions work and the process involved. The findings from this phase highlighted the importance of clearly and efficiently describing theory and to use a process that links intervention techniques to theoretical constructs that represent “mechanism of change”, that is, how the techniques propose to change behaviour (Connell et al., 2019, Michie et al., 2018). This approach develops knowledge on effective and reliable methods in changing behaviour (Hagger et al., 2020).

It was also found that fidelity of the intervention was important as without consideration of fidelity, conclusive statements about treatment effects cannot be made (Borelli, 2011). Findings from the systematic review (Chapter 3) showed that reporting was poor and may compromise the validity of the included studies in the review. Addressing treatment fidelity helps increase confidence that the changes in dietary behaviour are due to manipulations of the independent variable (Borrelli, 2011).

Application of SCMs have demonstrated promise in providing an understanding of the determinants of preventive behaviours (Hagger et al., 2020). SCMs help identify potential factors that can be modified and shown to be reliably related to behaviour. Once identified, these modifiable factors can inform the development of behaviour change interventions to promote adherence to healthy behaviours (Hagger et al., 2016). However, SCMs mostly target factors relating to reflective motivation, and focus less on automatic processes such as habit. SCMs also focus less on a person's capability and opportunity to perform behaviour, which are necessary factors for behaviour to occur (Michie et al., 2014).

Recently, new approaches to behaviour change, the implementation and evaluation of interventions has been developed, in particular, the BCW, COM-B model and the BCT taxonomy which helps build the bridge between predicting behaviour and actual behaviour, by specifying the "active ingredients" of the intervention, and this classification facilitates replication of interventions (Michie et al., 2014). Prominent approaches to intervention development with a strong focus on theoretical basis is provided by the BCW (Michie, 2011) therefore, the chosen theoretical underpinning for this thesis was the BCW, as this can be used as tool to guide intervention design (Michie et al., 2014).

8.3.1.1 What this systematic review adds to the literature

While there is an increasing body of literature examining whole dietary patterns (Imamura et al., 2015), the systematic review (Chapter 3) highlighted that very few studies assessed the effectiveness and use of psychological theory in dietary interventions that promote a whole dietary pattern. To our knowledge, this is the first review to examine psychological theory driven interventions that target a whole dietary pattern. The systematic review presented in this thesis used the TCS (Michie et al., 2010) which allowed for a deeper exploration of the extent of psychological theory driven interventions. This contributed to our understanding of shortcomings in the reporting and implementation on the use of psychological theory. Furthermore, assessing fidelity contributed to our understanding of the importance to determine the relationship between fidelity and programme outcomes to understand what level of fidelity is needed to ensure that programmes are effective. Finally, the findings from the systematic review (Chapter 3) in this thesis contributes knowledge to the literature by suggesting that common SCMs may not be most effective models to use in interventions promoting whole dietary patterns. Interventions designed by SCMs tends to target factors relating to “reflective” motivations, with little attention paid to capability and opportunity that are necessary factors for dietary behaviour to occur (Grombert et al., 2017). Consequently, new methods have been developed which take the behavioural problem as a starting point and use insights from different theories to assess, solve or prevent that problem (Michie et al., 2014). The findings from the systematic review (Chapter 3) highlights the need for further research incorporating new methods such as the BCW (Michie et al., 2014), that uses a systematic approach to designing an intervention, starting by understanding the behaviour, selecting determinants of that behaviour, before moving on to defining and developing the intervention content and mode of delivery. This chapter identified a gap in the literature, that is, to understand MIND diet behaviour and assess its effectiveness on cognitive function. The next step is to understand MIND diet behaviour. Chapter 4 (elicitation study) identifies factors influencing MIND diet behaviour that will inform an intervention.

8.3.3 Chapter 4: Phase 2 (behavioural diagnosis)

The behavioural diagnosis (Chapter 4) was the second phase of the research process. To achieve MIND diet adherence, the behavioural analysis identified the need to intervene across all three COM-B components and nine associated TDF domains (decision-making processes, social influences, behavioural regulation, environmental context and resource, belief about capabilities, belief about consequences, emotion, knowledge and skills). Four of the TDF domains mapped onto the capability component of the COM-B model, highlighting that optimising this component was important in changing behaviour. In terms of capability, lack of knowledge, self-monitoring, and cooking skills were key factors that could potentially influence MIND diet behaviour. Possessing the knowledge of what a healthy diet consists of, is very important, as it allows people to make the “right” choices (De Ridder et al., 2017). Nutrition knowledge is consistently reported as a main factor related to healthy eating (Guillaumie et al., 2010). Previous research has found lack of nutrition knowledge to be one of the largest barriers to healthy eating (Amore et al., 2019; Ashton et al., 2017). However, knowing what constitutes a healthy diet, does not necessarily prevent people from consuming unhealthy foods (Spronk et al., 2014). It is important to note, that while numerous countries around that world have installed dietary guidelines (Food and Agricultural Organisation of the UN, 2016), to help increase the public’s understanding of a healthy diet, there is less attention given to the public on how to adhere to the advice on diet, such as where, when and how the dietary guidelines can be implemented into the daily lives of people (De Ridder et al., 2017). Furthermore, these evidence-based guidelines may be hampered by non-scientific advice communicated to the public on social media platforms, which can often be trusted more than professional advice (Kroneman et al., 2016).

Behaviour regulation was highlighted as a factor that may influence MIND diet behaviour. While automatic influences such as emotion and habit may affect adherence to healthy eating (Ridder et al., 2017), in intervention design, it is important to consider other factors that may limit the impact of these automatic forces that steer us towards unhealthy but attractive food choices such as self-monitoring and stimulus control. Research found only a modest role for trait self-control in eating behaviour (De Ridder et al., 2012), however, self-regulatory strategies such as self-monitoring are consistently shown to have a positive association with dietary intake (Kliemann et al., 2017). According to Michie et al. (2009), interventions that aim to increase self-regulation skills are the most successful in affecting dietary patterns, with self-monitoring being the most important active ingredient. Luszczynska et al. (2016) conducted a longitudinal study over 2 years which indicated small to medium effect sizes of behaviour regulatory skills on fruit and vegetable intake were still present at 14 months follow up, demonstrating long term effects of behaviour regulation interventions. However, these effect sizes translated to a small increase in portion (1/4 to 1/3) per day, which may be too small to heave significant health benefits.

Barriers and facilitators reported fell into three TDF domains that can be mapped onto the motivation component of the COM-B model (emotion, belief about capabilities, belief about consequence), with the main factors affecting MIND diet behaviour being; the belief that convenience being a barrier to adopting MIND diet behaviour. Previous research also found convenience to be a barrier to healthy food choices (de Mestral et al., 2016), and that fast food and unhealthy snacks were more convenient (Sequin et al., 2014). However, Participants reported that planning and preparing food and being organised would help them adhere to the MIND diet, which is consistent with previous research that found preparing meals for the week ahead, saved on money and encouraged weight loss (Doldren et al., 2013). Laska et al. (2011), found that food preparation in emerging adulthood was associated with healthier diet in mid to late twenties, including higher intake of wholegrains, fruit and vegetables, and lower intake of sweetened drinks and saturated fat. Other research found that participants reported planning to be responsible for their success in healthy eating (Allom & Mullan, 2014).

It has been discussed how capability, motivation and behaviour regulation affects food choices, however, these factors can be influenced by external sources (social or environmental), that can either help or hinder people's efforts to consume a healthy diet. The results in the behavioural diagnosis (Chapter 4) found that social influence was a key facilitator to adopt the MIND diet. However, while family and friends can provide support to those contemplating changing their diet, by removing treats from the house and cooking healthy meals, the social environment can have negative effects, for example, family or friends may not agree with avoiding red meat leading the individual less likely to do so, or continuing to offer sweets and pastries at social gatherings, making it more challenging to regulate behaviour (De Ridder et al., 2017). Griffith et al. (2016) conducted a study with men whom either consumed the recommended daily consumption of fruit and vegetables and those who did not. One of the key findings to support healthy eating was social support, with those who consumed the recommended daily fruit and vegetables identified social support as an asset and those who consumed less fruit and vegetables struggled to identify sources of support to engage in healthier eating practices. Furthermore, even with knowledge of healthy eating and the importance of healthy food on disease prevention, social barriers such as cultural norms, unhealthy food at social events and poor exemplary roles of others impact people's food choices (Van Der Velde et al., 2019).

Physical environmental factors can either support or hinder healthy eating. The results from the behaviour diagnosis (Chapter 4) found that budget, access/availability of healthy foods, and time, are key barriers to the adoption of the MIND diet. Budget was found to be a perceived barrier in those of lower socio-economic status (SES). A large body of epidemiological data shows that SES is associated with an unhealthier diet (Orr et al., 2019). There is overwhelming evidence for a strong SES gradient in diet quality, with budget and access/availability of healthy foods being underlying mechanisms (De Ridder et al., 2017). The availability of (un)healthy foods has implications for what people eat and has been consistently associated with healthy diet (Caspi et al., 2012). Accessibility refers to the relative ease with obtaining certain foods, with one relevant aspect being “distance” from foods (De Ridder et al., 2017). This was highlighted as a barrier to MIND diet adoption from the findings in the behaviour diagnosis (Chapter 4), as participants felt that living in rural parts of Ireland presented difficulties with accessing fresh foods locally. According to a survey conducted in the UK about barriers to healthy eating (Corfe, 2018), rural areas have more restricted food choices than urban areas, however, with generally less social and economic deprivation, and higher car ownership, it was easier to travel longer distance to food stores. Despite this, one on eight people taking part in the survey, stated that not being near a supermarket with healthy foods was a barrier to healthy eating. However, those who could grow their own food or had access to farmers’ markets, was a facilitator to healthy eating (Sequin et al., 2014). Participants who received nutrition education and access to a garden to eat fruit and vegetables, reported to eat the recommended daily fruit and vegetables (Barnidge et al., 2015).

8.3.3.1 What the behavioural diagnosis adds to the literature

Formative research that applies behavioural theories to predict behaviour is important as it helps researchers understand behaviour and identify the determinants of behaviour in social and environmental contexts. Formative research helps build the foundations of many contemporary theories of behaviour and the basis for many methods used to change behaviour (Michie, 2008). The formative research in this thesis used the COM-B model and TDF which is a novel application to understand MIND diet behaviour in the context in which it occurs in adults at midlife. The MIND diet is a new behaviour and has not been investigated in this way before. The study presented in the behaviour diagnosis (Chapter 4) is the first study to explore barriers and facilitators to adoption of the MIND diet, and to understand MIND diet behaviour using the COM-B model. Furthermore, this was the first study to apply the TDF to explore peoples understanding and perceptions of a whole dietary pattern. The findings from this research identified potential levers of change, highlighting the importance of addressing these factors when designing behaviour change interventions. Developing interventions that target these salient barriers to MIND diet uptake will have greater potential to change behaviour.

8.3.4 Chapter 5: International Collaboration: Rome study

The research in the Rome study (Chapter 5) was undertaken to establish and compare components of the COM-B model that influence the uptake of the MIND diet in a 40-55-year old Italian and Northern Ireland (NI) sample. Furthermore, with globalisation deeply influencing people’s lifestyle choices, yielding a shift towards westernised eating habits, examining the degree of beliefs of which healthy diets have converged between the two countries, or remain distinct is important, as this will inform intervention design.

Results found similar barriers between the two countries, which were, environmental context and resources, belief about capabilities, behaviour regulation and knowledge (discussed in section 8.3.3). However, the main factors influencing MIND diet behaviour in the environment differed between the two countries, with the Italian sample reporting access/availability of foods being a major barrier compared to the NI sample. One interesting difference between the two samples under this barrier is that in NI, there is cheaper, better quality food in the bigger stores and cities.

However, it was reported that in Rome, it is in the country markets that cheaper, fresher food is found. The literature generally supports that access to fresh cheaper foods is a barrier in rural areas. Previous research found that shops selling healthier food was a long distance from country communities (Maley et al., 2010; Neill et al., 2011) and that limited access to food resources led to poorer dietary habits (Carnahan et al., 2016).

Furthermore, skills, and memory, attention and decision processes were not reported as key barriers in the Rome population. Generally, the Italian sample were more confident in cooking the MIND diet foods as this was close to their traditional diet. Instead, culture was highlighted as a key factor influencing uptake of the MIND diet. The Italian sample reported that certain foods were not part of their culture and serving certain foods to family and friends were not acceptable, such as wholegrain pasta and bread. This finding is in line with previous research that found, serving traditional food to be of cultural importance (Netto et al., 2007), and that dietary changes were difficult due to family members and wider social circle expectations (Penn et al., 2014). Cultural identity was associated with consumption of traditional foods in the Italian sample, who showed little Western dietary habits in their descriptions of their dietary preferences. The data from the Rome study support NICE guidance (NICE, 2017), highlighting the importance of culturally tailored dietary advice that needs to be central to any lifestyle intervention. This finding has important implications not only for health professionals working with populations within their own country. But, for professionals to address the needs of diverse populations.

8.3.4.1 What this chapter (Rome paper) adds to the literature.

This is the first study to describe a cross cultural theory-based qualitative approach exploring barriers and facilitators to the uptake of the MIND. This is also the first study to use the COM-B model to code and analyse cross-cultural qualitative responses from individuals at midlife regarding MIND diet behaviour. The findings from this chapter highlight the novelty and flexibility of using the COM-B model in understanding behaviour in the context in which it occurs, as it not only identifies the components of the COM-B/TDF that need to change in order change behaviour, but the cultural differences in terms of important factors that need addressed in intervention design. These important factors drawn from this study include, food preferences embedded in the Italian culture such as white bread and pasta, and cheese. Furthermore, another important factor to consider is family influences surrounding cultural foods, and what is deemed acceptable to eat and serve to others. This chapter also uses the subsequent stages of the BCW to identify potential intervention functions and behaviour change techniques that may bring about change in MIND diet behaviour.

8.3.5 Chapter 6: Phase 3: Methodology

The research presented in the methodology (Chapter 6) of this thesis was the third phase of the research process. This research described the systematic approach of designing an intervention, firstly, by applying the COM-B/TDF model to highlight the barriers and facilitators to capability, opportunity, and motivation towards adoption of the MIND diet (Chapter 3). The BCW guided researchers to link the barriers and facilitators to intervention functions and finally identifying and linking to BCTs that would bring about behaviour change when developing an intervention.

Despite interventions being carefully designed, they can often fail because researchers either do not understand, or appropriately target the processes that generate behaviour patterns (Kelly & Barker, 2016). Developing and using accurate descriptions of mechanisms (theories and theoretical constructs) to identify and assemble specific behaviour change techniques are key to effective behaviour change interventions. However, these mechanisms must be considered on a behaviour to behaviour and target population to target population basis. Stage 1 of the BCW is an important stage of the research and intervention design as it uses the COM-B model to understand antecedence of MIND diet behaviour in adults at midlife, that is, understanding the underlying mechanisms that influence and maintain MIND diet behaviour at midlife. The findings from stage 1 of the BCW (Chapter 4: behavioural diagnosis) found that to achieve MIND diet adherence, there was a need to intervene across all three COM-B components and nine associated TDF domains (e.g., decision-making processes, social influences, behavioural regulation, environmental context and resource, belief about capabilities, belief about consequences, emotion, knowledge and skills). Using the guide from the BCW and the consideration of the APEASE criteria (Michie et al., 2014) (Chapter 6: methodology), 6 intervention functions (including enablement, persuasion, education, training, environmental restructure, and modelling) were chosen to deliver the MIND diet intervention.

BCWs provide a means of characterising intervention content to facilitate the implementation, delivery, and evaluation of behaviour change interventions. They are defined as the observable, replicable components of the intervention, that in optimal circumstances, can bring about change. The BCW guided the mapping of BCTs that would best deliver the intervention functions and bring about change in the target behaviour. The Behaviour Change Technique Taxonomy v1(BCTTv1) (Michie et al., 2013), and the theory and techniques tool (Johnston et al., 2020), which explores the link between BCT's and TDF was used to identify which behaviour change techniques would best serve the COM-B behaviour analysis (Chapter 4) and the selected intervention functions. The Theory and Techniques Tool is based on evidence on links made by authors in previous research (Carey et al., 2019; Johnston et al., 2020) and by expert consensus (Connell et al., 2019) to support intervention designers develop and evaluate theory-based interventions. This tool identified which BCT's have direct links to the TDF domains being addressed in the MIND diet intervention.

However, this systematic approach of the behaviour change wheel has been criticised. There are many different theories within health psychology which can range from being focussed and detailed, to generic and inclusive. The BCW is considered broad and inclusive such as including environmental planning, legislation, and fiscal measure. Also, the BCTTv1 recognises the role of the individual level and, biological and external factors (Glassman, 2016), which limit their utility (Ogden, 2016). Although some researchers argue that, systems of synthesised evidence are essential to scientific advance (Johnston, 2016), and create a shared vocabulary and methods (Johnston, 2016). It is argued that the quality of data may not be ready to synthesis, as research on behaviour change is in its infancy (Teixeira, 2016). The goal in developing the BCW was to reduce theory variability and identify an integrated systematic approach which transcends individual perspectives and can be applied to all behaviours. However, whether the BCW can be tested remains to be seen (Ogden, 2016), and if its constructs remain broad, it is unclear how it can be falsified (Ogden, 2016). Furthermore, streamlining and integrating theories into one dominant model may help to remove overlap and redundancy, but this may reduce creativity in researchers by becoming "puzzle solvers" and not "problem solvers". Health psychology may become “normal” not “novel” and psychologists/researchers may not be challenged, with creative anomalies being marginalised before reaching fruition (Ogden, 2016).

Another possible problem the systemisation approach of the BCW is the lack of person variability. The BCW was developed to code protocol, to identify the most effective BCTs for different behaviours and train professionals to identify and select BCTs that are most effective in behaviour change interventions (Atkins et al., 2015). The aim was to maximise the effectiveness of interventions, participants to change their behaviour and the problem of person variability to be solved. However, Ogden (2016), argues that it is highly likely to be a gap between the individual persons behaviour and that of the protocol created for them if there is a gap in their own belief and subsequent behaviour. Ogden (2016) argues that there is also a gap between the professional’s beliefs and their behaviour with the patient, and also with the health professional beliefs and their training. This creates a lot of gaps between the protocol being coded and the behaviour of the person, leading to low intervention fidelity. If the persons own beliefs do not predict what they do next, it is unlikely that the protocol telling the professional to do with them, will do either. However, these gaps can be avoided with proper application of health psychology (Peters & Kok, 2016), with the acknowledgment for person variability. For example, Intervention Mapping (Bartholomew et al., 2011), distinguishes a number of aspects neglected by the BCTTV1 (Kok et al., 2016). One distinction being the concept of parameters of effectiveness, which is the “conditions that must be satisfied in practical applications for the method to be effective” (Kok et al., 2016). These parameters are key to effective behaviour change and to acknowledge variability between persons in behaviour change. For example, empathy training (Kok et al., 2016) requires the intervention recipient to be able to identify with the stigmatised person. Also, Implementation Intentions (Gollwitzer & Sheernan, 2006) requires an existing positive intention, both of which provide a means to acknowledge person variability, and determine which methods are appropriate for a particular population. Therefore, when behaviour change is regarded in its proper context, acknowledging person variability between persons becomes more straightforward (Peters & Kok, 2016). Therefore, it is important to put training in place for practitioners, not only to highlight the complexities of behaviour change but also to provide the tools they need to leverage this variability by searching for and evaluating theory, behaviour change methods and parameters that are important to allow for effective behaviour change.

Furthermore, The BCTTv1 has also been used to identify potential targets for intervention and is ‘step 7’ of the BCW (Michie et al., 2014). However, it is difficult to provide advice on which BCTs should be used to serve the intervention functions, without knowledge of which BCTs work best, for whom, in which contexts, and delivered by what means (Armitage et al., 2020). There has been some effort to address this issue, with researchers conducting systematic reviews to explore what is known about the unique properties of BCTs, and how they interact with other BCTs (Brown et al., 2017). Knowledge about how BCTs interact with the others would not only be invaluable to intervention developers, but may also lead to new theoretical insights by allowing one to test existing theories or develop new theories on the basis of the evidence (Brown et al., 2019).

However, gaps in knowledge that require further research was identified (Armitage et al., 2020). Recently, the Centre for Understanding Behaviour Change (CUBiC) approach and template has been proposed, which is a co-ordinated approach to understand BCTs. This CUBiC approach specifies: (1) a scoping review unrestricted by behavioural domain or scientific discipline to gauge the current state of knowledge, (2) a systematic review and also meta-analysis where there is sufficient evidence, and (3) identification of gaps in, or a surfeit of primary research. The CUBiC template has already been applied to 5 BCTs from the BCTTv1. This template could be expanded, and refined by expert consensus, and applied to the remaining 88 BCTs and other BCTs identified in future taxonomies.

8.3.5.1 What the methodology chapter adds to the literature

As discussed in the methodology (Chapter 6), the designing of the behavioural intervention for this thesis, goes beyond that of SCMs and uses a framework that systematically guides the development of a theory driven dietary intervention. The BCW is a relatively new theoretical framework, and while there is an increasing amount of interventions being designed using the BCW, there are very few interventions designed in the area of diet and nutrition. To our knowledge, there is only one other study that used the BCW to design an intervention to promote a whole dietary pattern (Mediterranean diet). However, the aim of their study was to design a peer support intervention, and target those at high risk of cardiovascular disease. The aim of the study presented in the methodology (Chapter 6) of this thesis was to design an online dietary intervention targeting healthy adults at midlife to promote brain health. The differences in the target population and overall aim of the design of the intervention, would lead to different barriers and facilitators being highlighted, ultimately leading to an entirely different intervention design and outcomes. This highlights the novelty of using the BCW to assess the target behaviour in context and its ability of designing interventions entirely on a target behaviour/population by target behaviour/population basis. Furthermore, the BCW also guides the transition of putting theory into practice and tracks the mechanisms of behaviour change that may not be done using other SCMs.

8.3.6 Chapter 7: Phase 4: Feasibility RCT

The research presented in the feasibility RCT (Chapter 7) of this thesis was the final phase of the research process. The main aim of the RCT was to assess the COM-B model effectiveness to plan and implement an intervention to facilitate adherence to the MIND diet. The 12-week dietary intervention found improvements for everyday mood, specifically positive affect, quality of life and MIND diet score. However, no improvements in cognitive function were found. One explanation for this is the small sample size, and duration of the study. More importantly, this study uses a sample at a preclinical stage, and it is possible that some associations between diet and cognitive function do not show during midlife (Nooyens et al., 2011). However, this intervention is a feasibility study, not a full RCT. Moving forward a full RCT should be conducted with larger samples to determine if the results can be replicated.

The RCT (Chapter 7) used the self-evaluation questionnaire guidance from the BCW (Michie et al., 2014), which enables participants to consider a wide spectrum of factors relating to the COM-B model, and finding from the behavioural diagnosis to construct the COM-B questionnaire. However, at the time of developing this questionnaire, there were no standardised measurement to capture the COM-B components. This is because the COM-B constructs depend on the sample and behaviour in question (Howlett et al., 2017). Unlike other theories such as the TPB, where there are set guidelines in questionnaire construction (Francis, 2004), the COM-B self-evaluation is used to structure wider information gathering from evidence in the literature (Michie et al., 2014). With few COM-B questionnaires reported in the literature, which are not clear on their development, posed a challenge in the design of the questionnaire in this this chapter. However, a generic questionnaire to operationalize fully the six subdomains of the COM-B model reliably and validly using rigorous psychometric evaluation has been developed (Keyworth et al., 2020). This will be a useful tool in future research using the COM-B model.

Overall, the findings from the RCT demonstrated that a COM-B intervention to promote adherence to the MIND diet was feasible and acceptable to the participants. This was particularly evident in the high self-monitoring rate shown in both the daily self-monitoring chart, and the 7 day food diaries at week one and week twelve. This is in line with findings from other studies showing that participant engagement is important to the success of behaviour change interventions (Blonstein et al., 2016). This finding is not surprising, as monitoring of behaviour is typically viewed as one of the processes by which intentions are translated into behaviour (Banas et al., 2017). Moreover, monitoring can influence motivation, as it informs decisions about whether the goals need to be revised, and because monitoring can influence the strength of motivation to act to further goal pursuit (Reynolds et al., 2018).

However, many participants in the intervention with support did not use the website as intended. Participants gained the information they needed in terms of MIND diet information and recipes, but many did not access the weekly information and tasks, therefore, many of the BCTs used to design the intervention were not delivered to the participants. For example, embedded in the weekly information, contained BCTs such as behaviour substitution and avoid/reduce exposure to cues for behaviour. These BCTs may not have been delivered to most of the participants due to not accessing these parts of the website. Lack of delivery of intervention could possibly affect the fidelity of the intervention. However, the self-monitoring of the MIND diet, which was also monitored by the researcher, addresses fidelity of the intervention. Particularly, self-monitoring demonstrates that receipt of the intervention, and enactment of the intervention was established. However, the BCTs not delivered were not necessary for intervention success. This highlights the criticisms by Ogden (2016) that variability and flexibility in intervention design is needed, rather than stringent components that must be implemented in a systematic approach provided by the BCW. The BCW was designed to remove variability, not only in behaviour and theory, but in practice (Ogden, 2016). Not only are BCTs a resource for intervention designers to draw upon, it is becoming a prescriptive approach which is apparent in previous research specifying which techniques are most appropriate and should be used for different behaviours (Michie et al., 2009; Michie et al., 2011). While the goal to promote evidence based practice is essential, the goal to specify which intervention tools are most appropriate ignores the need for variability, flexibility and change according to how the individual feels, thinks, behaves or responds at any given time (Ogden, 2016). Therefore, we recommend intervention designers, selectively draw upon different tools, and the BCTs identified as being appropriate for intervention design, given the needs of the target group, and be flexible in line with tailored interventions and patient centeredness (Richards et al., 2015).

Moving forward, the findings suggest that aspects of the intervention should be removed, and a less complex, intensive intervention programme with more direct support from the researcher would enhance engagement. While the findings from the RCT (Chapter 7) support the feasibility and acceptability of the intervention, reflecting on the implementation process can provide further information to refine the intervention. Therefore, a brief reflection is provided before presenting what this study adds to the literature.

Participants in the intervention with support adhered well to the MIND diet, despite engaging poorly with some aspects of the intervention. A different approach to delivering the intervention needs considering. Based on the results of the intervention, the successful strategies were self-monitoring, goal setting and action planning. However, other potential strategies, based on feedback from the participants, could be considered to maximise participants engagement with the intervention.

1. Send a text message weekly with a link to the exact section of the website for participants to read for that week. This saves time for the participant and may encourage them to click on the link to access the information. Research has found that a text messaging service is effective at changing dietary behaviour (Santo et al., 2018), and that text messages provided motivation to change their diet and promote healthier eating (Keely et al., 2019). Research also found that participants may engage with text messages rather than a study website (Van Blarigan et al., 2020).
2. Keep information short but effective. Research found that while text messages are short and targeted, which may increase the likelihood of participants reading and use of information, they are also convenient, have high adherence and promote behaviour change (Herring et al., 2014; Mhurchu et al., 2014; Steinberg et al., 2013).
3. Use less BCTs in the design of the intervention. This study found that less BCTs were effective at changing behaviour. Previous research found that greater number of BCTs is not necessarily more efficacious (Ashton et al., 2019). In fact, it is the utility of the BCT that may be more important. This supports our

finding that self-monitoring to be an important and effective behaviour change technique.

4. More contact with the researcher. This could include a telephone call at different time points with participants. This allows the participant to highlight with the researcher any difficulties with the diet or website, and also address participants individual needs. It also allows the researcher to identify aspects of fidelity of treatment, such as delivery of treatment, and address person variability. The one to one contact has been shown to maintain participant engagement and build rapport (Blonstein et al., 2015).
5. System in place to track participants access to website. Tracking participants engagement would help strengthen fidelity of delivery, as this would assess participants contact with the information provided on the website (Lambert et al., 2017).

8.3.6.1 What the feasibility RCT adds to the literature

This research contributes to the literature as it is the first RCT to test the effectiveness of the MIND diet on cognitive function, everyday mood, and quality of life in healthy middle aged adults. This study found that positive affect improved over the intervention period. PA has a well-established circadian rhythm and fluctuates constantly in response to the environment, while negative affect tends to be more stable across time unless faced with a stressful event (Watson, 2000). The current research is also the first RCT to examine the MIND diet at midlife that uses the BCW/COM-B model to design and deliver a dietary intervention using a whole dietary pattern. Previous research and findings from Chapter 3 (systematic review) in this thesis, show that the effectiveness of behavioural interventions regarding diet adherence are mixed, with studies only improving on few aspects of diet, or none. Compared to other theory driven dietary interventions, the results from this RCT showed that the BCW designed intervention was effective at increasing consumption of a range of elements within a diet within a short period of time. However, issues with previous theories may not have been able to address complex behaviours. This may be due to inadequate mapping of theory onto intervention components. Research has distinguished between “theory inspired” and “theory based” interventions (Michie et al., 2016), indicating that theory inspired interventions provide insufficient specification of links between theory and intervention strategies (Prestwich et al., 2014). However, the BCW addresses these issues by linking theoretical constructs to BCTs that are likely to bring about change in MIND diet behaviour. The findings from this feasibility RCT show that the BCW is an acceptable framework to design and deliver effective interventions to increase capability, opportunity, and motivation to adhere to the MIND diet. Consequently, the findings from the feasibility RCT (Chapter 7) is the first study to evaluate the feasibility and acceptability of a theory driven dietary intervention to promote the MIND diet in those at midlife, using the Behaviour Change Wheel.

8.4 Limitations and Strengths of the overall thesis

The systematic approach applied to developing the dietary intervention is a major strength and provides a strong coherent basis for intervention evaluation. The COM-B and TDF makes a novel application to understanding what would influence the uptake of the MIND diet, which informs the design of the intervention. Moreover, this study used the COM-B model as an additional step in the thematic analysis, which increased the study’s efficiency and showed that the entire framework was adequate for purpose. Furthermore, a major strength of the study is the design (RCT) that allowed for an objective examination of the effects of a 12 week dietary intervention on cognitive function, mood, and quality of life. Also, the use of CANTAB for measuring cognitive function, which is a highly sensitive battery of tests recognised as the gold standard cognitive assessment and data collection.

As with all work, there are several limitations to be considered when interpreting the findings from this research. One limitation was the small sample of the target population in phase 2 and 4 of the research process. However, the second phase of this research employed qualitative methodology, which small sample sizes are commonly used to gain an in-depth analysis of the phenomenon under investigation. Phase 4 of the research recruited a small sample size, although within power, it is important to note, that a larger scale study with a longer duration may produce different results on the study's outcome variables. However, this phase of the research was a feasibility and acceptability study, which is important preparatory work prior to a full scale RCT. Future research would include a full RCT with a longer duration to establish an association with MIND diet and cognitive function in adults at midlife. In addition, the researcher responsible for delivering the intervention, also conducted the evaluation. An independent evaluation should be conducted in future research (Siddiqui et al., 2018). It is possible that participants provided socially desirable responses (Acocella et al., 2012). However, to reduce this, participants were encouraged to discuss both positive and negative aspects of the intervention, as an independent evaluation was not possible in the context of this PhD. To conclude, despite a clear, well directed framework, the main limitation in the design of the intervention was the lengthy process, in particular, the coding of the BCTs and analysing qualitative data within the COM-B and TDF framework. However, this was overshadowed by the strength of the systematic approach in designing an intervention which provided a strong coherent basis for intervention evaluation.

8.5 Final conclusions and recommendations for future interventions and research

There is a clear need for larger scale interventions to establish an association with MIND diet and cognitive function. In particular, it is important that interventions promote adherence to the MIND diet. Previous theory driven research have limited success in promoting adherence to whole dietary patterns. The systematic review (Chapter 3) has suggested that studies are not rigorously applying theory to intervention design, implementation, and evaluation, and/or are failing to explicitly report theory use in sufficient detail. However, without implementing and evaluating an intervention, researchers would lack understanding of what components of the intervention work and what components do not work well. Researchers would also not understand if the intervention is feasible or acceptable to the target population. The research presented in this thesis informed the design of a theory driven intervention to promote uptake of the MIND diet using the BCW, to determine its feasibility and acceptability. The behavioural diagnosis was an important step in the design of the intervention, and shows that conducting formative research, could significantly inform an intervention design. Also, by doing formative research, intervention designers would have a better understanding of how to promote an intervention in any given population, which could aid uptake of the behaviour. In conclusion, the intervention was feasible to adults at midlife and deemed acceptable. However, the results of the intervention indicated that acceptability with the web-based components could be enhanced to increase engagement with the intervention. Therefore, the intervention should be refined prior to undertaking a full scale RCT to determine its effectiveness. Finally, we recommend that health professionals wanting to find effective ways to design lifestyle interventions and promote health and well-being in individuals and communities to use the BCW as an acceptable and effective approach to intervention design.

8.6 Intervention Recommendations

Prior to undertaking a full RCT of the intervention, the following amendments are recommended.

1. Use less BCTs in the design of the intervention, with a main focus on self-monitoring, goal setting and action planning.
2. Direct links to specific information on the website via text messages on a weekly basis
3. More contact with the researcher over the duration of the intervention to discuss engagement and provide feedback.
4. Remove the social support chat room
5. Provide a weekly meal planner
6. Provide a tracking system to access participants engagement with the website.

8.7 Research recommendations

Based on the findings from this thesis , the following recommendations for future research should be considered.

1. More research is needed, using a systematic approach to understand dietary behaviour, and in the development and evaluation of complex interventions.

2. The use of a systematic approach such as the BCW to design “whole dietary” interventions.
3. Future research with more explicit links between theory and outcome to identify which behaviour change theory and intervention techniques are the most salient in whole dietary interventions, advancing our understanding of behaviour change.
4. To use a fidelity framework to guide the reporting of treatment fidelity in future research, that will ultimately enhance the translation of theory into practice.
5. Public health campaigns should promote brain healthy diets as a strategy to promote cognitive function in younger age groups.
6. A larger scale RCT based on the intervention of this thesis should be undertaken after refinement of the intervention.
7. To determine generalisability, future research should evaluate this intervention more widely.
8. Consideration of a healthy diet, such as the MIND diet to improve aspects of psychological well-being and general health.

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Appendix 1

Study 1: Using the COM-B model to identify barriers and facilitators towards adoption of a diet associated with cognitive decline (MIND diet)

Ethical approval

UNIVERSITY OF ULSTER **RESEARCH GOVERNANCE**

RG1a APPLICATION TO UNDERTAKE RESEARCH ON HUMAN SUBJECTS

PLEASE REFER TO THE NOTES OF GUIDANCE BEFORE COMPLETING THIS FORM. (Available from the Research Governance website at http://www.ulster.ac.uk/research/rg/)

All sections of this form must be completed (use minimum font size 11). If the form is altered in any way, it will be returned unconsidered by the Committee.

This form should be used for research in categories A, B and D

Do not use this form for research being conducted in collaboration with the NHS/HPSS (category C).

SECTION A

Chief Investigator	Dr Liz Simpson
Title of	A qualitative study investigating the barriers and facilitators towards the uptake of a diet to promote brain health (MIND diet), in a sample of men and women aged 40-55 years in a Northern Irish and Italian population.

Project

Student and course (if applicable)	Deirdre Timlin (PhD Psychology)

Additional Investigators

Prof Jacqueline McCormack	School of Biomedical Sciences
Shannon Kenned	Placement student
Angela Polito (CRA-NUT Rome)	Centre for food and Nutrition
Donatella Ciarpica (CRA-NUT Rome)	Centre for food and nutrition
Elena Azzini (CRA-NUT Rome)	Centre for food and Nutrition
Barbara Giannantoni	Centre for food and nutrition

Declaration - Chief Investigator:

I confirm that

- this project meets the definition for research in category* ***(please insert)*** A
- this project is viable and is of research or educational merit.
- all risks and ethical and procedural implications have been considered.
- the project will be conducted at all times in compliance with the research description/protocol and in accordance with the University's requirements on recording and reporting.
- this application has not been submitted to and rejected by another committee; and
- Permission has been granted to use all copyright materials including questionnaires and similar instruments

Signed: **Date:**

Once complete, this application and all associated materials must be submitted for peer

***In addition, you should complete form RG1d for all category D research and form RG1e for both category B and D research**

Peer Review

Those conducting peer review should complete form RG2 and attach it to this form (RG1). RG1, RG2 and all associated materials should then be returned to the Chief Investigator.

- *Depending upon the outcome of peer review, the Chief Investigator should arrange to submit to the Filter Committee, resubmit the application for further review or consider a new or substantially changed project. The application must not be submitted to the Filter Committee until the peer review process has been completed (except as permitted below)*

- ***Please note that peer review can be conducted by the Filter Committee if time and capacity allow.*** *This is at the discretion of the Chairperson of each Filter Committee and is subject to change.*

- **Filter Committee**
- *The application must be considered by the Filter Committee in accordance with the requirements of the University*
- *The Filter Committee should complete form RG3 and write to the Chief Investigator indicating the outcome of its review*
- *Depending upon the outcome of the Filter Committee review, the Chief Investigator should arrange to proceed with the research OR submit to the University's Research Ethics Committee OR resubmit the application for further review OR consider a new or*

SECTION B

1. Where will the research be undertaken?

Ulster University or neutral venue in the community.

2. a. What prior approval/funding has been sought or obtained to conduct this. research? Please also provide the UU cost centre number if known

None

b. Please indicate any commercial interest in/sponsorship of the study

None

3. Duration of the Project

Start:October 2017	End: April 2018	Duration:7 months

4. eas ct

Please provide a brief summary in language comprehensible to a lay person or non-expert. Full details must be provided in the description/protocol submitted with this application (see Notes of Guidance)

The MIND diet (Morris et al., 2015) is a hybrid of the Mediterranean diet (Panagiotakos et al, 2007) and DASH (Dietary Approaches to stop Hypertension) (Sacks et al, 1998) diet. In previous research on the Mediterranean and DASH diets, it was found that both diets demonstrated protective effects on cardiovascular conditions that can adversely affect brain health, however, their dietary components may not specifically capture the levels and types of foods shown to optimize brain health. Therefore the MIND diet was designed to emphasize the dietary components and servings linked to neuroprotection and dementia prevention. Little is known about the pragmatic and cultural perspectives of adopting the MD in this non-Mediterranean country and the concept of how Irish citizens incorporate a Mediterranean/brain healthy diet into daily life (e.g. food availability, cost, personal preferences and preparation) has remained largely unexplored. This study addresses this gap and highlights the barriers and facilitators to eating a "brain healthy" diet, in an Irish population. The COM-B and

5. Aims of the Project

Please provide a brief summary in language comprehensible to a lay person or non-expert. Full details must be provided in the description/protocol submitted with this application (see Notes of

Guidance)

AIMS

The aim of the study is to establish facilitators and barriers to the uptake of the MIND diet.

OBJECTIVES:

- To determine participants perceived capability to the uptake of the MIND diet in 40-55 years old.
- To determine participants opportunity to the uptake of the MIND diet in 40-55 years old.
- To determine participants motivation to the uptake of the MIND diet in 40 -55 years old.
- To develop a dietary intervention to promote the MIND diet in 40-55 years old.

Please provide a brief summary in language comprehensible to a lay person or non-expert. Full details must be provided in the description/protocol submitted with this application (see Notes of Guidance)

DESIGN.

A qualitative study will be used to elicit beliefs surrounding Capability, Opportunity, Motivation and Behaviour (COM-B) with adhering to the “MIND” diet. Capability, motivation and opportunity will further be elaborated into 14 domains, using a more detailed tool to understand behaviour, the Theoretical Domains Framework. (TDF). Various forms of data collection will be used, including focus groups and interviews, using open ended questions.

PARTICIPANTS.

For the research, 25-30 Participants will be recruited onto the study, to take part in either a focus group or an interview. Participants will be both men and women aged between 40-55 years. Participants will be recruited via global university e-mail, Facebook and face to face, which will take place in Spring Island supermarket Coalisland and friends/family of the researcher (DC+EA)(DT). Interested participants will be given a participant information sheet (PIS)(appendix 1), consent form (appendix 2) and a “MIND DIET” leaflet (appendix 5) , explaining the elements of the MND diet. Participants approached face to face will be given a booklet explaining the MIND diet and asked to contact the researcher if interested in taking part. Participants will be excluded who follow a specific diet i.e gluten free diet. All interested participants will be asked to contact the researcher by email and dates, times and venue will be arranged for focus groups and interview. Participants will be informed that they can withdraw anytime they wish to do so. All data provided by participants will be held securely and in confidence.

b. Statistical techniques

Please provide details of the statistical techniques to be used within the project description/protocol (see Notes of Guidance)

The data will be analysed using Content Analysis, a well-established method for analyzing data (Braun & Clarke., 2006). This will involve reading each response to each question several times to get an overview of the general themes. Themes will be drawn out of the data and names assigned to these. Further reviews of all open ended questions will be carried out to ensure all themes and sub themes are identified, some may overlap, and themes will be merged to categorise the data. This will be further checked with links and relationships between themes being identified and explored. Two researchers will code the data to check the reliability of themes.

7. Subjects:

a. How many subjects will be recruited to the study (by group if appropriate)?

The COM-B model does not suggest how many participants to have in the study, however, it does advise on using more than one data collection technique, therefore, we will be using both focus groups and interviews. From the research, one study used 6 focus group containing 40 participants (Alexander, 2014). In Webb 2016, 14 interviews were conducted and Russel et al, 2016 had 29 interviews in their study. Based on this, the current study will conduct the following:

Minimum of 1 focus group	3-8
Interviews	12-15

b. Will any of the subjects be from the following vulnerable groups -

	YES	NO
Children under 18		X
Adults with learning or other disabilities		X
Very elderly people		X
Healthy volunteers who have a dependent or subordinate relationship to investigators		X
Other vulnerable groups		X

If YES to any of the above, please specify and justify their inclusion

c. Inclusion and exclusion criteria

Please indicate, with reasons, the inclusion criteria for the project

Inclusion criteria : Both male and female aged 40-55 (we are investigating midlife beliefs in consuming a diet to promote brain health)

Please indicate, with reasons, any exclusion criteria for the project

Exclusion criteria: Anyone on a specific diet i.e Gluten free diet

d. Will any inducements be offered? If 'Yes', please describe

No.

e. Please describe how and where recruitment will take place

Recruitment will take place online through an invitation on global university e-mails and Facebook and face to face. Interested participants will be asked to contact researcher by e-mail or private message on Facebook. Face to face participants will be recruited from the researchers (DT)(DC+EA) family and friends, and from a local supermarket in Coalisland (SprinIsland))

8. Ethical implications of the research

Please provide an assessment of the ethical implications of the project

The research questions are not of a sensitive nature. All participants will be given information about the study and what is involved if they decide to take part. They will be asked to complete a consent form. Also, participation is voluntary, and it will be explained that participants can withdraw from the study anytime and this will be explained to participants in the PIS, which they will read prior to consent and on the consent form.

Participants will be informed that all information is confidential, and that data will be stored securely at the researcher's home and at Ulster university and only accessible to the researcher. Confidentiality will be maintained by means of securing information and data on researcher's computer and locked in a safe place were only the researcher has access to it. After completion of the study, all information will be stored safely at the University of Ulster for 10 years after which it will be destroyed. Participants will be informed that focus group/interview recordings will be destroyed immediately after it has been transcribed.

9. Could the research identify or indicate the existence of any undetected healthcare concern?

Yes [ ] **No** [X]

If **Yes**, please indicate what might be detected and explain what action will be taken (e.g. inform subject's GP)

10. Risk Assessment **

Please indicate any risks to subjects or investigators associated with the project

No risks were identified to participants and the nature of the questions are not sensitive. Information on the MIND diet will be provided in a leaflet. The researcher will be conducting interviews and focus groups alone, therefore, measures will be put in place to reduce risk.

****If you wish, you can use form RG1c – Risk Assessment Record (available from the Research Governance website) to help you assess any risks involved**

11. Precautions

Please describe precautions to be taken to address the above

Information will be provided in a leaflet on the MIND diet. Information given on diet in PIS. Also, information can be found on the MIND diet at www.NHS.UK and Web MD. Researcher will inform CI when and where the interview/focus group

12. Consent form

It is assumed that as this study is being conducted on human subjects, an information sheet and associated consent form will be provided. A copy of the information sheet and form must be attached to this application. See Notes of Guidance.

If a consent form is not to be used, please provide a justification:

13. Care of personal information

Please describe the measures that will be taken to ensure that subjects' personal data/information will be stored appropriately and made available only to those named as investigators associated with the project.

All data will be handled confidentially. All consent forms, questionnaires and data will securely stored for 10 years in keeping with UU policy

14. Copyright

Has permission been granted to use all copyright materials including questionnaires and similar instruments?

x	

Yes **No** If **No**, please provide the reason

Once you have completed this form you should also complete form RG1d for all category D research and form RG1e for both category B and D research

Appendix 2

Ulster University

PARTICIPANT INFORMATION SHEET

1. Study title

A qualitative study investigating the barriers and facilitators towards the uptake of a diet that promotes brain health (MIND diet), in a sample of men and women aged 40-55 years in a Northern Irish and Italian population.

2. Invitation paragraph

My name is Deirdre Timlin, this study is being undertaken as part fulfilment of a PhD in Psychology under the supervision of Dr Liz Simpson.

You are being invited to take part in a research study to explore your beliefs about consuming a diet that promotes brain health. Before you decide whether or not to take part, it is important that you understand what the research is for and what you will be asked to do. Please read the following information and do not hesitate to ask any questions about anything that might not be clear to you. Make sure that you are happy before you decide what to do. Thank you for taking the time to consider this invitation.

3. What is the purpose of the study?

This study is looking at attitudes and beliefs about eating the MIND diet, which is a diet to promote brain health. Reasons why people may or may not consume a "healthy" diet. It is being carried out, so we can get a better understanding of the barriers and facilitators to the uptake the MIND diet.

4. Why have I been chosen?

You have been chosen to take part in this study as you are a male or female aged between 40-55 years old and you are not consuming a restrictive or special diet i.e. gluten free diet.

5. Do I have to take part?

It is up to you to decide whether or not to take part. If you do decide to take part, you will be given this information sheet to keep. You will also be asked to complete a tick box consent form and given a leaflet containing information on the MIND diet. If you choose to take part, you can change your mind and withdraw from the study without giving a reason up until the focus group/interview begin.

6. What will happen to me if I take part?

If you agree to take part, you will be asked to take part in a focus group (informal group discussion) or a one to one interview about barriers and facilitators to consuming a brain heathy diet. It should take no longer than 60 minutes.

7. Risks and/or disadvantages?

This research does not pose any threat to you as a participant, the questions are not of a sensitive nature. However, if you want more information on the MIND diet and its benefits, you will find help information on the Participant Information Sheet.

8. Are there any possible benefits in taking part?

The main aim of this research is to provide us with a better understanding of people's beliefs and attitudes towards consuming the MIND diet, and to identify barriers and facilitators to the uptake of the diet. It will be used to develop an intervention to assess the diets benefits on cognitive function.

9. What if something goes wrong?

It is very unlikely that anything will go wrong, and risks are minimal in this study. If something does go wrong the University has procedures in place for reporting, investigating, recording, and handling adverse events. Any complaints will be taken seriously and should be made to the Chief Investigator, whose contact details are given at the bottom of this information sheet.

10. Will my taking part in this study be kept confidential?

All data provided by you will be held securely and in confidence. The only people to have access to the data are myself, the chief investigator and two other additional investigators.

11. What will happen to the results of the study?

The results of this study will be used to design an intervention looking at the benefits of the diet on cognitive function.

12. Who has reviewed this study?

This study has been reviewed by other people who are knowledgeable in the subject area and by the School of Psychology's Ethics Filter Committee in accordance with the University procedures.

13. Contact details

Student contact details:
Deirdre Timlin
E-Mail: Timlin-D1@ulster.ac.uk
Chief investigator:
Dr Liz Simpson
E-mail: eea.simpson@ulster.ac.uk
Tel: 02870123207

Appendix 3

Consent Form

Title of Project: A qualitative study investigating the barriers and facilitators towards the uptake of a diet to promote brain health (MIND diet), in a sample of men and women aged 40-55 years in a Northern Irish population.

Name of Chief Investigator: Dr Liz Simpson

- I confirm that I have been given and have read and understood the information sheet for the above study and have asked and received answers to any questions raised [ ]
- I understand that my participation is voluntary and that I am free to withdraw up until I start the focus group/interview. [ ]
- I understand that the researchers will hold all information and data collected securely and in confidence for 10 years, and that all efforts will be made to ensure that I cannot be identified as a participant in the study (except as might be required by law) and I give permission for the researchers to hold relevant personal data [ ]
- I agree to take part in the above study [ ]
- I agree to being recorded [ ]
- Would you be interested in taking part in further research? yes [ ] no [ ]
- Do you consent to being contacted regarding further research? yes [ ] no [

Signed

- Participant……………………………………………………………………………………….
- Researcher……………………………………………………………………………………….

Appendix 4: E-mail invitation

Participants required for study investigating beliefs and attitudes towards consuming a diet that promotes brain health. (MIND diet).

MIND stands for Mediterranean-DASH Intervention for Neurodegenerative Delay. It's similar to two other healthy diets: the DASH diet and the Mediterranean diet.

Researchers have found that people who stuck to a diet that included foods like berries, leafy greens, and fish has been associated with lowering the risk and slowing the progression of Alzheimer's disease.

If you are aged 40-55years and reside in Northern Ireland, we would like to invite you to participant in this study.

Participants will be asked to take part in an interview or focus group (informal group discussion) lasting 30-60 minutes.

If you are interested in taking part, you can contact Deirdre Timlin on Timlin-D1@ulster.ac.uk, or private message Deirdre Timlin on Facebook.

Many thanks.

This e-mail and the study to which it applies have been approved by the School of Psychology Filter Committee.

Appendix 5

Personal information form.

Please complete the following form by giving the required information and ticking the appropriate boxes

AGE:

GENDER:

TELEPHONE NUMBER:

OCCUPATION:

HEIGHT:

WEIGHT:

MARITAL STATUS

Please tick the appropriate box

- o Married [ ]
- o Co-habiting [ ]
- o Separated [ ]
- o Widowed [ ]
- o Single [ ]

EDUCATION

Please tick appropriate box

- o No formal qualification [ ]
- o A 'level [ ]
- o NVQ/HNC/HND [ ]
- o Degree [ ]
- o Masters or above [ ]

WHERE DO YOU LIVE?

- o City [ ]
- o Town [ ]
- o Village [ ]
- o Countryside [ ]

PLEASE SAY HOW OFTEN YOU EAT THE FOLLOWING FOODS BY TICKING THE APPROPRIATE BOX.

	More than once a day	Daily	2-3 times a week	Once a week	Less than once a week
Fruit and veg					
Fish					
Chicken					
Nuts					
Whole grains					
Red meat					
Cheese					
Fast/fried food					
Sweets/pastries					
Butter					
Alcohol					

Do you follow any specific diet i.e. Gluten free, fat free, Atkinson etc?

Yes [ ] No [ ]

Appendix 6

Permission to collect data

Springisland
fresh & local market

2 Washingbay Road
Coalisland
Co. Tyrone
BT71 4ND

Tel: 028 8774 7272
Fax: 028 8774 7841

20.10.17

To Whom It May Concern,

I, Austin Kelly give Deirdre Timlin permission to hand out booklets for her study in my shop.

Austin Kelly
Manager

Registered Office:
2 Washingbay Road, Coalisland, Co. Tyrone, BT71 4ND
Registered in Northern Ireland
Reg. No. 51615

Who are we looking for:

- ❖ Men and women aged between 40-55 years old

What will volunteers have to do?

- ❖ Complete a consent form.
- ❖ Complete a personal information form.

Take part in either a group discussion or an interview, discussing what it would take to consume a healthy diet that promotes brain health.

Contact E-mails

Timlin-D1@ulster.ac.uk

Chief Investigator:

eea.simpson@ulster.ac.uk

Mailing Address:

School of Psychology

Ulster University

Coleraine

Co. Londonderry

What is the MIND diet?

The MIND diet stands for, Mediterranean-Dash Intervention for Neuro-degenerative delay and research shows it has been attributed to lowering the risk and slowing the progression of Alzheimer's disease, the leading cause of dementia.

What are the elements of the MIND diet?

There are 15 dietary components to the MIND diet (10 brain healthy and five unhealthy)

BRAIN HEALTHY.

- Leafy greens: Every day
- Other vegetables: Every day
- Nuts: Most days
- Berries: Twice a week
- Beans: Every other day
- Whole grains: Three times a day
- Fish: Once a week
- Poultry: Twice a week
- Olive oil:
- Wine: One glass a day

UNHEALTHY. Less than once a week.

- Red meat
- Butter and stick margarine
- Cheese
- Pastries and sweets
- Fried or fast foods

Appendix 8

Study 2: Cross cultural “behavioural diagnosis” examining the uptake of the MIND diet, using the COM-B model to inform an intervention.

Ethics application

Amendments RG6

UU Ref No:

UNIVERSITY OF ULSTER

RESEARCH GOVERNANCE

Form RG6 Notification of a proposed substantial amendment

Chief Investigator: Dr Liz Simpson

Approved Study Title:

A qualitative study investigating the barriers and facilitators towards the uptake of a diet to promote brain health (MIND diet), in a sample of men and women aged 40-55 years in a Northern Irish and Italian population.

New/Amended Title (if appropriate):

Type of Amendment (please indicate any that apply):

- Amendment to application form [x]
- Amendment to description/protocol [ ]
- Amendment to the information sheet/consent or other supporting information [ ]

Summary of Changes:

Main changes:

Additional investigators: Barbara Giannantoni page 10

Declaration:

I confirm that the information in this form is accurate and that implementation of the proposed amendment will benefit the study appropriately.

Signed: D Timlin Date: 18.3.18

List of enclosed documents:

N/A

Additional ethical considerations:

The study does not foresee any additional ethical considerations.

Appendix 9

Study 3: ***The MIND diet, cognitive function, and well-being among healthy adults at midlife. A randomised feasibility trial***

Ethics application

UNIVERSITY OF ULSTER **RESEARCH GOVERNANCE**

RG1a APPLICATION TO UNDERTAKE RESEARCH ON HUMAN SUBJECTS

PLEASE REFER TO THE NOTES OF GUIDANCE BEFORE COMPLETING THIS FORM. (Available from the Research Governance website at http://www.ulster.ac.uk/research/rg/)

All sections of this form must be completed (use minimum font size 11). If the form is altered in any way it will be returned unconsidered by the Committee.

This form should be used for research in categories A, B and D

Do not use this form for research being conducted in collaboration with the NHS/HPSS (category C).

SECTION A

Chief Investigator	Dr Liz Simpson
Title of Project	**A feasibility pilot RCT to promote adherence of a diet associated with cognitive decline (MIND diet) in midlife**
Student and course (if applicable)	Deirdre Timlin (PhD Psychology)
Additional Investigators	Prof Jacqueline McCormack Clinical Health and Nutrition Centre, Sligo Institute of Technology, Ireland Dr. Maeve Kerr : School of Biomedical Science

Declaration - Chief Investigator:

I confirm that

- this project meets the definition for research in category* ***(please insert)*** A
- this project is viable and is of research or educational merit;
- all risks and ethical and procedural implications have been considered;
- the project will be conducted at all times in compliance with the research description/protocol and in accordance with the University's requirements on recording and reporting;
- this application has not been submitted to and rejected by another committee; and
- Permission has been granted to use all copyright materials including questionnaires and similar instruments

Signed: **Date**

Once complete, this application and all associated materials must be submitted for peer

***In addition, you should complete form RG1d for all category D research and form RG1e for both category B and D research**

Peer Review

- *Those conducting peer review should complete form RG2 and attach it to this form (RG1). RG1, RG2 and all associated materials should then be returned to the Chief Investigator.*

- *Depending upon the outcome of peer review, the Chief Investigator should arrange to submit to the Filter Committee, resubmit the application for further review or consider a new or substantially changed project. The application must not be submitted to the Filter Committee until the peer review process has been completed (except as permitted below)*

- **Filter Committee**
- *The application must be considered by the Filter Committee in accordance with the requirements of the University*
- *The Filter Committee should complete form RG3 and write to the Chief Investigator indicating the outcome of its review*
- *Depending upon the outcome of the Filter Committee review, the Chief Investigator should arrange to proceed with the research OR submit to the University's Research Ethics Committee OR resubmit the application for further review OR consider a new or substantially changed project*
- *The Filter Committee should retain a complete set of original forms.*

SECTION B

1. Where will the research be undertaken?

Ulster University or neutral venue in the community.

2. a. What prior approval/funding has been sought or obtained to conduct this. research? Please also provide the UU cost centre number if known

None

b. Please indicate any commercial interest in/sponsorship of the study

None

3. Duration of the Project

Start: March 2019	End: September 2019	Duration: 8 months

4. Background to and reason(s) for the Project

Please provide a brief summary in language comprehensible to a lay person or non-expert. Full details must be provided in the description/protocol submitted with this application (see Notes of Guidance)

Maintaining healthy dietary behaviours is crucial for population health and the prevention of non-communicable disease. Statistics show that there are 850,000 people in the UK with dementia (Alzheimer's Society. Dementia UK update, 2014). It is estimated that by 2025, 20% of the population will be over 65 and with this increased longevity, there is a need to identify potential variables such as diet to promote healthy ageing.

A Mediterranean-like dietary pattern has been strongly encouraged for the prevention of major chronic diseases (Trichopoulou et al., 2014). There are several credible organisations in the UK that provide dietary information have promoted consumption of the Mediterranean Diet (MD) to the public, including *NHS Choices* and *Patient.co.uk.*

The MIND diet (Morris et al., 2015) is a hybrid of the Mediterranean diet (Panagiotakos et al, 2007) and DASH (Dietary Approaches to stop Hypertension) (Sacks et al, 1998) diet. In previous research on the Mediterranean and DASH diets, it was found that both diets demonstrated protective effects on cardiovascular conditions that can adversely affect brain health, however, their dietary components may not specifically capture the levels and types of foods shown to optimize brain health. Therefore, the MIND diet was designed to emphasize the dietary components and servings linked to neuroprotection and dementia prevention.

To our knowledge, this is the first RCT to be conducted on the MIND diet. This is also the first study examining the MIND diet at midlife, and also the first study examining the MIND diet using a theoretical framework to understand behaviour.

5. Aims of the Project

Please provide a brief summary in language comprehensible to a lay person or non-expert. Full details must be provided in the description/protocol submitted with this application (see Notes of Guidance)

Objectives

To assess the effectiveness of a 12-week dietary intervention designed to promote adherence to the MIND diet

To assess the effectiveness of a 12-week dietary intervention to increase capability, opportunity and motivation in the uptake of the MIND diet

To assess the effectiveness of the MIND on the cognitive function

To evaluate acceptability of the 12-week intervention and explore participants experiences of the intervention

6. Procedures to be used

a. Methods

Please provide a brief summary in language comprehensible to a lay person or non-expert. Full details must be provided in the description/protocol submitted with this application (see Notes of Guidance)

Method: Design

This study will be a 2 (control Vs intervention) x 2(baseline Vs follow up) factorial variance on repeated measures design. Outcome measures for COM-B, cognitive function?, mood and quality of life will be recorded for both the intervention and control groups.

Intervention

Participants in the intervention will be asked to take part in a 12 week online dietary intervention (click here for link to website). Participants will meet with the researcher twice. Once at baseline to take measures and be introduced to the website, and again at follow up to take final measures. The intervention has been designed based on the guidance and approach of the Behaviour Change Wheel and the results from phase 1 qualitative research (see appendix 1 for intervention map). Participants will be asked to engage in each week of the intervention which provides advice and information on adhering to the MIND diet. Participants will also be asked to monitor their food intake by means of a food frequency questionnaire and food dairy (2 days, 2 weekend days) in week 1,6 and 12. Participants will also be asked to complete a food chart daily by tick box to monitor adherence to the MIND diet elements. Participants will receive a weekly text message to remind them to complete food chart. To allow participants to engage with each other and the researcher, MOODLE (chat room) will be on the website and the researcher will engage and monitor participants throughout the intervention period.

Control

The control group will be asked to follow the diet without the 12 week intervention to support them. The control group will be asked to complete all the same measures as the intervention group at the same baseline and follow up. The control group will also record their food intake using the food frequency questionnaire, food diary and chart.#

Participants and recruitment

Forty to fifty will be selected to take part in the study. Participants will be healthy male and female aged between 40-55 years old living in Northern Ireland. Participants will be excluded if they do not eat certain elements of the MIND diet, such as vegans or vegetarians. An advertisement will be posted around the local communities for interested people to contact the researcher (appendix). Also, a notice will be posted on social media (appendix) and Ulster university global email (appendix). All interested participants will be asked to contact the researcher by email and dates, times and venue will be arranged for baseline data collection. Participants will be emailed a participant information sheet (PIS) to gain further information on the study.

Materials

Cognitive function? CANTAB? Paper measure? MMSE?
Panas?
COM-B questionnaire
QOL: WHOQOL
FFQ: Harvard Willet FFQ ?
MIND diet chart
Food diary

Procedure

Following ethical approval, participants will be approached by Ulster university staff, student e-mail, social media and face to face. The invitation email/social media message (appendix 3) will contain some brief information about the study. Participants approached face to face will be given an information leaflet (appendix 7) on the MIND diet. All Interested participants will be asked to contact the researcher by email and they will be sent a participant information sheet (PIS), consent form and information leaflet on the MIND diet. Date, time and venue will be arranged data collection.

b. Statistical techniques

Please provide details of the statistical techniques to be used within the project description/protocol (see Notes of Guidance)

The data will be analysed using Content Analysis, a well-established method for analyzing data (Braun & Clarke., 2006). This will involve reading each response to each question several times to get an overview of the general themes. Themes will be drawn out of the data and names assigned to these. Further reviews of all open-ended questions will be carried out to ensure all themes and sub themes are identified, some may overlap and themes will be merged to categorise the data. This will be further checked with links and relationships between themes being identified and explored. Two researchers will code the data to check the reliability of themes.

7. Subjects:

a. How many subjects will be recruited to the study (by group if appropriate)?

The COM-B model does not suggest how many participants to have in the study, however, it does advise on using more than one data collection technique, therefore, we will be using both focus groups and interviews. From the research, one study used 6 focus group containing 40 participants (Alexander, 2014). In Webb 2016, 14 interviews were conducted and Russel et al, 2016 had 29 interviews in their study. Based on this, the current study will conduct the following:

Intervention With support	15
Intervention no support	15
Control	15

b. Will any of the subjects be from the following vulnerable groups -

	YES	NO
Children under 18		X
Adults with learning or other disabilities		X
Very elderly people		X
Healthy volunteers who have a dependent or subordinate relationship to investigators		X
Other vulnerable groups		X

If YES to any of the above, please specify and justify their inclusion

c. Inclusion and exclusion criteria

Please indicate, with reasons, the inclusion criteria for the project

Inclusion criteria : Both male and female aged 40-55 (we are investigating midlife adherence in consuming a diet to promote brain health)

Please indicate, with reasons, any exclusion criteria for the project

Exclusion criteria: Anyone on a specific diet i.e vegetarian, vegan

d. Will any inducements be offered? If 'Yes', please describe

No.

e. Please describe how and where recruitment will take place

Recruitment will take place online through an invitation on global university e-mails and social media and face to face. Interested participants will be asked to contact researcher by e-mail. Face to face participants will be recruited from the researchers (DT) family and friends, and from a local community in Coalisland

8. Ethical implications of the research

Please provide an assessment of the ethical implications of the project

All participants will be given information about the study and what is involved if they decide to take part. They will be asked to complete a consent form. Also, participation is voluntary, and it will be explained that participants can withdraw from the study anytime and this will be explained to participants in the PIS, which they will read prior to consent and on the consent form. Participants will be informed that all information is confidential, and that data will be stored securely at the researcher's home and at Ulster university and only accessible to the researcher. Confidentiality will be maintained by means of securing information and data on researcher's computer and locked in a safe place were only the researcher has access to it. After completion of the study, all information will be stored safely at the University of Ulster for 10 years after which it will be destroyed. Participants will be informed that focus group/interview recordings will be destroyed immediately after it has been transcribed.

9. Could the research identify or indicate the existence of any undetected healthcare concern?

Yes [ ] **No** [X]

If **Yes**, please indicate what might be detected and explain what action will be taken (e.g. inform subject's GP)

10. Risk Assessment **

Please indicate any risks to subjects or investigators associated with the project

****If you wish, you can use form RG1c – Risk Assessment Record (available from the Research Governance website) to help you assess any risks involved**

11. Precautions

Please describe precautions to be taken to address the above

Information will be provided in a leaflet on the MIND diet. Information given on diet in PIS. Also, information can be found on the MIND diet at www.NHS.UK and Web MD. Researcher will inform CI when and where the data collection takes place and always have a phone at hand.

12. Consent form

It is assumed that as this study is being conducted on human subjects, an information sheet and associated consent form will be provided. A copy of the information sheet and form must be attached to this application. See Notes of Guidance.

If a consent form is not to be used, please provide a justification:

13. Care of personal information

Please describe the measures that will be taken to ensure that subjects' personal data/information will be stored appropriately and made available only to those named as investigators associated with the project.

All data will be handled confidentially. All consent forms, questionnaires and data will securely stored for 10 years in keeping with UU policy

14. Copyright

Has permission been granted to use all copyright materials including questionnaires and similar instruments?

Yes [x] **No** [ ] If **No**, please provide the reason

Once you have completed this form you should also complete form RG1d for all category D research and form RG1e for both category B and D research

Appendix 2

Appendix 10: Consent Form RCT

Title of Project: A feasibility pilot RCT to promote adherence of a diet associated with cognitive decline (MIND diet)

Name of Chief Investigator: Dr Liz Simpson

- I confirm that I have been given and have read and understood the information sheet for the above study and have asked and received answers to any questions raised [ ]
- I understand that my participation is voluntary and that I am free to withdraw up until I start the focus group/interview. [ ]
- I understand that the researchers will hold all information and data collected securely and in confidence for 10 years, and that all efforts will be made to ensure that I cannot be identified as a participant in the study (except as might be required by law) and I give permission for the researchers to hold relevant personal data [ ]
- I agree to take part in the above study [ ]
- I agree to being recorded [ ]
- Would you be interested in taking part in further research? yes [ ] no [ ]
- Do you consent to being contacted regarding further research? yes [ ] no [

Signed

- Participant…………………………………………………………………………………………….
- Researcher…………………………………………………………………………………………….

Appendix 11
Participant information sheet: Intervention with no support
Study title

A feasibility pilot RCT to promote adherence of a diet associated with cognitive decline (MIND diet)

2. Invitation paragraph

My name is Deirdre Timlin, this study is being undertaken as part fulfilment of a PhD in Psychology under the supervision of Dr Liz Simpson.

You are being invited to take part in a 12-week study to explore your capability, opportunity and motivation on dietary patterns associated with brain health and to assess the effects of dietary intake on your cognitive function, mood and quality of life. Before you decide whether or not to take part, it is important that you understand what the research is for and what you will be asked to do. Please read the following information and do not hesitate to ask any questions about anything that might not be clear to you. Make sure that you are happy before you decide what to do. Thank you for taking the time to consider this invitation.

3. What is the purpose of the study?

The primary aim of the study is to investigate participants capability, opportunity and motivation on consuming a diet that promotes brain health. The study will also examine the effectiveness of the MIND diet on participants uptake of the diet, mood, quality of life and cognitive function.

4. Why have I been chosen?

You have been chosen to take part in this study as you are a male or female aged between 40-55 years old and you are not consuming a restrictive or special diet i.e. Vegan

5. Do I have to take part?

It is up to you to decide whether or not to take part. If you do decide to take part, you will be given this information sheet to keep. You will also be asked to complete a tick box consent. If you choose to take part, you can change your mind and withdraw from the study without giving a reason.

6. What will happen to me if I take part?

If you agree to take part, you will be randomised into one of 3 groups: You have been randomised into the intervention group with no support. You will be asked to consume foods that are healthy for the brain and reduce some foods that are not healthy for your brain for 12 weeks. You will receive information on the foods to eat and portion sizes. You will be asked to complete questionnaires on mood, quality of life, alcohol and complete a computerised memory test before and after the 12-week intervention. You will also be asked to keep track of your food intake by a daily chart that you tick the relevant box, and a food diary which is kept for 7 days of the week, only in week 1 and 12.

7. Risks and/or disadvantages?

This research does not pose any threat to you as a participant. However, if you want more information on the MIND diet and its benefits, you will find help information on the Participant Information Sheet and in the link below. https://www.nhs.uk/news/food-and-diet/new-brain-diet-slows-mental-decline/

8. Are there any possible benefits in taking part?

The main aim of this research is to provide us with a better understanding of the effectiveness of the diet on brain health, mood and quality of life, and the effectiveness of the specifically designed 12-week intervention programme on improving your capability, opportunity and motivation on consuming the MIND diet.

9. What if something goes wrong?

It is very unlikely that anything will go wrong, and risks are minimal in this study. If something does go wrong the University has procedures in place for reporting, investigating, recording and handling adverse events. Any complaints will be taken seriously and should be made to the Chief Investigator, whose contact details are given at the bottom of this information sheet.

10. Will my taking part in this study be kept confidential?

All data provided by you will be held securely and in confidence. The only people to have access to the data are myself, the chief investigator and four other additional investigators. After completion of the study, all information will be stored safely at the University of Ulster for 10 years in a locked cabinet after which it will be destroyed.

11. What will happen to the results of the study?

The results of this study may be used to conduct further, larger studies to confirm the effectiveness and benefits of the diet. It is also possible that results may inform policy makers in diet recommendations for brain health

12. Who has reviewed this study?

This study has been reviewed by other people who are knowledgeable in the subject area and by the School of Psychology's Ethics Filter Committee in accordance with the University procedures.

13. Contact details

Student contact details:
Deirdre Timlin
E-Mail: Timlin-D1@ulster.ac.uk
Chief investigator:
Dr Liz Simpson
E-mail: eea.simpson@ulster.ac.uk
Tel: 02870123207

Appendix 12
Participant information sheet: Intervention with support
Study title

A feasibility pilot RCT to promote adherence of a diet associated with cognitive decline (MIND diet)

2. Invitation paragraph

My name is Deirdre Timlin, this study is being undertaken as part fulfilment of a PhD in Psychology under the supervision of Dr Liz Simpson.
You are being invited to take part in a 12-week study to explore your capability, opportunity and motivation on dietary patterns associated with brain health and to assess the effects of dietary intake on your cognitive function, mood and quality of life. Before you decide whether or not to take part, it is important that you understand what the research is for and what you will be asked to do. Please read the following information and do not hesitate to ask any questions about anything that might not be clear to you. Make sure that you are happy before you decide what to do. Thank you for taking the time to consider this invitation.

3. What is the purpose of the study?

The primary aim of the study is to investigate participants capability, opportunity and motivation on consuming a diet that promotes brain health. The study will also examine the effectiveness of the MIND diet on participants uptake of the diet, mood, quality of life and cognitive function.

4. Why have I been chosen?

You have been chosen to take part in this study as you are a male or female aged between 40-55 years old and you are not consuming a restrictive or special diet i.e. Vegan

5. Do I have to take part?

It is up to you to decide whether or not to take part. If you do decide to take part, you will be given this information sheet to keep. You will also be asked to complete a tick box consent. If you choose to take part, you can change your mind and withdraw from the study without giving a reason.

6. What will happen to me if I take part?

If you agree to take part, you will be randomised into one of 3 groups: You have been randomised into the intervention group with support. You will be asked to consume foods that are healthy for the brain and reduce some foods that are not healthy for your brain for 12 weeks with online support. This support consists of hints, tips and advice on brain heathy foods and social support. You y
complete a computerised memory test before and after the 12-week intervention. You will also be asked to keep track of your food intake by a daily chart that you tick the relevant box, and a food diary which is kept for 7 days of the week, only in week 1 and 12.

7. Risks and/or disadvantages?

This research does not pose any threat to you as a participant. However, if you want more information on the MIND diet and its benefits, you will find help information on the Participant Information Sheet and in the link below.
https://www.nhs.uk/news/food-and-diet/new-brain-diet-slows-mental-decline/

8. Are there any possible benefits in taking part?

The main aim of this research is to provide us with a better understanding of the effectiveness of the diet on brain health, mood and quality of life, and the effectiveness of the specifically designed 12-week intervention programme on improving your capability, opportunity and motivation on consuming the MIND diet.

9. What if something goes wrong?

It is very unlikely that anything will go wrong, and risks are minimal in this study. If something does go wrong the University has procedures in place for reporting, investigating, recording and handling adverse events. Any complaints will be taken seriously and should be made to the Chief Investigator, whose contact details are given at the bottom of this information sheet.

10. Will my taking part in this study be kept confidential?

All data provided by you will be held securely and in confidence. The only people to have access to the data are myself, the chief investigator and four other additional investigators. After completion of the study, all information will be stored safely at the University of Ulster for 10 years in a locked cabinet after which it will be destroyed.

11. What will happen to the results of the study?

The results of this study may be used to conduct further, larger studies to confirm the effectiveness and benefits of the diet. It is also possible that results may inform policy makers in diet recommendations for brain health

12. Who has reviewed this study?

This study has been reviewed by other people who are knowledgeable in the subject area and by the School of Psychology's Ethics Filter Committee in accordance with the University procedures.

13. Contact details

Student contact details:
Deirdre Timlin
E-Mail: Timlin-D1@ulster.ac.uk
Chief investigator:
Dr Liz Simpson
E-mail: eea.simpson@ulster.ac.uk
Tel: 02870123207

Appendix 13
Participant information sheet: Control group
Study title

A feasibility pilot RCT to promote adherence of a diet associated with cognitive decline (MIND diet)

2. Invitation paragraph

My name is Deirdre Timlin, this study is being undertaken as part fulfilment of a PhD in Psychology under the supervision of Dr Liz Simpson.
You are being invited to take part in a 12-week study to explore your capability, opportunity and motivation on dietary patterns associated with brain health and to assess the effects of dietary intake on your cognitive function, mood and quality of life. Before you decide whether or not to take part, it is important that you understand what the research is for and what you will be asked to do. Please read the following information and do not hesitate to ask any questions about anything that might not be clear to you. Make sure that you are happy before you decide what to do. Thank you for taking the time to consider this invitation.

3. What is the purpose of the study?

The primary aim of the study is to investigate participants capability, opportunity and motivation on consuming a diet that promotes brain health. The study will also examine the effectiveness of the MIND diet on participants uptake of the diet, mood, quality of life and cognitive function.

4. Why have I been chosen?

You have been chosen to take part in this study as you are a male or female aged between 40-55 years old and you are not consuming a restrictive or special diet i.e. Vegan

5. Do I have to take part?

It is up to you to decide whether or not to take part. If you do decide to take part, you will be given this information sheet to keep. You will also be asked to complete a tick box consent. If you choose to take part, you can change your mind and withdraw from the study without giving a reason.

6. What will happen to me if I take part?

If you agree to take part, you will be asked to follow your regular diet for 12 weeks. You will be asked to complete questionnaires on mood, quality of life, alcohol and complete a computerised memory test before and after the 12-weeks. You will also be asked to keep track of your food with a food diary which is kept for 4 days of the week, only in week 1,6 and 12.

7. Risks and/or disadvantages?

This research does not pose any threat to you as a participant. However, if you want more information on the MIND diet and its benefits, you will find help information on the Participant Information Sheet and in the link below.
https://www.nhs.uk/news/food-and-diet/new-brain-diet-slows-mental-decline/

8. Are there any possible benefits in taking part?

The main aim of this research is to provide us with a better understanding of the effectiveness of the diet on brain health, mood and quality of life, and the effectiveness of the specifically designed 12-week intervention programme on improving your capability, opportunity and motivation on consuming the MIND diet.

9. What if something goes wrong?

It is very unlikely that anything will go wrong, and risks are minimal in this study. If something does go wrong the University has procedures in place for reporting, investigating, recording and handling adverse events. Any complaints will be taken seriously and should be made to the Chief Investigator, whose contact details are given at the bottom of this information sheet.

10. Will my taking part in this study be kept confidential?

All data provided by you will be held securely and in confidence. The only people to have access to the data are myself, the chief investigator and four other additional investigators. After completion of the study, all information will be stored safely at the University of Ulster for 10 years in a locked cabinet after which it will be destroyed.

11. What will happen to the results of the study?

The results of this study may be used to conduct further, larger studies to confirm the effectiveness and benefits of the diet. It is also possible that results may inform policy makers in diet recommendations for brain health

12. Who has reviewed this study?

This study has been reviewed by other people who are knowledgeable in the subject area and by the School of Psychology's Ethics Filter Committee in accordance with the University procedures.

13. Contact details

Student contact details:
Deirdre Timlin
E-Mail: Timlin-D1@ulster.ac.uk
Chief investigator:
Dr Liz Simpson
E-mail: eea.simpson@ulster.ac.uk
Tel: 02870123207

Appendix 14

E-mail invitation RCT

Are you worried about your brain health? Does dementia run in your family?

Participants required for study investigating the effectiveness a diet that promotes brain health. (MIND diet).

MIND stands for Mediterranean-DASH Intervention for Neurodegenerative Delay. It’s similar to two other healthy diets: the DASH diet and the Mediterranean diet.

Researchers have found that people who stuck to a diet that included foods like berries, leafy greens, and fish has been associated with lowering the risk and slowing the progression of Alzheimer’s disease.

If you are aged 40-55years and reside in Northern Ireland, we would like to invite you to participant in this study.

Participants have the opportunity to have access to an online 12-week programme designed to support you in consuming the MIND diet.

If you are interested in taking part, you can contact Deirdre Timlin on Timlin-D1@ulster.ac.uk, or private message Deirdre Timlin on Facebook.

Many thanks.

This e-mail and the study to which it applies have been approved by the School of Psychology Filter Committee.

Appendix 15 COM- questionnaire

	TDF domains	Questionnaire item 1 2 3 4 5 Strongly disagree disagree not sure agree strongly agree
Psychological capability	Knowledge	• I am familiar with the MIND diet 1 2 3 4 5 Strongly disagree disagree not sure agree strongly agree • I know what foods are healthy for my brain 1 2 3 4 5 Strongly disagree disagree not sure agree strongly agree
	Behaviour regulation	• I keep on track of my food intake by monitoring what I eat 1 2 3 4 5 Strongly disagree disagree not sure agree strongly agree • It is beneficial to me to record my food intake 1 2 3 4 5 Strongly disagree disagree not sure agree strongly agree • I eat brain healthy foods without thinking 1 2 3 4 5 Strongly disagree disagree not sure agree strongly agree
	Memory, attention and decision processes	• I find it easy to consume MIND diet foods

		1 2 3 4 5 Strongly disagree disagree not sure agree strongly agree
Physical capability	Skills	1 2 3 4 5 Strongly disagree disagree not sure agree strongly agree • I have the skills to cook MIND diet foods 1 2 3 4 5 Strongly disagree disagree not sure agree strongly agree • I have the ability to source recipes to cook MIND diet meals
Physical opportunity	Environmental resources and context	• MIND diet foods are affordable 1 2 3 4 5 Strongly disagree disagree not sure agree strongly agree • I have adequate access to MIND diet foods 1 2 3 4 5 Strongly disagree disagree not sure agree strongly agree • I have enough time to prepare/cook MIND diet foods/meals 1 2 3 4 5 Strongly disagree disagree not sure agree strongly agree • There are many opportunities to consume MIND diet foods both at work and home 1 2 3 4 5 Strongly disagree disagree not sure agree strongly agree

Social opportunity	Social influence	• I am easily influenced in my food choices by my friends and family 1 2 3 4 5 Strongly disagree disagree not sure agree strongly agree • I can consume MIND diet foods in social situations 1 2 3 4 5 Strongly disagree disagree not sure agree strongly agree
Reflective motivation	Belief about capabilities	• I am confident I can consume MIND diet foods even when there is little time 1 2 3 4 5 Strongly disagree disagree not sure agree strongly agree • For me, eating the MIND diet is: very difficult – very easy 1 2 3 4 5 Strongly disagree disagree not sure agree strongly agree • I have a plan for consuming the MIND diet foods 1 2 3 4 5 Strongly disagree disagree not sure agree strongly agree • I would be willing to make a plan of how of much MIND diet foods to eat each week 1 2 3 4 5 Strongly disagree disagree not sure agree strongly agree • I am confident I can eat MIND diet foods even when I am not motivated

	Belief about consequences	1 2 3 4 5 Strongly disagree disagree not sure agree strongly agree • There are many benefits to the MIND diet 1 2 3 4 5 Strongly disagree disagree not sure agree strongly agree • I feel good about myself when I eat MIND diet foods 1 2 3 4 5 Strongly disagree disagree not sure agree strongly agree • For me, eating MIND diet foods are bad---good 1 2 3 4 5 Strongly disagree disagree not sure agree strongly agree
Automatic motivation	Emotion	• Consuming MIND diet foods makes me feel happy 1 2 3 4 5 Strongly disagree disagree not sure agree strongly agree • Consuming MIND diet foods makes me feel 1 2 3 4 5 Strongly disagree disagree not sure agree strongly agree

Appendix 16: : WHOQOL BREF

THE WHOQOL-BREF

1. How would you rate your quality of life?

(1)Very poor (2) Poor (3) Neither poor nor good (4) Good (5) Very good

2. How satisfied are you with your health?

(1) Very dissatisfied (2)Dissatisfied (3) Neither satisfied nor dissatisfied (4)Satisfied (5) Very satisfied

The following questions ask about how much you have experienced certain things in the last two weeks.

(1)Not at all (2) A little (3) A moderate amount (4)Very much (5)An extreme amount

3. To what extent do you feel that (physical) pain prevents you from doing what you need

to do?

1 2 3 4 5

4.How much do you need any medical treatment to function in your daily life?

1 2 3 4 5

5 How much do you enjoy life?

1 2 3 4 5

6 . To what extent do you feel your life to be meaningful?

1 2 3 4 5

(1)Not at all (2) A little (3)A moderate amount (4)Very much Extremely

7 How well are you able to concentrate?

1

2

3

4

5

8 How safe do you feel in your daily life?

1

2

3

4

5

9

(F22.1)

How healthy is your physical environment?

1

2

3

4

5

The following questions ask about

how completely

you experience or were able to do certain things in the last two

weeks.

(1)Not at all (2)A little (3)Moderately (4)Mostly (5)Completely

10 Do you have enough energy for everyday life?

1 2 3 4 5

11 Are you able to accept your bodily appearance?

1 2 3 4 5

12 Have you enough money to meet your needs?

1

2

3

4

5

13 How available to you is the information that you need in your day-to-day life?

1 2 3 4 5

14 To what extent do you have the opportunity for leisure activities?

1 2 3 4 5

(1)Very poor (2)Poor (3)Neither poor nor good (4)Good (5)Very good

15 How well are you able to get around?

1

2

3

4

5

The following questions ask you to say how good or satisfied you have felt about various aspects of your life over the last two weeks.

(1)Very dissatisfied (2)Dissatisfied (3)Neither satisfied nor dissatisfied (4)Satisfied (5)Very

satisfied

16 How satisfied are you with your sleep?

1

2

3

4

5

17 How satisfied are you with your ability to perform your daily living activities?

1 2 3 4 5

18 How satisfied are you with your capacity for work?

1 2 3 4 5

19 How satisfied are you with yourself?

1

2

3

4

5

20 How satisfied are you with your personal relationships?

1 2 3 4 5

21 How satisfied are you with your sex life?

1

2

3

4

5

22 How satisfied are you with the support you get from your friends?

1	2	3	4	5

23 How satisfied are you with the conditions of your living place?

1	2	3	4	5

24 How satisfied are you with your access to health services?

1	2	3	4	5

25 How satisfied are you with your transport?

1

2

3

4

5

The following question refers to how often you have felt or experienced certain things in the last two weeks.

(1) Never (2) Seldom (3) Quite often (4) Very often (5) Always

26 How often do you have negative feelings such as blue mood, despair, anxiety,

depression?

1	2	3	4	5

Appendix 17

PANAS SCALE

Scale & Scorecard

1	2	3	4	5
Very slightly or not at all	A little	Moderately	Quite a bit	Extremely

#	Score	Feelings/emotions
1		Interested
2		Distressed
3		Excited
4		Upset
5		Strong
6		Guilty
7		Scared
8		Hostile
9		Enthusiastic
10		Proud
11		Irritable
12		Alert
13		Ashamed
14		Inspired
15		Nervous
16		Determined
17		Attentive
18		Jittery
19		Active
20		Afraid

MIND DIET

A healthy diet promoting brain health

Contact E-mails
Timlin-D1@ulster.ac.uk
Chief Investigator:
eea.simpson@ulster.ac.uk

Mailing Address:
School of Psychology
Ulster University
Coleraine
Co. Londonderry

What is the MIND diet?

The MIND diet stands for, Mediterranean-Dash Intervention for Neuro-degenerative delay and research shows it has been attributed to lowering the risk and slowing the progression of Alzheimer's disease, the leading cause of dementia.

What are the elements of the MIND diet?

There are 15 dietary components to the MIND diet (10 brain healthy and five unhealthy)

BRAIN HEALTHY.

- Leafy greens: Most days
- Other vegetables: Every day
- Nuts: Most days
- Berries: Twice a week
- Beans: Every other day
- Whole grains: Three times a day
- Fish: Once a week
- Poultry: Twice a week
- Olive oil:
- Wine: One glass a day

Restrict

- Red meat: No more than 4xweek
- Butter: No more than 1tbspxday
- Cheese: Less than 1xweek
- Pastries and sweets: less than 5xweek
- Fried or fast foods: Less than 1xweek

Would you like to take part in this study and help us investigate the effectiveness of consuming a healthy diet that promotes brain health?

MIND DIET

A healthy diet promoting brain health

Mailing Address:
School of Psychology
Ulster University
Coleraine
Co. Londonderry

Contact E-mails
Timlin-D1@ulster.ac.uk
Chief Investigator:
eea.simpson@ulster.ac.uk

Appendix 17

Homepage of the website

The face of the website provided information on each food group from the MIND diet. Information provided included examples of foods in each food group, portion sizes, frequency of foods to be eaten each week, research on the benefits of each foods on the brain. A range of recipes for breakfast, lunch, dinner and snacks were available, access to a chat room for peer support, which was moderated by the researcher and access to week's 1-12 where information was given to support adherence to the MIND diet.

Week one:

Week one focused on raising awareness of dementia, dementia statistics and risk factors associated with it. There was also information given on the benefits of the MIND diet and links to further information on dementia and diet. Participants were given an action plan for week one which included:

1. Recording their daily intake of food in the chart provided
2. Trying an easy meal from the recipes provided
3. Writing down the pros and cons of eating the MIND diet
4. Joining the chat room for peer support.

Week two:

Week two focussed on workplace diet traps providing hints and tips in how to adhere to the MIND diet at work and avoid unhealthy foods, such as bring your own lunch, eat breakfast, plan your snacks. Actions for week 2 included:

1. Plan your healthy snacks daily

2. Take a healthy snack to work with you
3. Buy in MIND diet foods
4. Take a walk at work instead of having a snack.
5. Record daily food chart

Week 3 & 4

Week 3 & 4 focussed on encouraging participants to be positive, encouraged positive thinking regarding eating habits, self-monitoring, and barriers and facilitators to healthy eating, in particular, Time, Taste preference, Tired, Mindset and hints and tips on how to overcome barriers such as preparation, online shopping and plan weekly meals.

Actions for week 3&4 included

1. Complete daily food chart
2. If you have a smoothie maker/blender, set it on your worktop within your sight, to prompt healthy smoothie making
3. Plan your meals for the week and stick it on the fridge for you to see each day.

Week 5&6

This week focussed on social opportunity and how to deal with peer pressure. This week also aimed to motivate participants to cook more often, to enjoy cooking and involve the family to help promote healthy eating. Actions for the week

1. Tell a friend or family how you are doing, their support may be helpful

2. Complete daily food chart

Week 7&8

This week provided hints and tips on eating out such as, read online menu, stick to one course, eat tomato based, avoid deep fried, and healthier option examples. This week also provided hints and tips on food cravings, and healthier alternatives to unhealthy snacks. Actions for this week included:

1. Why not arrange a meal out and put in motion this week's tips?

2. Complete your food chart daily

Week 9&10

This week provided information on comfort eating, how to identify, deal with and triggers of comfort eating, and provided some non-food comfort fixes. This week also provided information on mindful eating, what mindful eating is and how to do it.

Actions for week 9&10

1. Complete daily food chart

2. Set your goals for the week and stick it on the fridge for you to see each day.

Week 11&12

This week focussed on maintenance relapse prevention and weight management. This week also introduced SMART goals and encouraged participants to use this concept in maintaining healthy dietary patterns going forward. SMART stands for specific, measurable, achievable, relevant and time specific.

Actions for week 11&12

1. Reward yourself with that non-food treat you promised yourself!

2. Be aware of your food portions

3. Set your SMART goals

4. Complete your food diary in week 12.

5. Complete daily food chart