University of Southampton

Faculty of Medicine

Human Development and Health

Improving the Diets of Older People

by

Ilse Bloom

Thesis for the degree of Doctor of Philosophy

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Abstract

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Despite the recognised importance of diet for health in older age and how common poor diet quality and nutritional status are at this stage of the life course, little is known about the complexity of influences on diet quality at this age, particularly in community-living people. Furthermore, there is limited understanding of how a transition between relatively good quality diets in early old age, to poorer quality diets and greater risk of malnutrition observed at older ages, might occur.

In this project, participants were recruited from the Hertfordshire Cohort Study (HCS) and focus groups were run to explore influences on diet among community-dwelling older people living in the county of Hertfordshire, UK. Drawing upon the qualitative findings, a secondary data analysis of previously collected HCS data was carried out to identify psychosocial correlates of diet quality in older community-dwelling men and women, and determine their associations with change in diet quality over 10 years. This was followed by a mapping study in the local context of the city of Southampton, to describe services or interventions available to local community-dwelling older people that might support their diets. This study formed part of the process evaluation of the GENIE (Generating Engagement in Network Involvement) pilot intervention study. The last piece of work was a pilot study of the GENIE social network intervention, which was carried out in a group of older community-dwelling adults in the Southampton area. In this pilot study, the potential of improving social networks to promote diet quality was evaluated.

The findings from the qualitative study suggested that social and psychological factors were important influences on diet and that they may mediate some of the effects of age-related factors on the diets of older people. Findings from the quantitative study showed that a range of social factors, including greater participation in social and cognitive leisure activities, were associated with diets of better quality in cross-sectional analyses. The mapping study identified a range of services that could support the diets of community-living older people in Southampton, however these did not appear to be adequately joined-up. The results of the pilot study suggest that a social network intervention of this kind may hold promise for the promotion of diet quality of community-based older adults.

This thesis has added to the evidence-base on influences on older people's diets, particularly in a UK context. It has especially highlighted modifiable factors, such as social isolation, that could be targeted in interventions and public health strategies to promote the diets and health of community-living older adults. Further larger intervention studies, with appropriate evaluation, are needed to establish the effectiveness of such interventions. In addition, psychological factors such as resilience, self-efficacy and outcome expectancies, should also be considered as a part of such strategies. It may be crucial for these interventions to be put in place early on to prevent decline in diet quality and associated poor health outcomes.

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DECLARATION OF AUTHORSHIP

I, Ilse Bloom, declare that this thesis and the work presented in it are my own and has been generated by me as the result of my own original research.

IMPROVING THE DIETS OF OLDER PEOPLE

I confirm that:

1. This work was done wholly or mainly while in candidature for a research degree at this University;
2. Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated;
3. Where I have consulted the published work of others, this is always clearly attributed;
4. Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work;
5. I have acknowledged all main sources of help;
6. Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself;
7. Parts of this work have been published: Please see Outputs from this project (page xiii).

Signed: .....

Date: .....

Declaration – details of my contribution

I specify below the tasks that I have undertaken for this research project.

Chapter 3: I set up the data collection for this qualitative study; I contributed to writing the ethics application for the study, I developed the protocol and accompanying materials (e.g. participant information sheet) for the focus groups, with guidance from Dr Wendy Lawrence, and I recruited study participants and organised the focus groups. Together with Dr Wendy Lawrence, I conducted focus groups; both of us had moderator and observer roles. I transcribed verbatim the focus group discussion audio recordings. I analysed and interpreted the qualitative data with the assistance of other members of the research team. I wrote this work up for publication – I wrote the first draft of the paper, helped to revise the manuscript and approved the final version.

Chapter 4: I developed the analysis plan and contributed to directing the statistical analyses that were carried out; analyses were performed by a statistician in the MRC LEU (Karen Jameson). Together with other members of the research team, I interpreted the results of the statistical analyses, and I wrote this work up as a first draft of a paper for publication. I liaised with the other authors of the paper to finalise the manuscript for publication.

Chapter 5: I performed online searches both to describe the local policy context in Southampton and to identify relevant local services in the area. To achieve these aims, I also developed a network of contacts from the Southampton City Council, the NHS Southampton City Clinical Commissioning Group (CCG) and the voluntary sector within Southampton, and engaged in discussions and attended meetings with local policymakers and commissioners.

Chapter 6: I established a collaboration with researchers in the NIHR CLAHRC Wessex; I developed the questionnaire that was used in this study to collect data on health behaviours, and contributed to developing the materials such as the protocol and participant information sheet. I contributed to writing the ethics amendment application for this study. I trained collaborating researchers to administer the health behaviour questionnaire and supervised data collection. I cleaned and analysed the study data, with assistance from a statistician (Karen Jameson) and the MRC LEU computer team, and interpreted the results of the analyses.

I performed the search and review of the literature on the influences on older people's diets and wrote the Introduction chapter (Chapter 1). I wrote this thesis.

Related published peer-reviewed articles:

Appendix H: I performed, together with another researcher (Calum Shand), the literature screening and data extraction and assessment of risk of bias. I wrote the first draft of the article and liaised with the other authors to finalise the manuscript for publication.

Appendix I: I contributed to the interpretation of the data, helped to revise and draft the manuscript and approved the final version.

Outputs from this PhD project

Publications

Chapters published as peer-reviewed articles:

Chapter 3: Bloom I, Lawrence W, Barker M, Baird J, Dennison E, Sayer AA, Cooper C and Robinson SM. What influences diet quality in older people? A qualitative study among community-dwelling older adults from the Hertfordshire Cohort Study, UK. *Public Health Nutrition*. 2017; 20(15):2685-2693. https://doi.org/10.1017/S1368980017001203 (Appendix D)

Chapter 4: Bloom I, Edwards M, Jameson KA, Syddall HE, Dennison E, Gale CR, Baird J, Cooper C, Sayer AA and Robinson SM. Influences on diet quality in older age: the importance of social factors. *Age and Ageing*. 2017; 46(2):277-83. https://doi.org/10.1093/ageing/afw180 (Appendix E)

Related published peer-reviewed articles:

Bloom I, Shand C, Cooper C, Robinson SM and Baird J. Diet Quality and Sarcopenia in Older Adults: A Systematic Review. *Nutrients*. 2018; 10, 308. https://doi.org/10.3390/nu10030308 (Appendix H)

Robinson SM, Jameson KA, Bloom I, Ntani G, Crozier SR, Syddall HE, Dennison E, Cooper C and Sayer AA. Development of a short questionnaire to assess diet quality among older community-dwelling adults. *The journal of nutrition, health & aging*. 2017; 21(3):247-253. https://doi.org/10.1007/s12603-016-0758-2 (Appendix I)

Published abstracts:

Conference abstract 'Diet quality in later life: the importance of social factors': The 11th Nordic Nutrition Conference NNC2016. Food & Nutrition Research. 2016; 60: 31961. http://dx.doi.org/10.3402/fnr.v60.31961.

Conference abstract 'Influences on diet quality in older age: the importance of social factors': The 12th International Congress of the European Union Geriatric Medicine Society. European Geriatric Medicine. 2016, 7, Supplement 1: S29–S259. http://dx.doi.org/10.1016/S1878-7649(16)30149-8.

Conference abstract 'A social network intervention to promote diet quality in older adults: a pilot study': Abstracts of the 14th International Congress of the European Geriatric Medicine Society. European Geriatric Medicine. 2018, 9, Supplement 1: S1–S367. https://doi.org/10.1007/s41999-018-0097-4.

Presentations

Event/location	Date	Title of presentation	Type of presentation
Ageing 2016 Conference, London, UK	9-11 February 2016	Diet quality in later life: the importance of social factors	Poster
11th Nordic Nutrition Conference, Gothenburg, Sweden	20-22 June 2016	Diet quality in later life: the importance of social factors	Poster
Faculty of Medicine Research Conference, Southampton, UK	23 June 2016	Diet quality in later life: the importance of social factors	Oral presentation
12th International Congress of the European Union Geriatric Medicine Society (EUGMS) 2016, Lisbon, Portugal	5-7 October 2016	Influences on diet quality in older age: the importance of social factors	Poster
Doctoral Research Showcase 2018, Southampton, UK	16 May 2018	How does diet affect loss of muscle in older people?	Poster *(won award)*
Southampton Medical and Health Research Conference, Southampton, UK	6 June 2018	Diet quality and sarcopenia in older adults: a systematic review	Oral presentation
14th International Congress of the European Geriatric Medicine Society (EuGMS) 2018, Berlin, Germany	10-12 October 2018	A Social Network Intervention To Promote Diet Quality In Older Adults: A Pilot Study	Poster

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List of abbreviations

BMI – Body Mass Index

CI – Confidence interval

CVD – Cardiovascular disease

FFQ – Food Frequency Questionnaire

GENIE – Generating Engagement in Network Involvement

HCS – Hertfordshire Cohort Study

HQS – Hertfordshire Qualitative Study

MRC – Medical Research Council

NIHR CLAHRC – National Institute for Health Research Collaboration for Leadership in Applied Health Research and Care

NDNS – National Diet and Nutrition Survey

NICE – National Institute for Health and Care Excellence

PCA – Principal Component Analysis

RCT – Randomised controlled trial

SACN – Scientific Advisory Committee on Nutrition

SD – Standard Deviation

UK – United Kingdom

US or USA – United States of America

WHO – World Health Organization

Chapter 1: Introduction

1.1 An ageing population

The global population is ageing in parallel with increasing life expectancy. Between 2000 and 2050, the proportion of the world's population aged over 60 years is set to double from about 11% to 22%, and in absolute terms it will more than triple from 600 million to 2 billion (World Health Organization, 2014). In the UK, there are now over 11.6 million people aged 65 or over (17.8% of the population) (Office for National Statistics, 2016), and the number of people aged 65 years and above is projected to rise; by 2030, one in five people will be over 65 (House of Lords Select Committee on Public Service and Demographic Change, 2013, Oliver et al., 2014). Increases in the oldest older people are also evident; since 2005, the UK population aged 85 years and over has increased by 31% (Office for National Statistics, 2016).

For individuals, an increase in life expectancy may not be matched by a rise in health expectancy. An estimated 40% of all people aged 65 or over in the UK have a limiting longstanding illness (Age UK, 2017). The combination of an ageing population and the increase in chronic conditions have a substantial impact on health and social care needs; this was estimated to require an additional expenditure of £5 billion by 2018 (Age UK, 2017). People aged 65 and over currently account for 51% of local authority spending on adult social care (Health and Social Care Information Centre, 2013).

There are multiple ways of defining 'older people'. A definition of 'older age' could encompass various dimensions, including not only chronological age but also change in social role, for example, becoming a grandparent or a pensioner, and change in functional, mental or physical capabilities (United Nations, 2012). Although categorisation by age can be useful in a practical sense, the loss of functional ability typically associated with ageing is only loosely related to an individual's chronological age (World Health Organization, 2015). The United Nations uses 60 years to refer to older people, but in many developed countries (including the UK), the most widely accepted definition of an older person is an individual who is aged 65 years or over, as this is often the age at which individuals become eligible for old-age social security benefits. In contrast, the WHO (World Health Organization) defines an 'older person' as 'a person whose age has passed the median life expectancy at birth' (World Health Organization, 2015), which in the UK is currently 81.4 years for both men and women (World Health Organization, 2016). To take into account the variation in definitions used across the literature, in the context of this thesis the

concept of 'older age' refers mainly to ages 65 years and over, although it should be noted that some of the literature relating to 'older age' does include younger ages, from 50 years and over.

Understanding the determinants of good health in older age is crucial to be able to support older people to maintain their independence and quality of life.

1.2 Diet and nutrition in older age

Healthy lifestyle behaviours, even after the age of 75, are associated with increased life expectancy, probably through effects on reducing morbidity (Rizzuto et al., 2012). Adequate diet and nutrition is an important part of healthy ageing, helping to maintain health and independence into older age. Diet plays a central role in preventing disease, managing existing illness and minimising physical dependency with increasing age (Haveman-Nies et al., 2003, Drewnowski and Evans, 2001).

Recent nationally representative data from the National Diet and Nutrition Survey (NDNS) (collected from 2014/2015 to 2015/2016) show that diets are relatively similar in terms of 'healthiness' in adults aged 65 years and over, when compared to younger adults (Public Health England, 2018). This was indicated by similar intakes of free sugars (average intakes were above the recommended maximum of no more than 5% of daily total energy intake; 11.2% for adults 65 years and over, 11.1% for adults 19-64 years); similar fibre intakes (average intakes were well below the recommendation of 30g/day for adults; 17.5g/day for adults ≥65 years, 19g/day for adults 19-64 years); similar average consumption of saturated fat (average intakes were above the recommended maximum of 11% of food energy; 13.8% for adults ≥65 years, 12.5% for adults 19-64 years), and of fruit and vegetables (average consumption was below the recommended 5 portions per day; 3.9 portions for adults ≥65 years, 4.2 portions for adults 19-64 years). Age differences in terms of dietary intake were more obvious between the two age groups of older adults (65-74 years and 75 years and over) that were considered separately in this most recent NDNS survey (Public Health England, 2018). Mean consumption of fruit and vegetables was lower (3.4 portions per day) for adults aged 75 years and over, than for 65- to 74-year-olds (4.3 portions); only 18% of men and 20% of women aged 75 years and over, compared to 31% of men and 32% of women aged 65 to 74 years, met the "5 A Day" recommendation for fruit and vegetables. Average saturated fat intakes were higher for adults aged 75 years and over (14.6% of energy intake) than for adults aged 65 to 74 years (13.1%), both exceeding the recommendation (no more than 11% of food energy). Mean daily intakes of most vitamins from food sources were close to or above the RNI (Reference Nutrient Intake) for both the older age groups; however, mean intakes of vitamin D (excluding supplements) were below the RNI in both older age groups

(35% of the RNI for adults aged 65 to 74 years and 28% of the RNI for adults aged 75 years and over). Mean intakes of most minerals were also close to or above the RNI for both older age groups, with the exception of magnesium, potassium and selenium. For selenium, a substantial proportion of older adults in both older age groups had intakes below the LRNI (Lower Reference Nutrient Intake). A higher proportion of women aged 75 years and over had intakes below the LRNI compared to the other older adult age/sex groups for most micronutrients. Overall, the survey results give some indications that diets may be relatively 'healthier' in adults aged 65 to 74 years, when compared to adults aged 75 years and over.

Nonetheless, despite these suggestions, poor diet quality has been described in older adults in the UK (aged 60 years and over) (Maynard et al., 2006, Johnson et al., 1998, Margetts et al., 2003) and poor nutritional status is common in people aged 65 years and over (Elia et al., 2010, Margetts et al., 2003). Indeed, malnutrition (or undernutrition) has become a serious concern; BAPEN (the British Association for Parenteral and Enteral Nutrition) estimates that 1.3 million people over 65 years in the UK are affected by it, the majority of whom are living in the community (BAPEN, 2016). Furthermore, very old adults (at least 85 years of age) in the UK may be at increased risk of micronutrient deficiencies, and it is likely that a sizeable proportion of very old adults have low protein intakes (defined as <0.8g of protein/kg of adjusted bodyweight/day) (Mendonça et al., 2016, Mendonça et al., 2017). These dietary inadequacies could contribute to muscle loss, disability and loss of physical function in very old adults (Mendonça et al., 2016, Mendonça et al., 2017).

Thus, despite some encouraging evidence that diet quality might be relatively good in early old age, there is a transition between this stage (with adequate diet) to the onset of poorer diets and greater risk of malnutrition seen at older ages. Trajectories of diet are poorly described and it is not clear what leads to the deterioration of diet quality and nutritional status that is common in older people (Nieuwenhuizen et al., 2010, Otsuka et al., 2018). It is likely that this transition could be affected by the physiological, psychological, and social changes that often accompany ageing (Elsner, 2002), which can pose a threat to adequate dietary intake and lead to poorer diet quality, and ultimately poor nutritional status, especially at older ages.

1.2.1 Age-related changes in dietary intake

Longitudinal data indicate a decline in dietary intake with older age, both in terms of energy and some nutrients (Wakimoto and Block, 2001, Moreiras et al., 1996, Amorim Cruz et al., 1996, Otsuka et al., 2016). It has been estimated that from 40 to 70 years of age average energy intake drops by about 25% (Nieuwenhuizen et al., 2010). Data from the NDNS show that there is a

decrease in energy intake in older age, with mean daily energy intakes below the SACN EAR (estimated average requirement) recommendations for both older age groups considered (65-74 years and 75+ years) (Public Health England, 2018). Even though in later life lower activity levels lead to lower energy needs, the reduction in food intake is only partially offset by lower energy expenditure. As a result, older people can lose body weight, especially due to loss of muscle mass (Nieuwenhuizen et al., 2010). Furthermore, in many older adults decreased food or energy intake can lead to monotonous diets with inadequate nutrient intakes, including low intakes of protein and micronutrients (Bartali et al., 2003, Drewnowski and Evans, 2001). Although energy requirements decrease in older age, requirements for most vitamins and minerals remain stable (Public Health England, 2016b), which means that a higher nutrient density may be important to ensure nutrient needs are met (Bartali et al., 2003).

Criteria often used to identify malnutrition include low BMI (usually defined as BMI <20 kg/m^2) and unintentional weight loss (Stratton et al., 2007). These criteria may be less effective in predicting inadequacies in other nutrients. Nonetheless, a higher risk of malnutrition or undernutrition (assessed according to a composite measure of low BMI and recent weight loss) has been associated with lower micronutrient status in community-dwelling older adults, with individuals at high risk of malnutrition more likely to have poorer status of micronutrients such as zinc and vitamins A, D, E and C (Margetts et al., 2003). This highlights the importance of adequate diet quality to ensure nutrient intakes are sufficient, since diets of better quality are likely to provide higher micronutrient intakes (Robinson et al., 2009). There is currently little evidence regarding the link between poor diet quality and development of overt malnutrition, and whether changes in diet quality precede weight loss. In a recent prospective study of US community-dwelling older adults aged 70–79 years, poor diet quality (as assessed by poor Healthy Eating Index (HEI) scores, reflecting poorer adherence to dietary recommendations for the US population) was not identified as a risk factor for the long-term development of protein-energy malnutrition (defined as BMI <20 kg/m^2, involuntary weight loss of ≥5% in the preceding year, or both) in community-dwelling older adults (Hengeveld et al., 2018). The findings did, however, suggest that a lower protein intake was associated with a higher risk of protein-energy malnutrition.

A decline in energy intakes in older adults, as well as changes in dietary choices and habits, could be partly explained by age-associated changes in metabolism or physiological function, physical decline (e.g. mobility) as well as changes in social circumstances (Elsner, 2002, Morley, 2001). It is also likely that illness and comorbidities affect appetite and dietary intake in older age through a multitude of mechanisms including molecular, sensory, and functional pathways (Lee et al., 2006, Pilgrim et al., 2015, Langhans, 2007). Furthermore, some of the medications that older adults may

require due to various conditions could alter their senses of taste and smell or cause nausea, also leading to reduced appetite (Schiffman, 1997). **Figure 1** highlights the diverse range of age-related factors that may affect nutritional intake in older adults, eventually leading to an increased risk of malnutrition in older adults.

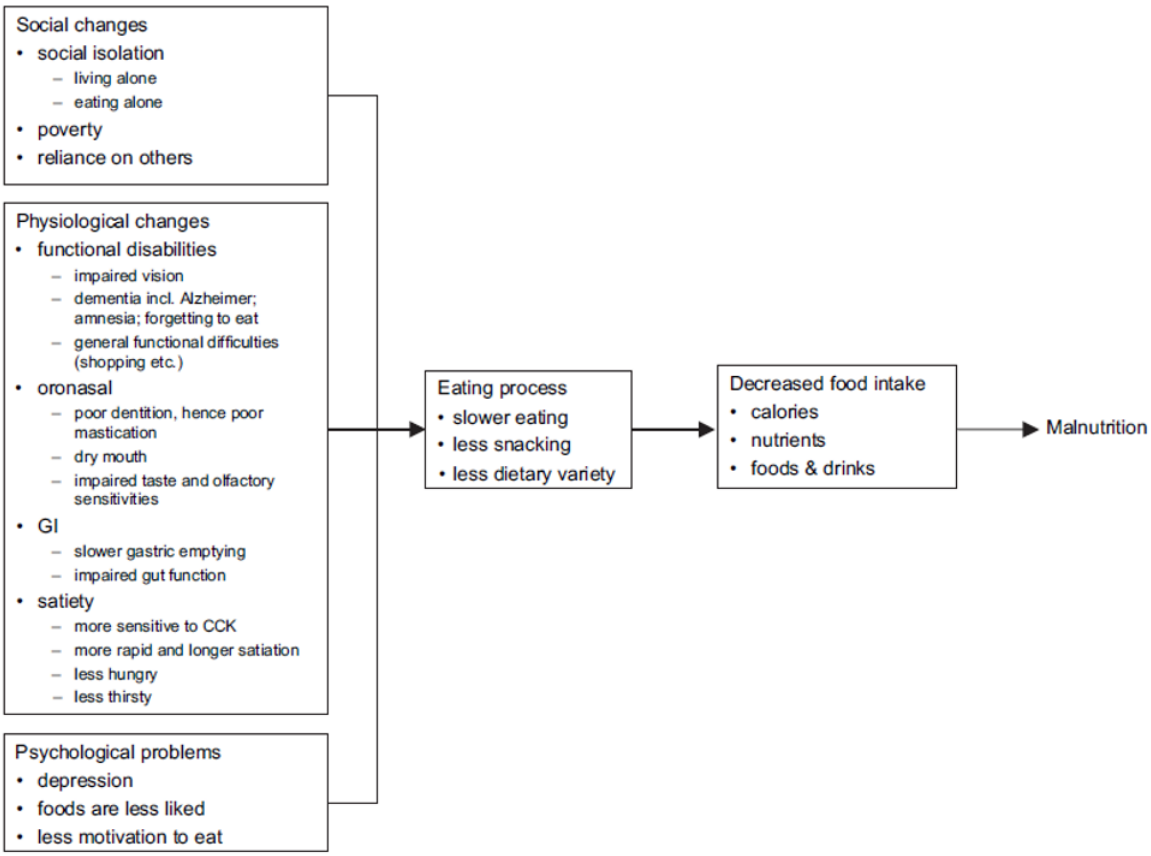


Figure 1 Age-related factors that affect nutritional intake in older adults, and could lead to malnutrition in older adults, from Nieuwenhuizen et al. (Nieuwenhuizen et al., 2010). GI: gastrointestinal; CCK: cholecystokinin.

1.3 Diet quality

1.3.1 Assessment of diet quality

Traditionally, research in the field of nutrition and health has been centred on individual nutrients or single foods or food groups, but in the last three decades there has been a growing focus on the diet as a whole, or dietary patterns. This constitutes an alternative approach to using single nutrients or single foods/food groups to assess diet, often described as overall diet quality. This approach considers that foods are eaten in combinations, that there are likely to be complex interactions between nutrients, and that other constituents of foods and the balance of these might be important (Hu, 2002).

Dietary patterns can be defined using two approaches; the first is a data-driven or empirical approach, where patterns are derived *a posteriori* using multivariate statistical techniques, such as cluster analysis, while the second approach uses diet quality indices, which are dietary scoring methods based on *a priori*-defined patterns (Waijers et al., 2007, Kant, 1996).

A posteriori methods, including principal component analysis (PCA) or factor analysis, use dietary data to identify common underlying factors or patterns of food consumption, and then combine correlated dietary items. *A priori* methods usually use diet quality indices or scores to assess how well the diet agrees with a particular predetermined 'optimal' diet, for example by assessing adherence to dietary recommendations or to a specific type of diet, such as the Mediterranean diet (Hu, 2002, Milte and McNaughton, 2016). Although both of these dietary pattern approaches possess certain limitations when attempting to assess diet quality, overall, they provide a useful way of describing diet and are widely used. Despite using different methods (e.g. different statistical techniques and numerous dietary indices with differing scoring approaches), they often share common features (e.g. high fruit and vegetable consumption), and the core principles of these measures are similar since the "healthiness" of diets is typically described by similar foods (Waijers et al., 2007, Willcox et al., 2014). As such, these methods of diet quality assessment can be useful for studying which factors have an impact on diets in older people and to research the effects of existing dietary behaviours and patterns on the health of older populations.

1.3.2 Importance of diet quality in older age

In line with the evidence for younger adults (Carlos et al., 2018), better diet quality in older adults has been linked with beneficial effects on health outcomes, including with a reduced risk of common age-related diseases (e.g. cardiovascular disease and dementia) and with longevity. The following subsections describe some of the evidence for the importance of diet quality in older age.

The term 'diet quality', referring to the quality of the whole diet, is generally used to describe how well an individual's diet adheres to dietary recommendations. When compared with less healthy dietary patterns, healthy dietary patterns are marked by greater intake of beneficial foods (e.g. fruit and vegetables, whole grains, fish, lean meat, low-fat dairy, nuts, and olive oil) and lower intake of nutrient-poor foods (e.g. refined grains, sweets and animal products that are high in saturated fats), which leads to diets that are dense in essential nutrients but lower in energy (Willcox et al., 2014).

1.3.2.1 Mortality

In older people, consistent longitudinal associations have been found between high diet quality and a lower risk of all-cause mortality, a lower risk of cardiovascular disease mortality, and a lower risk of cancer mortality (McNaughton et al., 2012, Reedy et al., 2014).

Data from the European Prospective Investigation into Cancer and Nutrition (EPIC-Elderly) cohort, which includes Europeans who were 60 years or older at recruitment into the EPIC study (from multiple centres in ten European countries), found that an *a posteriori* plant-based dietary pattern, with high consumption of vegetables, fruit, grains and legumes and low consumption of potatoes, margarine and non-alcoholic beverages, was associated with a longer life expectancy (lower all-cause mortality) (Bamia et al., 2007). A large-scale US prospective cohort study found that higher diet scores (assessed by four diet quality indices; the Healthy Eating Index–2010 (HEI-2010), the Alternative Healthy Eating Index–2010 (AHEI-2010), the alternate Mediterranean Diet (aMED), and Dietary Approaches to Stop Hypertension (DASH)) were related to a 12% to 28% decreased risk in all-cause, cardiovascular disease, and cancer mortality among older men and women (this was similar across all four diet indices) (Reedy et al., 2014). The authors suggest that these findings are generalisable to the population of older adults in the US. A study of 972 British NDNS participants aged ≥65 years at baseline, who were followed-up for around 14 years, used three indices to assess diet quality; the Healthy Diet Score (HDS), which had been previously adapted for use in the British population, the Recommended Food Score (RFS), and the Mediterranean Diet Score (MDS) (McNaughton et al., 2012). The study found that both the MDS and RFS measures of diet quality were inversely associated with risk of all-cause mortality (for MDS: highest vs. lowest quartile; HR = 0.78 (95% CI 0.62–0.98); for RFS: HR = 0.67 (95% CI 0.52–0.86)), but no significant association was found for the HDS. While the HDS is heavily nutrient-focused in terms of the indicators of dietary intake that it includes, the other two measures of diet quality are predominantly focused on food-based indicators, which might suggest that these types of diet quality measures could be better at predicting mortality and longevity than indicators based mostly on nutrient intakes (McNaughton et al., 2012).

1.3.2.2 Cardiovascular disease risk

Higher quality diets have been associated with a reduced risk of cardiovascular events in older age (Hlebowicz et al., 2013, Huijbregts et al., 1995). Cross-sectional findings from the Zutphen Study, where the dietary patterns of 518 men aged 70-89 years were assessed using cluster analysis, indicated that total serum cholesterol concentrations were lower in men with a healthy dietary pattern (characterised by a high intake of bread, cereals, potatoes, legumes, vegetables, and fruit, and lower than average intake of meat, fish, eggs, cheese, milk products, edible fats, and sugar) –

total serum cholesterol was 0.26 mmol/l higher in the high meat cluster compared to the healthy diet cluster (95% CI -0.17–0.69) – suggesting that a healthy diet might be associated with more beneficial levels of cardiovascular risk factors in older age (Huijbregts et al., 1995). Longitudinal data from a population-based cohort in Sweden of 6940 men and 10 186 women, mean age 59 years, showed that better diet quality (as assessed by an index (DQI-SNR) based on the 2005 Swedish dietary recommendations) was associated with reduced risk of cardiovascular events over a mean follow-up period of 14 years, when compared to poor diet quality (the risk reduction was 32% (HR = 0.68, 95% CI 0.49–0.73) in men and 27% (HR = 0.73, 95% CI 0.59–0.91) in women) (Hlebowicz et al., 2013). A large prospective study of 23 232 men and women from the EPIC-Norfolk study (mean age at baseline 59.1 years), who were followed-up for 17 years, found that greater adherence to a Mediterranean diet (defined using the modified Mediterranean diet score (MDS)) was associated with a significantly lower risk of stroke in the whole population (quartile 4 of the MDS vs quartile 1: HR = 0.83, 95% CI 0.74–0.94) and in women (quartile 4 vs quartile 1: HR = 0.78, 95% CI 0.65–0.93), however a statistically significant association was not observed in men (Paterson et al., 2018).

1.3.2.3 Quality of life

A systematic review of dietary patterns and successful ageing found few longitudinal studies that have investigated the relationship between dietary patterns and quality of life, although the majority of studies considered reported a positive relationship between better diet quality and better quality of life outcomes in older people (Milte and McNaughton, 2016). Six of the studies included in the review examined quality of life or health status, which were assessed using self-report measures, ranging from a single-item measure (participants rated their health status as very good, good, fair, bad or very bad) to more detailed multiple-item measures, such as the 12- or 36-item Short-Form Health Survey (SF-12 or SF-36). Most of these six studies had either a high or moderate risk of bias, and only one had a low risk of bias.

A more recent systematic review focused specifically on the association between dietary patterns and quality of life in older adults (Govindaraju et al., 2018). This review included five of the six studies included in the previously described systematic review. The majority of the studies included in the review by Govindaraju and colleagues (13 out of the 15 included studies) found higher diet quality to be associated with better quality of life outcomes in older adults. Outcomes were assessed using self-report measures similar to those used in the review by Milte and McNaughton described above, as well as disease-specific quality of life questionnaires. The studies included in the review were mostly observational, and more than half of them had a cross-

sectional design, with most of the studies included in the review rated as being of moderate quality.

1.3.2.4 Physical function

There is a growing evidence base for an association between a healthier diet and better physical function outcomes, especially for frailty outcomes, but more longitudinal evidence is needed for other physical function outcomes (Milte and McNaughton, 2016). For example, a study that included data from three prospective cohorts of community-dwelling older adults found that fruit and vegetable intake was associated with a lower short-term risk of frailty in a dose-response manner (Garcia-Esquinas et al., 2016). Furthermore, a recent systematic review found better diet quality to be associated with lower risk of prevalent, as well as future, frailty (Lorenzo-López et al., 2017).

Better diet quality has been associated with greater muscle strength in older adults (Robinson et al., 2008). In addition, adherence to a 'healthy diet' has also been associated with better overall physical performance (Perala et al., 2016) and a slower decline of mobility over time in community-dwelling older adults (Milaneschi et al., 2011). A recent systematic review of the evidence of the relationship between diet quality and the individual components of sarcopenia (muscle mass, muscle strength and physical performance), and the overall risk of sarcopenia, among older adults, included 23 studies, approximately half of them longitudinal, and all observational (Bloom et al., 2018). Although the review found limited evidence of relationships between higher diet quality and better muscle mass outcomes, better muscle strength outcomes, and lower likelihood of sarcopenia, there was a sizeable body of longitudinal evidence demonstrating a link between higher diet quality and smaller declines in physical performance in later life. Another systematic review examined the relationship between adherence to a Mediterranean diet and musculoskeletal outcomes (including fracture incidence, osteoporosis, and sarcopenia) in all ages (Craig et al., 2017). Of the 18 relevant studies that were identified (for both the systematic review and the evidence map), 10 included study populations with mean ages of 50 years and over. Overall, the authors conclude that further research is needed to clarify the relationship between a Mediterranean diet and bone and muscle outcomes in all age groups.

1.3.2.5 Mental health and cognitive function

The systematic review by Milte and McNaughton included 18 studies (8 of those cross-sectional) that assessed cognitive function, using measures that included assessment of global cognitive function using the Mini–Mental State Examination (MMSE), and assessment of various cognitive functions, including short-term verbal memory, verbal and mathematical reasoning, and

vocabulary and verbal fluency (Milte and McNaughton, 2016). Overall, the evidence suggested an association between a 'healthy' diet and improved cognitive function or lower risk of decline. With regards to mental health, most of the available evidence included in the review pointed to a consistent relationship between better diet quality and better mental health outcomes (Milte and McNaughton, 2016).

A systematic review of the effects of the Mediterranean diet on cognitive function, cognitive impairment, Alzheimer's disease, and all-type dementia, that included mostly observational studies, and in which most of the studies included participants aged over 60 years, concluded that adherence to a Mediterranean diet was associated with better cognitive performance (Petersson and Philippou, 2016). A recent longitudinal study from the US examined associations between diet quality indices (the alternate Mediterranean diet score and the Alternate Healthy Eating Index (AHEI)-2010 score) and dietary patterns defined by factor analysis and cognitive function (assessed using measures of global cognitive function, executive function, verbal fluency and episodic memory) in 1499 older community-dwelling adults (Richard et al., 2018). This study found that greater adherence to a Mediterranean dietary pattern or higher loading on a plant polyunsaturated fatty acid (PUFA)/vitamin E factor were associated with better baseline performance on cognitive tasks, while a high sugar/low protein diet pattern was associated with poorer baseline cognitive test performance; conversely, adherence to the AHEI was not significantly associated with cognitive performance. Despite a long follow-up period, no significant association was found between any of the diet quality measures and cognitive decline. On the other hand, findings from a US prospective cohort study of older people had previously shown that greater adherence to both the DASH (Dietary Approach to Stop Hypertension) and Mediterranean diet patterns was associated with slower rates of cognitive decline in older people, over an average follow-up of 4.1 years (Tangney et al., 2014).

1.4 What factors are associated with food choice and diet quality in community-dwelling older people?

Despite the relatively promising data from the recent NDNS (Public Health England, 2018), indicating that diet quality might be relatively good in early old age (as discussed in section 1.2), there is evidence to suggest that poor diet quality may be common in UK community-dwelling older adults aged 50 years and above (Maynard et al., 2006, Irz et al., 2014b).

A growing literature has identified several factors that are linked with dietary choices and diet quality in older people, and also points to gender-based differences in the effects of some of these, as described in the following subsections. Yet, despite the recognised importance of diet

for health in older age and how common poor nutrition and diet are at this stage of the life course, especially at older ages, little is known about the complexity of influences on diet quality at this age, particularly in community-living people. Furthermore, a systematic review of factors associated with diet quality (defined using *a priori* diet quality indices) in older age (ages 60 years and older) has highlighted that there is very little longitudinal research available and little evidence from a UK context (Freisling et al., 2013). A recent systematic review of the literature on food choice in community-living older people (aged 50 years and above) suggested that the interplay between numerous factors might be important in determining food choice at this age, however it is concluded that there is a need for further research to identify and understand the factors that influence the food choices and diets of older adults (Host et al., 2016a).

In addition to age-related and demographic influences, psychosocial factors may be important determinants of food choice and diet quality (Lawrence et al., 2009). The systematic review of predictors of diet quality in older age by Freisling and colleagues, identified a variety of factors associated with diet quality in this age group, however much of the evidence-base regarding psychological and social factors was largely confined to aspects such as marital status and living arrangements (Freisling et al., 2013).

The main outcome of this PhD thesis is 'diet quality' in later life, making reference to the quality of the whole diet. However, the thesis also focuses on 'food choice' as an outcome, focusing on the factors that affect the foods that are eaten; conceptually this consumption of foods combines to result in the overall quality of the diet. The following subsections consider what is known about the factors that are associated with food choice and the quality of older people's diets. The sections have been structured according to the different layers of influence on dietary behaviour, and based loosely on an ecological framework of eating behaviour that considers different levels of influence on food choice and diet (**Figure 2**) (Story et al., 2008), although very much adapted to the findings of this review of the literature. The following subsections start with the environmental context of the diets of older people and then move on to individual-level factors, such as demographic factors, then addressing the social context and finishing with psychological factors.

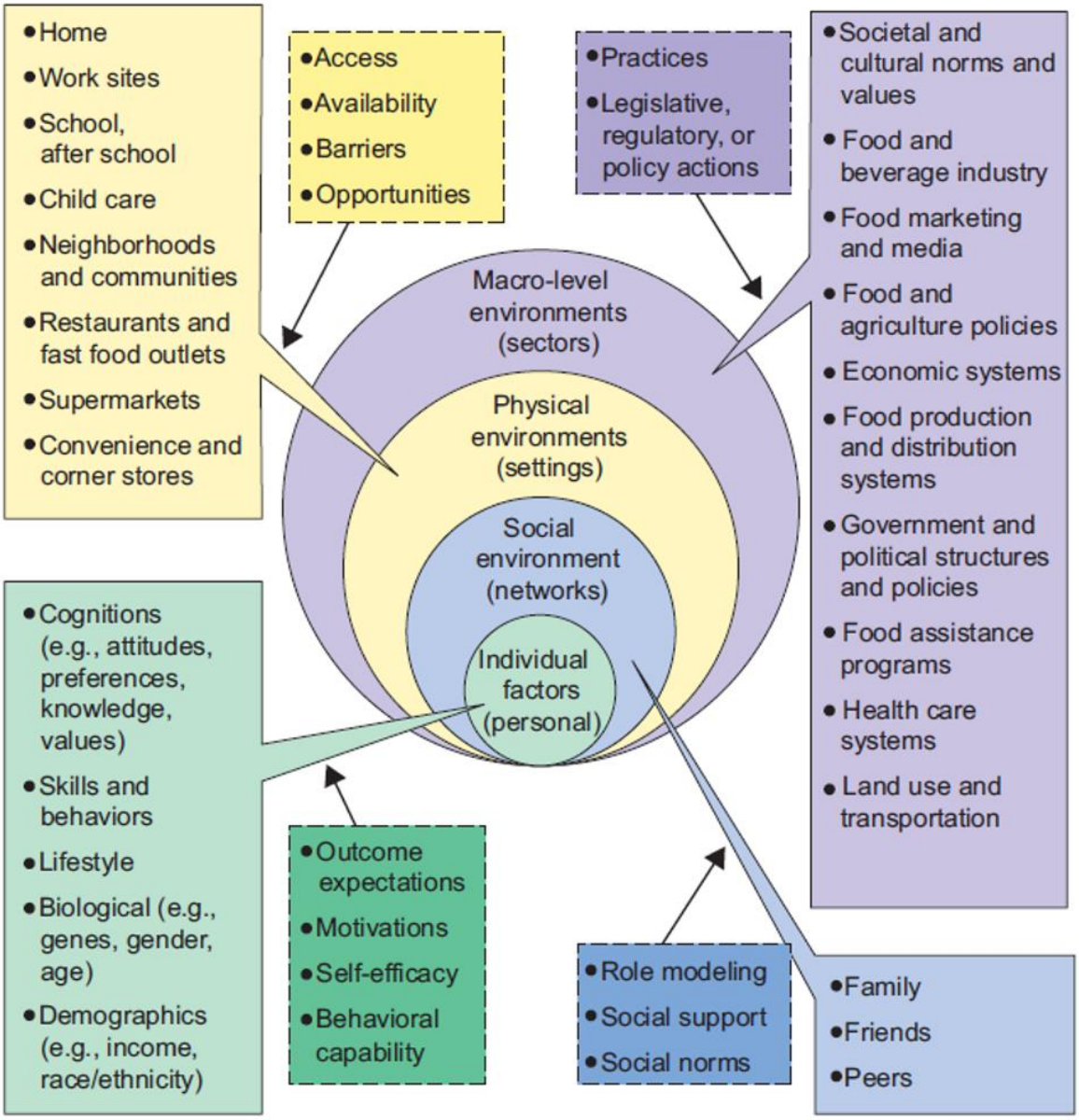


Figure 2 An ecological framework depicting the multiple influences on what people eat, from Story et al. (Story et al., 2008).

1.4.1 Environmental factors

Environmental aspects can influence decisions related to food purchasing and act as barriers or facilitators to a healthy diet, in younger as well as older adults; these include the information environment, the variety, quality and price of available foods and also structural aspects such as the accessibility of food retail outlets, as well as the in-store location of healthy and unhealthy foods (Hawkesworth et al., 2017).

A UK cross-sectional study of 112 older people aged over 60 years found no significant relationship between measures of usage of food shops, or physical access to these, and dietary variety scores (Wilson et al., 2004). In a similar way, a large cross-sectional study of 2007 men and

women, aged 69 – 92 years, embedded within two nationally representative cohorts in the UK, found no evidence of an association between frequency of fruit and vegetable intake and various aspects of the food environment, including density of shops selling fruits and vegetables, density of fast food outlets, the area food retail diversity, area walkability, transport accessibility, or the local food marketing environment (Hawkesworth et al., 2017). There was, however, strong evidence of an association between area-level income deprivation and fruit and vegetable intake; older participants in the most deprived areas had 27% (95% CI 7–42) lower odds of being in a higher fruit and vegetable consumption category, compared to those in the least deprived areas.

A survey of 3200 community-living adults aged over 65 years, from eight European countries (Poland, Portugal, United Kingdom, Germany, Sweden, Denmark, Italy and Spain), found an association between the perceived level of different community environment factors, such as good access to food and access to good food service providers, and greater diet variety (Dean et al., 2009). Similarly, in a US study of adults aged 45–84 years, participants with no supermarkets near their homes were less likely to have a healthy diet (diet quality was assessed using the Alternate Healthy Eating Index (AHEI) and adherence to an *a posteriori* 'fats and processed meats' (FPM) dietary pattern) than those with the most supermarkets; in addition, poorer diets were observed for people living in areas with the worst-ranked food environments (ranked in terms of the availability of healthy foods, by participants' or their neighbours' reports) (Moore et al., 2008). A US panel of community nutrition experts highlighted access to food outlets, in terms of both food accessibility and affordability, as a critical factor in promoting healthy eating among older adults (Sylvie and Cohen, 2012).

The information environment may also be important with regards to the health and nutrition information that is directed to the public. Older people have been found to be attentive to information about the health benefits and harms of certain foods and nutrients, about how to avoid unhealthy foods, and what they should eat to maintain a healthy diet, e.g. recommendations to eat a lower-fat diet (Lundkvist et al., 2010, Pot et al., 2015). However, perceived contradictory messages on food and health have been found to cause confusion and make it more difficult for older adults to understand dietary recommendations and advice (Lundkvist et al., 2010).

1.4.2 Demographic factors

Various demographic characteristics such as gender, social class and level of education have been linked with diet quality in older adults, although much of the current evidence is cross-sectional. Being a woman (Robinson et al., 2009, Irz et al., 2014a, Baker and Wardle, 2003, Hsiao et al.,

2013, Mercille et al., 2016) has been found to be associated with better diet quality in older age and, just as with younger adults, poor diets are also more common among older adults of lower social class (Robinson et al., 2009, Maynard et al., 2006) and those with lower levels of education (Robinson et al., 2009, Irz et al., 2014a).

Findings from a cross-sectional study of 369 older people living in Nottingham, UK, indicated that gender and living status were linked to intake of fruit and vegetables, and that living status, itself a social factor, had different effects depending on gender; older single men living in a household on their own consumed fewer portions of fruits and vegetables per day, compared with the average consumption for all study participants (2.7 portions of fruit and vegetables/day vs. 4.1 portions) (Donkin et al., 1998). In addition, participants who were older and less educated consumed fewer vegetables and participants with a lower income or social class ate less fruit. Consistent with this finding, in their survey of 3200 community-living older adults (aged over 65 years) from eight European countries, Dean and colleagues found that higher income and access to a car were associated with a more varied diet (Dean et al., 2009).

In a large cross-sectional analysis of Dutch community-dwelling older adults, aged 55-85 years, socio-economic status was assessed using self-reported levels of education, household income and occupational prestige (participants' occupations were classified into categories according to the level of skill required to perform occupation-related tasks) (Dijkstra et al., 2014a). Education and income were independently associated with dietary guidelines adherence; after adjustment for confounders and the other two socio-economic status indicators, participants in the lowest education group adhered less to the guideline for vegetable intake (OR 0.39, 95% CI 0.22–0.70), compared to those in the highest education group; and participants in the lowest income group adhered less to the guidelines for fruit (OR 0.44, 95% CI 0.22–0.91) and fish (OR 0.55, 95% CI 0.33–0.91), compared to those in the highest groups. Occupational prestige levels were not independently associated with adherence with any of the guidelines. 'Healthier' foods (e.g. fruit and fish) that are nutrient-rich and less energy-dense are often more expensive (as a source of dietary energy) compared to nutritionally poor and more energy dense foods, which could be a factor for people with lower incomes (Schoufour et al., 2018, Dijkstra et al., 2014c).

A large cross-sectional study of 4252 older British men, aged 60–79 years, observed that both childhood and adult socio-economic factors were independently associated with diet quality (Atkins et al., 2015). Men from a manual social class in childhood and men of adult manual social class were less likely to consume fruit and vegetables daily, compared with men from a non-manual social class ((OR 0.80, 95% CI 0.66–0.97) and (OR 0.65, 95% CI 0.54–0.79), respectively). A

combined adverse childhood and adulthood socio-economic score was related to poor diet quality.

A recently published longitudinal study from the Netherlands (Schoufour et al., 2018) examined the relationship between three different indicators of socio-economic status (income, education and occupation) and diet quality in 5434 older people (aged ≥55 years), both at baseline and after a 20-year follow-up. The study found that education was the socio-economic indicator most strongly associated with both current diet quality and diet quality over time in older participants, higher educational levels were associated with better diet quality at baseline and higher diet quality at follow-up; on the other hand, participants with higher income at baseline had poorer diet quality at follow-up and there were no differences in diet quality in relation to occupational status. Of note is that the study used two different food frequency questionnaires at baseline and at follow-up to collect dietary data, which is an important limitation in terms of ability to assess differences in diet between baseline and follow-up. Another longitudinal study of older adults (aged 68–82 years at baseline), from the Canadian NuAge Cohort Study, found that for men, education was a positive predictor of diet quality over a 3-year follow-up period, while among women diet knowledge was a positive predictor of change in diet quality (indicating greater improvement, or less decline, in diet quality over the follow-up period) (Shatenstein et al., 2016).

The systematic review by Freisling and colleagues (Freisling et al., 2013) found that the influence of age on diet quality was unclear. Some of the examined studies found diet quality to be better among older age groups (≥65 years) than in younger individuals (<65 years), on the other hand, the studies that reported poorer diet quality in older age included participants of at least 75 years or older (Freisling et al., 2013). The fact that some of the studies found diet quality to be better among older people and other studies found diet quality to be poorer in older age may be due to discrepancies between chronological and biological age in older people (Freisling et al., 2013). Conversely the results may point to poorer diet quality in the upper end of the chronological age spectrum. In their large cross-sectional study of older British men and women, Hawkesworth and colleagues found older ages to be associated with lower fruit and vegetable consumption. Participants aged 85 years and over had 22% (95% CI -4, 42) lower odds of being in a higher fruit and vegetable consumption category compared to those younger than 75 years (Hawkesworth et al., 2017).

1.4.3 Nutrition knowledge and cooking skills

It has been suggested that differences in diet quality by socio-economic status (poorer diet quality in people with lower socio-economic status than those with higher socio-economic status) could

in part be due to a possible greater ability of better-educated people to understand dietary guidelines and food labels, and having better cooking skills (Schoufour et al., 2018, Dijkstra et al., 2014c).

For both younger adults and older adults, knowledge of nutritional requirements, nutritional composition of foods and cooking skills are linked to healthier food choices (Stroebele-Benschop et al., 2016, Shatenstein et al., 2013). Cross-sectional evidence suggests that good diet and nutrition knowledge, or older people's *perception* that their food knowledge is good, is associated with better diet quality in older age (≥65 years) (Dean et al., 2009, Shatenstein et al., 2013). A survey of 426 older people from Northern Ireland (Appleton et al., 2009) found that greater awareness of government recommendations for fruit and vegetable intake was associated with greater fruit and vegetable consumption.

Nutrition knowledge and cooking skills have been found to differ by gender among older people. A study of UK older adults (Baker and Wardle, 2003) found that fewer men than women knew the recommendations for fruit and vegetable intake, and fewer men knew about the relationship between fruit and vegetable consumption and health; furthermore, the study's results indicated that the poorer nutrition knowledge demonstrated by men explained, in part, their poorer diets (lower intake of fruit and vegetables). Moreover, poor cooking skills appear to have a negative impact on diet in older men (Hughes et al., 2004). A cross-sectional study of older people living in Nottingham, UK, found that men were less likely to be able to cook a variety of meals, to have had an occupation that included cooking or to watch television programmes related to cookery (Donkin et al., 1998).

1.4.4 General health factors

A recent systematic review of the functional determinants of dietary intake in older people (aged at least 65 years) focused on chemosensory, oral, cognitive or physical function as determinants of dietary intake in community-dwelling older adults (Kiesswetter et al., 2018). While numerous studies were found for oral factors, the evidence for other fields (chemosensory, cognitive and physical function) was, overall, limited or inconsistent. The review included a broad range of 'dietary intake' outcomes, with only nine studies of the 36 that were included in the review using a measure of diet quality or diversity as outcomes. The review found a lack of evidence on the functional 'determinants' of dietary intake, as such. Since most of the studies identified were cross-sectional and no intervention studies were found, the evidence-base was limited to correlates or factors related to dietary intake.

Nonetheless, there is evidence to support an association between health-related factors, such as physical health and level of appetite, and quality and variety of diet in later life. In a large cross-sectional study by Dean and colleagues of 3200 community-living older adults, those in better physical and mental health had a more varied diet than those in poorer health; and those who perceived their level of appetite to be good had a more varied diet than those who perceived their appetite to be poor (Dean et al., 2009); conversely, perceived ability to taste and smell were not associated with diet variety. In their cross-sectional study of Dutch community-dwelling adults, aged 55–85 years, Dijkstra and colleagues found poor appetite for vegetables to be one of the most frequently perceived barriers to adherence to dietary guidelines (Dijkstra et al., 2014c). Consistent with these findings, another cross-sectional analysis, this one of community-dwelling adults aged 70–79 from the US, found that participants with poor appetite had poorer diet quality (lower Healthy Eating Index), compared to participants with a very good or good appetite; participants with a poor appetite ate significantly less protein rich foods, whole grains, fruits and vegetables, and ate more dairy foods, fats, oils, and sweets, compared to participants with a very good appetite (Van Der Meij et al., 2017). A cross-sectional survey of 662 people aged 65 and over from the United Kingdom Low Income Diet and Nutrition Survey (2003–2005) (Holmes and Roberts, 2011) found a good appetite to be associated with better diet quality in women but not in men. Conversely, this study did not find an association between long-standing illness or disability limiting shopping and/or food preparation and diet quality (Holmes and Roberts, 2011). A longitudinal study of older adults from the Canadian NuAge Cohort Study found that for men, sensations of hunger were positive predictors of diet quality over a 3-year follow-up period (Shatenstein et al., 2016). Poor appetite is an important issue in the older population; a systematic review that assessed the regulation of appetite in older people and the development of anorexia of ageing, estimated that between 15% and 30% of older people living in the community experience a decrease in appetite and/or food intake (also termed the 'anorexia of ageing') (Malafarina et al., 2013).

Numerous studies have found poor mobility and function to be barriers to food access and preparation for older people (Host et al., 2016a). In older men, poor perceived physical health has been shown to be associated with poorer diet quality (Shatenstein et al., 2013).

In terms of cognitive function, the evidence appears to be inconsistent, as suggested by the systematic review by Kiesswetter and colleagues (Kiesswetter et al., 2018). Over an 8-year follow-up period, decrease in intellectual activity score was a significant predictor of decline in dietary variety in a study of community-dwelling Japanese older people (Kwon et al., 2006). On the other hand, a longitudinal study of Canadian older adults found baseline cognitive status to be a negative predictor of change in diet quality over time in men but not in women, counterintuitively

indicating greater deterioration, or less improvement, in diet quality over time among men with better cognitive status at recruitment (Shatenstein et al., 2016).

Poor oral health such as the use of dentures (Shatenstein et al., 2013) and chewing problems (Shatenstein et al., 2013, Holmes and Roberts, 2011), have been associated with poorer diet quality. This is of significance given that data from a representative sample of older British men, suggest a substantial burden of oral health problems in the UK older population, including tooth loss, poor self-rated oral health, and oral impacts on eating (Ramsay et al., 2015). An 8-year follow-up study of community-dwelling Japanese older people found that a deterioration of chewing ability was a significant predictor for decline in dietary variety (Kwon et al., 2006), while a longitudinal study of Canadian older adults did not identify chewing ability as a predictor of change in diet quality over a 3-year follow-up (Shatenstein et al., 2016).

As described previously in section 1.3.2, poor diet quality has been associated with poor physical function and cognitive function outcomes. Thus, it is necessary to consider that some of the evidence described above could be subject to reverse causality. It is possible to look at the evidence on health factors the other way around, e.g. it is possible that poor diet quality leads to poorer physical function, poorer cognitive function, and poor oral health.

1.4.5 Lifestyle factors

Alongside age-related changes, lifestyle has also been related to diet in older age. Poor diets have consistently been found to be more common among older adults who smoke (Robinson et al., 2009, Maynard et al., 2006, Holmes and Roberts, 2011). This is a concern as data from the Health Survey for England (HSE) show that 11% of adults aged 65 to 74 and 6% of adults aged 75 years and over were smokers in 2016, indicating that smoking may be linked to the diets of a sizeable proportion of the older population (NatCen Social Research and UCL, 2017).

A UK cross-sectional study of older men found greater alcohol consumption to be linked to lower fruit and vegetable intake (Hughes et al., 2004). Similarly, in a Canadian cohort study, the NuAge study, cross-sectional analyses showed a relationship between alcohol consumption and diet quality among men, such that in men greater alcohol consumption was associated with worse diet quality (Shatenstein et al., 2013). In the systematic review by Freisling and colleagues, out of the five studies that looked at the association between physical activity and diet, four found being less physically active to be associated with poorer diet quality (Freisling et al., 2013).

Unhealthy lifestyle behaviours (e.g. poor diet, low physical activity levels, smoking, high alcohol consumption) often co-occur in older people (Shankar et al., 2010b, Robinson et al., 2013).

Furthermore, clustering of multiple unhealthy behaviours appears to be more common in people with a lower socio-economic status (Shankar et al., 2010b). The nature of the above described associations with diet quality are therefore not clear; lifestyle factors may be on the causal pathway between demographic factors and diet quality or, it could be that demographic factors (e.g. income and education) may determine lifestyle behaviours (smoking, alcohol consumption and physical activity), with these simply clustering together with diet quality.

1.4.6 Social factors

With the ageing process, along with a decline in physical and cognitive function, social networks can also shrink with the passage of time. While prevalence estimates vary depending on the definition and outcome measure used, a consistent finding is that social isolation is a common issue amongst older people, with a prevalence estimated to be between 7% and 17% (Dickens et al., 2011). Social isolation could play an important role in the decreased dietary intakes observed at older ages (McIntosh et al., 1989). It is likely that inadequate social support, limited social networks, especially living alone or being divorced, or widowed, might increase the risk of poor dietary intake or nutritional status in older people (Locher et al., 2005). Social isolation and loneliness were found to be independently associated with a higher risk of malnutrition, in a cross-sectional study of older people from Lebanon (Boulos et al., 2016). However, findings from a recent cross-sectional US study of community-dwelling African American men, African American women, white men, and white women (≥75 years of age) were less clear, suggesting that the influence of social factors on nutritional risk may differ according to the type of social measure, and according to race and gender (Buys et al., 2018). On the other hand, there is increasing evidence that social factors are important influences on older people's diets (Conklin et al., 2014, Sahyoun and Zhang, 2005, Vesnaver and Keller, 2011, Dean et al., 2009).

Social isolation is the lack of structural and functional social support or relationships. Conceptually, structural social support (or structural components of social relationships) is a more objective characteristic that represents the size and frequency of social contact, which theoretically makes support functions possible, while functional social support (or functional components of social relationships) relates to the quality or perceived value of emotional, instrumental and informational support provided by others (Broadhead et al., 1989, Dickens et al., 2011). Although greater social support has been strongly associated with better diet quality in younger adults (Ferranti et al., 2013, Shaikh et al., 2008), the association in older adults, and the relationship with other factors that might influence diet in older age, is less clear.

There is limited cross-sectional evidence to suggest that social isolation and lack of social support may contribute to poorer diets in older age (Romero-Ortuno et al., 2011, Vesnaver and Keller, 2011, Kalousova, 2014). There is more evidence for an association between marital status, living arrangements and frequency of contact with friends, and diet quality in older age. For example, less frequent social contact has been related to low fruit and vegetable intake in older adults (Sahyoun et al., 2005), and both living alone and having less frequent contact with friends have been found to enhance the negative association of widowhood with diet (Conklin et al., 2014, Friedman, 2014). It is likely that these more structural components of social relationships enable other more complex social processes, including social support and social engagement (Conklin et al., 2014, Vesnaver and Keller, 2011).

Findings from a large survey of older adults aged over 65 years, from eight European countries including the UK, showed that people who lived with a partner ate a more varied diet than those who lived alone (Dean et al., 2009). In a large cross-sectional study of older British men (aged 60–79 years) diet quality (assessed using daily fruit and vegetable intake and the Elderly Dietary Index (EDI)) was higher in married men and those not living alone; diet quality was not however associated with social contact (i.e. how often they saw or spoke to their children, siblings, friends and neighbours) (Atkins et al., 2015). Similarly, in their cross-sectional study of older people from four EU countries (Finland, Sweden, UK and Italy), Irz and colleagues found that not living alone was associated with better diet quality (assessed using a modified version of the Diet Quality Index (DQI) and the alternative Recommendation Compliance Index (RCI)) (Irz et al., 2014a). In a large Japanese survey of community-dwelling men and women aged ≥65 years, people who exclusively ate alone were significantly more likely to have a lower frequency of vegetable and fruit intake compared with people who shared meals with others (Tani et al., 2015). A comprehensive review examined the evidence from observational studies as to whether there is a difference in food and nutrient intake between adults living alone and those living with others (Hanna and Collins, 2015). Of the 41 eligible studies identified for inclusion in the review, approximately half focused exclusively on older adults (≥50 years), with the other half including either both younger and older adults combined, or only younger adults. Most of the available evidence was cross-sectional, and only three of the included studies (all three of which included younger age groups) investigated whether a change in living arrangements was related to changes in dietary patterns. Overall the findings suggested that, compared with people who do not live alone, those who live alone have a lower diversity of food intake, a lower intake of particular food groups (fruits, vegetables, and fish), and are more likely to have an unhealthy dietary pattern. The review concludes that further research is needed, including consideration of the reasons why living alone might influence dietary intake.

A cross-sectional study of 9580 older British adults (≥50 years of age) in the EPIC-Norfolk cohort study found that all the social relationships examined (marital status, living arrangement and friend contact) were independently associated with fruit variety in men and with vegetable variety in both genders. Furthermore, the authors found that a combination of both low economic resources and a lack of social relationships was linked to much lower fruit variety and vegetable variety than when either measure was considered alone, with men being most negatively affected (Conklin et al., 2015). Surprisingly, a Canadian longitudinal study of older adults (aged 68–82 years at baseline) found that having a good social network at baseline was a negative predictor of change in diet quality over the 3-year follow-up period, indicating greater deterioration, or less improvement in diet quality over time, among men and women with a better social network at recruitment (Shatenstein et al., 2016).

An 8-year follow-up study of community-dwelling Japanese older people found the loss of a spouse was a significant predictor for decline in dietary variety (Kwon et al., 2006). In men, marital status appears to be particularly relevant to diet, since single or divorced men have been found to be at increased risk of having poor eating habits and diets (Freisling et al., 2013, Vesnaver et al., 2012, Holmes and Roberts, 2011). Longitudinal data from a UK population-based cohort of older adults (Vinther et al., 2016), showed that men are more likely than women to undergo unhealthy changes to their diets accompanying marital transitions; in men, becoming widowed was associated with a decrease in the quantity and variety of fruits and vegetables consumed, and there was a decrease in most of the indicators of diet quality studied in men who were separated/divorced or remained unmarried.

As is the case for social support, there is also a gap in the evidence regarding an association between participation in social/leisure activities and diet quality in older age. A study of Scottish adults (average age of 58 years) (Sani et al., 2015), found that the greater the number of social groups with which someone identified, the healthier their behaviour for any of four health dimensions assessed, i.e. diet quality (based on the number of portions of fruit and vegetables consumed per day), physical activity, smoking, and alcohol consumption. In their longitudinal study of 325 community-living older disabled women in the US, Nicklett and colleagues (Nicklett et al., 2012a) found that attending more social activities predicted an increase in diet quality over the period of one year (the authors used serum carotenoid levels as an indicator of diet quality in this study).

It should be noted that since much of the above evidence regarding social factors is cross-sectional, the direction of the associations is not clear, and there could be reverse causality. It is possible that poor diet quality could lead to poorer health (poorer physical function, cognition,

oral health etc.), which could lead to people to engage less with family, friends, neighbours and social groups/activities, thus impacting on their social network and also the levels of social support that they receive.

1.4.7 Psychological factors

Among younger adults, psychological factors have been shown to be important determinants of diet quality. In their review of the literature, Shaikh and colleagues found strong evidence for self-efficacy and knowledge as predictors of diet quality (expressed as fruit and vegetable intake) in adults (Shaikh et al., 2008). Moreover, in younger women, a perceived lack of control over life has been linked to diets of poorer quality (Lawrence et al., 2009), and appears to mediate effects of social disadvantage on diet. In comparison, there is a gap in our understanding of the role of psychological factors in older age and how they might mediate the effects of illness, disability and disadvantage, on diet.

The key role of life transition points, such as bereavement, divorce, and onset of illness, in influencing foods chosen and in potentially leading to changes in diet has been highlighted (Blane et al., 2003). Although it is as yet unclear how some older people might develop adaptive strategies to the various ageing related barriers to having a healthy diet. Psychological factors such as depressive symptoms, low emotional well-being, and low hardiness have been associated with poor appetite in older people, which could impact negatively on their diet and nutritional status (Engel et al., 2011).

In their large survey of community-living older adults (≥65 years) from eight European countries, Dean and colleagues found that older people who had goals such as wanting to eat a varied diet, wanting to cook for others and wanting to control their weight consumed a more varied diet than those who did not have these goals (Dean et al., 2009). A large cross-sectional study of older independently living Dutch adults (aged 65-80 years), examined what motivations older adults have to eat healthily and found that these motivations depended on the characteristics of the older adults (Dijkstra et al., 2014b). The most reported motivations were ‘feeling fit’, ‘current health’ and ‘body weight’. Older adults with physical health problems and poor self-rated health were more likely to report ‘current disease’ as a motivation to eat healthily. Whereas disease prevention and health appeared to be less important as motivations to eat healthily for older adults of lower socio-economic status, or for those who were obese. A discrete choice experiment study conducted with Dutch older adults indicated that healthiness, taste, price, and travel time to grocery shops were all motives that influenced older adults’ meal decisions (Kamphuis et al., 2015), with healthiness found to be the most important motive. Furthermore, participants from

higher socioeconomic groups were found to value healthiness more than participants from lower socioeconomic groups.

Qualitative interviews with older British men (aged between 62 and 94 years), living alone, suggested that low motivation to change eating habits could have a negative influence on diet in this group (Hughes et al., 2004). There is also qualitative evidence that points to a role of food apathy (a lack of interest or enthusiasm regarding eating) as a factor that could be linked to food choices and diet quality in older age (Blane et al., 2003, Vesnaver et al., 2012). Findings from the Québec Longitudinal Study on Nutrition and Successful Aging (NuAge), including 30 men and women aged 68–86 years, have highlighted the roles of resilience (a process comprising positive adaptation despite significant adversity (Luthar et al., 2000)) and self-efficacy (an individual's belief in their own ability to achieve a desired outcome) in predicting diet quality (Vesnaver et al., 2012). This is consistent with a study from Japan (Sugisawa et al., 2015) that found that psychosocial factors, namely increased control expectancy, self-efficacy and social influence, attenuated the association between lower socioeconomic status and poorer diets in older people. The qualitative study of Vesnaver and colleagues (Vesnaver et al., 2012) identified four main themes of resilience to dietary decline, including 'prioritizing eating well', 'doing whatever it takes to keep eating well', 'being able to do it yourself', 'getting help when you need it'. In a similar way, a qualitative study that explored the factors influencing food shopping, cooking and eating behaviours of older community-dwelling Australians (≥60 years) (Host et al., 2016b) found that although a number of different factors appeared to influence dietary behaviours, of note was participants' strong desire for continued independence and for control over their health outcomes. Another qualitative study, of US older adults (aged 65 – 95 years), where participants were interviewed about their motivations to change diet and physical activity behaviours, found that factors that could affect participants' likelihood of making a lifestyle change included perceptions of old age (perceiving health problems as a normal part of ageing and low expectations for old age appeared to diminish motivation to improve diet and physical activity), personal motivation (motivation appeared to be influenced by health concerns and anticipated benefits of behaviour changes), and perceived confidence in the ability to make effective changes (Bardach et al., 2016).

1.4.8 Theoretical model

In the context of this thesis and based on the above review of the literature, a theoretical model was developed to depict the multiple influences on older people's diets, and how they might work in combination to affect diet quality (**Figure 3**). Given the complexity of dietary behaviour, the development of this model was based on the ecological framework of health behaviour, as

adapted by Story and colleagues for eating behaviour (Story et al., 2008). Although the present model resembles this ecological framework, both in terms of the different levels of influence on food choice and diet, and its focus on connections between individuals and their environments, it was adapted to fit with the types of factors found in the literature to be related to diet in older age, and also to show the potential interrelationships between the different levels of influence.

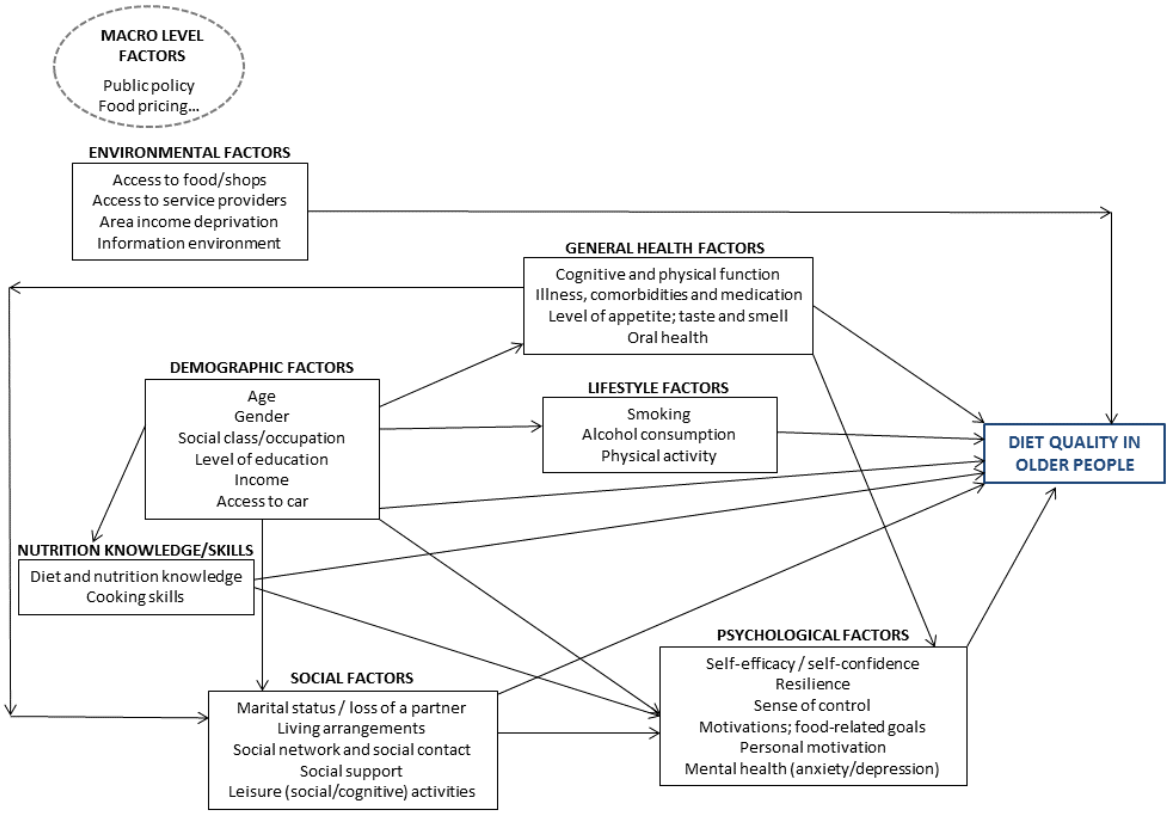


Figure 3 Theoretical model showing potential determinants of older adults' diet quality and possible relationships between these factors, adapted from the framework by Story et al. (Story et al., 2008).

The model comprises eight contexts of dietary influence as follows:

- Macro-level factors, including the legislative and policy influences related to health and the food system (e.g. health and agriculture policies), food production and distribution systems, and food prices;
- Environmental factors, including the physical environment related to eating or obtaining food, such as the home, restaurants, and retail outlets;
- Demographic factors;
- Nutrition knowledge and cooking skills;
- General health factors, including biological and medical factors;
- Lifestyle factors, including health-related behaviours, such as smoking and physical activity;

- Social factors, including interactions with family, friends, and community members, role modelling, social support and social norms;
- Psychological factors, including mental health, motivations, resilience, and self-efficacy.

Although macro-level factors are known to be important influences on diet (Story et al., 2008), it was not within the main scope of this thesis to examine these.

It must be emphasized that this theoretical model is hypothetical and although most of the depicted factors have been linked to diet quality in later life, the evidence for some of them (especially some of the health, psychological, and social factors), as well as for the depicted relationships between the factors, is limited or lacking. To my knowledge there is little evidence of the causal pathways by which specific factors might interrelate with others to influence diet in older age. Furthermore, there is a gap in the understanding of which factors are more influential than others.

Contributions of the present PhD research project:

Although numerous factors have been linked to food choice and diet quality in older age, it remains unclear how they might work in combination to affect diet quality in community-living older adults. The present thesis examines what interrelationship there might be between the various factors related to food choice and diet quality in community-dwelling older people.

Psychological and social factors may be important determinants of food choice and diet quality in community-living older adults, however the evidence-base is largely limited particular aspects, such as marital status and living arrangements. This PhD project aims to build on the current evidence and expand the evidence for other psychological and social factors.

Moreover, there is little evidence from a UK context and there is a lack of longitudinal studies designed to assess determinants of diet quality and little is known about which factors predict diet quality change in the course of ageing. Addressing the gap in understanding about what factors influence diet as we age, particularly in a UK context, is important for the development of future interventions to improve diet quality in older people. This research project sets out to address these gaps in a UK context, to examine what services are provided locally to community-dwelling older adults that support their diets, and then to assess the potential of a local intervention to promote diet quality in an older community-based UK population.

1.5 Research questions

The research presented in this thesis aims to contribute in some way to addressing the gaps in the evidence base that were identified in the previous section.

This PhD thesis aimed to address the following research questions:

> Research question 1: What factors are associated with food choice and diet quality in UK community-dwelling older adults? (Chapter 3 – page 38)
>
> Research question 2: What is the interrelationship between the various factors related to food choice and diet quality in community-dwelling older people and what is the role of psychosocial factors? (Chapters 3 and 4 – pages 38 and 62, respectively)
>
> Research question 3: What local services are currently provided to community-dwelling older adults that support their diets? (Chapter 5 – page 81)

And in light of these findings,

> Research question 4: What is the potential of a local intervention to promote diet quality in an older population? (Chapter 6 – page 102)

Chapter 2: Methods

This chapter provides an overview of the general methodological background concerning the work presented in this PhD thesis. Detail of individual study designs, participants, procedures and analyses are presented in the relevant individual chapters.

To address research question 1 (What factors are associated with food choice and diet quality in UK community-dwelling older adults?), participants were recruited from the Hertfordshire Cohort Study (HCS) and focus groups were run to explore influences on diet among community-dwelling older people living in the county of Hertfordshire (Chapter 3 – page 38).

To address research question 2 (What is the interrelationship between the various factors related to food choice and diet quality in community-dwelling older people and what is the role of psychosocial factors?), the qualitative findings were drawn upon (Chapter 3 – page 38), and a second piece of work was carried out – a secondary data analysis of previously collected HCS data to identify psychosocial correlates of diet quality in older community-dwelling men and women, and determine their associations with change in diet quality over 10 years (Chapter 4 – page 62).

The third research question of this thesis (What local services are currently provided to community-dwelling older adults that support their diets?) was addressed by undertaking a mapping study of the service provision in the local context of the city of Southampton, in terms of services or interventions available to local community-dwelling older people that might support their diets (Chapter 5 – page 81).

The fourth and final research question (What is the potential of a local intervention to promote diet quality in an older population?) was addressed by carrying out a pilot study of a social network intervention GENIE (Generating Engagement in Network Involvement) to promote diet quality in a group of older community-dwelling adults in the Southampton area (Chapter 6 – page 102).

2.1 The Hertfordshire Cohort Study

A large set of birth records were maintained in the county of Hertfordshire, UK, during the early 20th century, by a team of midwives and nurses who were responsible for trying to improve the health of children in Hertfordshire at that time (Syddall et al., 2005). Midwives visited women when they gave birth and documented the birth weight of their babies on a card. Subsequently, a health visitor visited each baby at home during its infancy and documented any illnesses, its

development and the method of infant feeding; the baby was then weighed again at one year of age (Syddall et al., 2005). This information was transcribed into ledgers at the Hertfordshire county office, which include all births in Hertfordshire from 1911 until the NHS was formed in 1948 (Syddall et al., 2005). Later, these records were found by researchers working at the MRC Environmental Epidemiology Unit (MRC EEU), University of Southampton. The ledgers contained records for 42 974 births in Hertfordshire between 1931 and 1939, of which 39 764 were live born (Syddall et al., 2005). Records with deaths during childhood, missing birth weight or weight at one year, or with insufficient tracing information were excluded. In 1998, 7106 men and women, born between 1931 and 1939, who were still living in Hertfordshire were traced using the NHS central registry; these people comprised the HCS target population (Syddall et al., 2005).

A total of 1684 (54%) men and 1541 (52%) women agreed to be interviewed at home; at this point diet was assessed by a trained research nurse and information on the participant's medical and social history was collected. A range of demographic factors, socioeconomic status indicators, and lifestyle factors were assessed at this stage, including age, gender, social class, age left full-time education, marital status, alcohol consumption and smoking status, and diet was assessed. The study had ethical approval from the Bedfordshire & Hertfordshire Local Research Ethics Committee and the West Hertfordshire Local Research Ethics Committee.

This thesis includes data from the whole cohort and from a subsequent sub-study. From the original HCS cohort, 642 participants, resident in East Hertfordshire, took part in a sub-study in 2004-2005 to collect musculoskeletal data (**Figure 4** summarises the baseline recruitment process of HCS participants and subsequent follow-up studies). In 2011, these participants were recruited to the EPOSA (European Project on Osteoarthritis) study (van der Pas et al., 2013) – 592 individuals (of 642, those who were still alive, resident in Hertfordshire and willing to take part) were invited by letter to participate, of whom 443 (75%) agreed to be followed up (van der Pas et al., 2013). The participants recruited to the qualitative study described in Chapter 3 (page 38) were drawn from this follow-up sub-group, whose diets had been re-assessed in the 2011 follow-up sub-study. The secondary data analysis described in Chapter 4 (page 62) included baseline data from HCS participants who had social health and dietary data at baseline (n=1910), and follow-up dietary data that was collected in the 2011 sub-study (372 participants had follow-up dietary data, and had also completed the social health questionnaire at baseline).

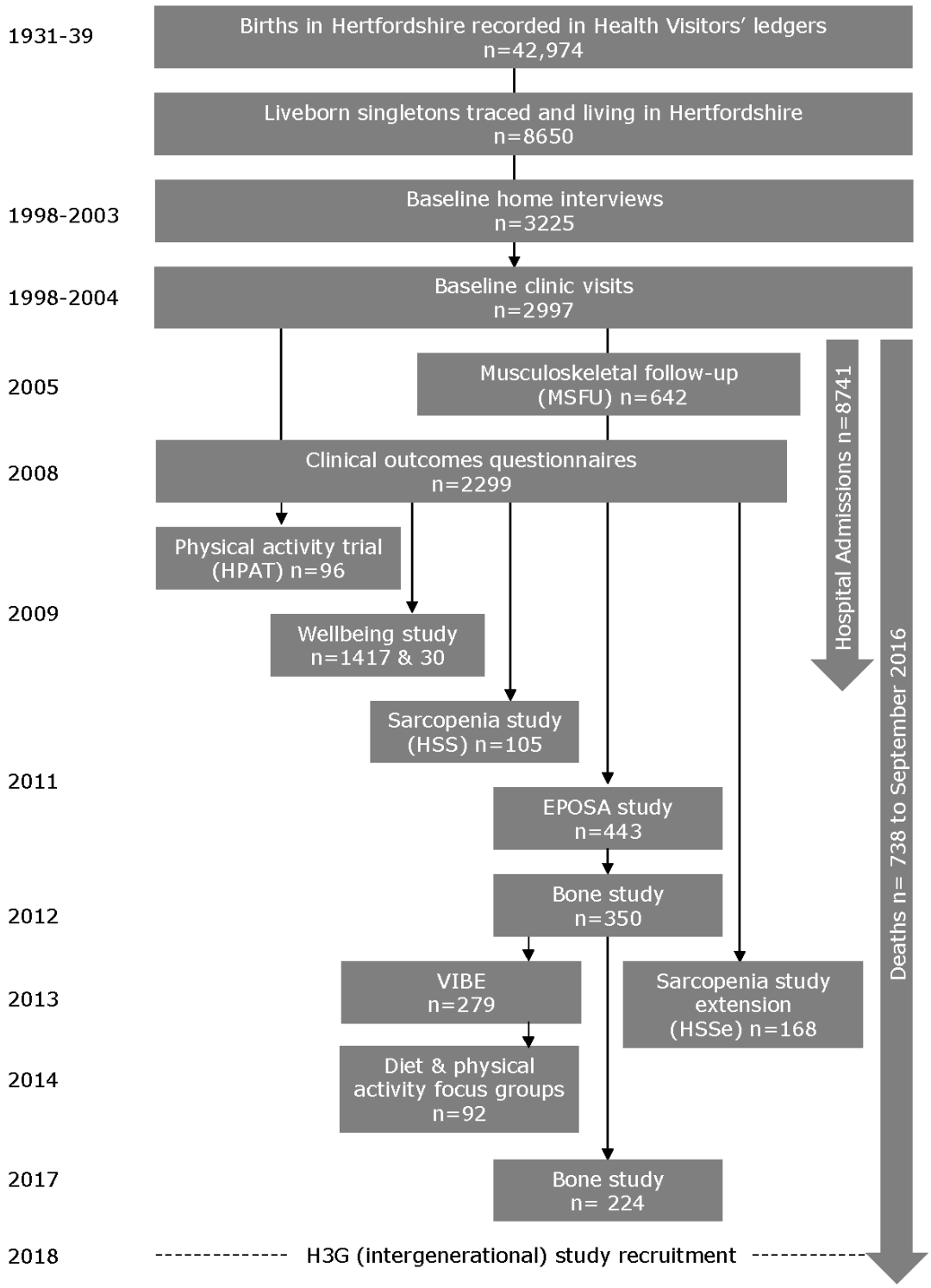


Figure 4 Summary of HCS participant recruitment and subsequent studies carried out with cohort participants (from 1998-2018), from Syddall et al., 2019 (Syddall et al., 2019).

2.1.1 Dietary assessment

At baseline (1998-2003), the diets of 1677 men and 1540 women (3217 participants), taking part in the HCS, were assessed at the home interview, using an administered food frequency questionnaire (FFQ) (Robinson et al., 2009). The FFQ was based on the questionnaire that was

used in the European Prospective Investigation of Cancer (EPIC) (Bingham et al., 1994) and included 129 foods and food groups. This FFQ was used to assess an average frequency of consumption of the listed foods (never, less than once/month, 1-3 times/month, once/week, 2-4 times/week, 5-6 times/week, once/day, 2-3 times/day, 4-5 times/day, ≥6 times/day), over the 3-month period preceding the interview. For each participant, the FFQ was administered by a trained research nurse; prompt cards were used to indicate which foods were included in each food group, to try to ensure standardised responses to the FFQ. Frequencies of foods that were not included in the FFQ were also recorded, if these foods were eaten at least once per week. Except for milk and sugar (for these foods daily quantities consumed were recorded), standard portion sizes, based on published average portion sizes for foods and drinks (mainly derived from previous national dietary surveys), were allocated to each food (Robinson et al., 2006, Ministry of Agriculture Fisheries and Food, 1993). In order to calculate nutrient intakes from the baseline FFQ, the frequency of consumption of a portion of each food was multiplied by its nutrient content as set out in the UK national food composition database or manufacturers' composition data (Robinson et al., 2006).

Prior to performing the dietary patterns analysis, the foods listed in the FFQ were combined into 51 food groups based on similarity of type of food and nutrient composition (Robinson et al., 2009). For instance, cabbage, broccoli and peas were included in the 'green vegetables' group; lettuce, tomatoes and coleslaw were incorporated into the 'salad vegetables' group; while foods such as mackerel and salmon were incorporated into the 'oily fish' group. Principal component analysis (PCA) of weekly frequencies of intake of these food groups was used to determine baseline dietary patterns in HCS participants. PCA produces components that are independent linear combinations of the dietary variables. Each component identifies a pattern of foods, the first of which explains the largest variance in the dietary data (Robinson et al., 2009).

Dietary patterns of the HCS, defined using PCA of the FFQ data, have previously been described (Robinson et al., 2009). The first component in the PCA described a dietary pattern that was characterised by high consumption of fruit and vegetables, wholegrain cereals and oily fish but low consumption of white bread, full-fat dairy products, added sugar, chips and processed meat. This pattern was labelled a 'prudent' diet, to be consistent with other studies that had used this terminology, as it reflects the UK government's food-based recommendations for a healthy diet (Public Health England, 2016a). The other components that were identified by the PCA explained less of the variance in the dietary data, and were not as easily interpretable as patterns of diet.

At baseline, a prudent diet score was calculated for every participant using the following steps (Robinson et al., 2017): (i) fat spreads and milks were classified as full fat or reduced fat versions

(reduced fat spreads <69g fat per 100g; milks <3.5g fat per 100g); (ii) weekly frequencies of food consumption were calculated as: never=0, less than once/month=0.2, 1-3 times/month=0.5, once/week=1, 2-4 times/week=3, 5-6 times/week=5.5, once/day=7, 2-3 times/day=17.5, 4-5 times/day=31.5, ≥6 times/day=42; (iii) standardised food frequency variables were created by subtracting the means and dividing by the standard deviations (SDs) for the HCS population; (iv) the coefficient defined by the PCA for each food was multiplied by the standardised food frequency variable; (v) these values were added, producing one score for each participant. The prudent diet score is a standardised z-score (with mean 0 and SD 1.0). The score shows to what extent a participant's diet adheres to the prudent pattern, and can be interpreted as a marker of their diet quality (Robinson et al., 2017). For both men and women, high prudent diet scores have been related to lower fat intakes and to higher intakes of protein, fibre and most micronutrients (Robinson et al., 2009). At baseline, in addition to the administered FFQ, the diets of a subset of HCS participants (n=1407), had also been assessed using a 24-hour food diary. The correlation coefficient between the prudent diet scores calculated from the full FFQ and the prudent diet scores from the food diaries was 0.73 (P<0.001) (unpublished data).

2.1.1.1 Short diet quality questionnaire

A shorter 24-item food frequency questionnaire (FFQ) was developed from the full-length FFQ to include only the key foods that characterised the prudent dietary pattern and contributed to the overall pattern scores (Robinson et al., 2017). To calculate prudent diet scores using a smaller number of foods, the coefficients from the original PCA (of the full FFQ) were multiplied by the frequency of consumption of these 24 foods. Prudent diet scores calculated using the short FFQ have been shown to be highly correlated with scores calculated from the full FFQ (0.912 in men, 0.904 in women) (Robinson et al., 2017). Both short FFQ and full FFQ scores have been shown to have comparable associations with blood biomarkers in community-dwelling older adults – in men and women, higher scores have been associated with higher plasma vitamin C concentration and higher serum HDL concentration; higher scores have also been associated with lower serum triglyceride concentration in women (Robinson et al., 2017).

In the study of HCS participants described in Chapter 4, baseline prudent diet scores were calculated for each participant based on their consumption of 24 indicator foods, as described above (Robinson et al., 2017), indicating the participant's compliance with the prudent pattern, and were used as an indicator of diet quality.

At follow-up (2011), the diets of 221 men and 221 women were re-assessed using the short 24-item FFQ that was administered by trained research nurses (Bloom et al., 2017a). Prudent diet scores were calculated for each participant, as described above, based on their consumption of

the 24 indicator foods. Changes in prudent diet scores from baseline were calculated by subtracting baseline diet scores from follow-up scores, such that a positive change value indicates an increase in diet quality and a negative change value indicates a decline (Bloom et al., 2017a). These change in prudent diet scores were used in both Chapters 3 and 4.

2.2 Qualitative research methods

Qualitative research can be especially pertinent for health research that seeks to investigate how and why people behave in specific ways (Swift and Tischler, 2010). Qualitative methods are often used to further understanding of complex issues, like those related to food choices (Swift and Tischler, 2010). As such, these methods were chosen in Chapter 3 of this thesis, to explore influences on diets of older adults living in the community. I wanted to explore participants' experiences of food and eating and to examine what they felt most influenced them when they made food-related decisions.

Quantitative research methods, such as surveys and psychometric scales, can also be used to investigate attitudes and behaviour (Swift and Tischler, 2010). However, unlike qualitative methods, these do not tend to produce data that give detailed descriptions or generate explanations (Swift and Tischler, 2010). It may not be possible to fully understand people's knowledge, attitudes and behaviour solely by considering their answers to direct questions (Kitzinger, 1995). While quantitative methods are more useful for explaining how many people have a particular behaviour or hold a particular pre-defined opinion, qualitative methods, such as focus groups, are more appropriate for exploring how those opinions are constructed, and can explain, for example, why there are gaps between health knowledge and health behaviour (Kitzinger, 1995).

Qualitative research encompasses a wide range of approaches and techniques (Swift and Tischler, 2010). Focus groups are a type of group interview that specifically uses group interaction as part of the research method, using communication between research participants in order to generate data (Kitzinger, 1995). This qualitative method is especially useful for exploring people's knowledge and experiences and for examining not only what people think, but how and why they think that way, providing researchers with deep insights into how and why participants feel and behave the way they do. This method is meant to assist participants to discuss and explain their views, which may not be as easy to achieve in a one to one interview (Kitzinger, 1995). Focus groups allow access to forms of communication that are commonly used everyday interactions (e.g. jokes, anecdotes, and arguing), which can provide rich information about what people know

or experience, which would often be inaccessible by using more conventional data collection techniques, such as questionnaires or interviews (Kitzinger, 1995).

The use of focus groups as a method can have various advantages, such as encouraging participation from people who are not keen to participate in one to one interviews, and prompting contributions from people who do not feel like they have anything to contribute; in addition, participants may tend to express views more strongly in a group that they would in private. On the other hand, participants may feel under pressure to agree with the dominant view, the group dynamic could silence individuals who do not agree with the general consensus; also, there can be disagreements and irrelevant discussion that can distract from the main focus, so it is important for group discussions to be controlled and managed appropriately (Kitzinger, 1995).

As indicated from the review of the literature in Chapter 1, influences on older people's diet quality are a complex issue. Surveys are useful for observing associations between factors and older people's food choices and quality of diet, but cannot provide information on why such associations arise and what underlies them. Focus groups can be useful for understanding the complexity of influences on food-related behaviours or motivations in later life, and to provide context for the associations seen in quantitative data.

Chapter 3 (page 38) of this thesis uses qualitative methodology to explore subjective experiences and attitudes to food and eating, to provide deeper insights into what influences older people's food-related decisions and behaviours, and ultimately the quality of their diets.

2.3 Mapping of local Southampton services

This subsection relates to the mapping study described in Chapter 5 (page 81) of this thesis.

Chapter 6 (page 102) of this thesis sets out a pilot study that was carried out to implement and evaluate a social networking tool (GENIE—Generating Engagement in Network Involvement), which facilitates engagement with local support resources and activities. One of the aims of the pilot study was to assess the impact of GENIE on diet quality in a group of older community-dwelling adults in the Southampton area. However, before we can intervene, we need to understand the local Southampton context, which is the focus of Chapter 5.

The MRC guidance for process evaluation of complex interventions emphasizes that at the piloting stage of an intervention, process evaluation is essential to understand the feasibility of the intervention and to optimise its design and evaluation (Moore et al., 2015). The MRC process evaluation framework sets out three key components of a process evaluation, i.e.

implementation, mechanisms of impact, and context. The context in which an intervention is delivered affects both what is implemented and how outcomes are achieved, meaning that the same intervention may produce different outcomes in different contexts. It is thus essential to assess the context in which the intervention will be carried out.

Pre-existing contextual factors may influence how the target population responds to an intervention. As the GENIE pilot study was delivered to community-living older adults in Southampton, it is important to understand how the local context, in terms of services, resources and policies, may influence how the participants respond to the intervention. Also, there could be mechanisms within the context which act to sustain the existing circumstances, or enhance the effects of the intervention. The GENIE social networking intervention is meant to facilitate engagement with local support resources and activities, therefore it is important to understand what is available in the Southampton area that is relevant to community-living older people. One of the stages of delivering the GENIE intervention consists of linking participants to valued activities and resources that feature in a pre-created database where local organisations and resources have been listed and categorised; thus, it is likely that the implementation of this intervention, and its effects, will be affected by the existing context in Southampton. It could be that there are insufficient/inadequate activities and resources for people to engage with, which would counteract the effects of the intervention, or conversely that the local community and policy environment (i.e. the context) could actually enhance the effects of the GENIE intervention.

The mapping study, described in Chapter 5, forms part of the process evaluation for the development of the GENIE pilot intervention study. It comprises the contextual component of the process evaluation and aims to measure the context into which the intervention will be introduced. This will help to provide a more detailed understanding of how the intervention might work on a small scale. The focus of Chapter 5 is to map what services or interventions are already available to community-dwelling older people in Southampton that might support their diets.

The other components of the process evaluation of the intervention, namely implementation and mechanisms of impact, will be addressed in the chapter about the GENIE intervention pilot study (Chapter 6).

2.4 The GENIE tool: a social network intervention

This subsection relates to the pilot study of a social network intervention GENIE (Generating Engagement in Network Involvement) to promote diet quality in a group of older community-dwelling adults with Chronic Obstructive Pulmonary Disease (COPD), described in Chapter 6 (page 102).

To address whether changes in social networks can be used as an intervention to promote positive changes in diet quality, I established a collaboration with researchers (Lindsay Welch, Dr Ivo Vassilev, and Professor Anne Rogers) in the National Institute for Health Research Collaboration for Leadership in Applied Health Research and Care (NIHR CLAHRC) Wessex (Theme 5). They are running a programme of work to implement and evaluate the novel GENIE social network intervention tool in various settings, including in a local Southampton COPD clinic. The focus of part of their programme of work is to assess the impact of GENIE on quality of life, healthcare utilisation, burden of disease and psychological impact of the disease in this clinic.

The GENIE tool was developed by the above team of researchers, and is an online social network tool, that helps individuals to map their social network and to use their existing contacts and add new ones where needed. The GENIE tool has been previously implemented in practice in a community setting (Kennedy et al., 2016) and was found to be acceptable and appropriate to participants when delivered by trained facilitators. As advanced by Kennedy and colleagues, GENIE is designed to work by 'initiating positive disruption of established self-management practice through mapping and reflection on personal network membership and support', which presents 'possibilities for reconstructing self-management differently from current practice' (Kennedy et al., 2016). Some of the elements that have been identified as key to GENIE's success are the visual maps of networks and support options, the guided help to assist engagement and discussion of support and preferences for activities, and a reliable database (Kennedy et al., 2016). The GENIE intervention is envisaged to be co-produced with the user, in which a facilitator (in the present study, a researcher) guides them through the process.

The effective implementation of GENIE in the 'My Life a Full Life' (MLAFL) project, based on the Isle of Wight (Kennedy et al., 2016), centred on people with type 2 diabetes. In the present work, implementation and evaluation of this tool in a COPD service was undertaken to enable understanding of differences in the utility of GENIE for different long-term conditions, of the barriers to social engagement, including those linked to a person's physical condition, and of the response, uptake and practical benefits of GENIE for COPD patients.

The process of delivering the GENIE intervention consists of the following stages:

- Filter questions: The participant is prompted to enter background information about their postcode, gender, age, and health condition. This helps the tool to tailor results to the participant.
- Stage 1: Mapping of the participant's current social support network using a concentric circles method, to gain insight into the participant's current situation regarding social networks and social support and then to suggest people and groups who could potentially

provide extended support. In this stage, social network members (family, friends, groups, professionals) are represented and mapped onto three concentric circles, depending on their importance to the participant (an example is shown in **Figure 5**). Details of relationship and frequency of contact are recorded.

- Stage 2: Choices are tailored using a series of questions to elicit the participant's values and preferences for activities and support resources, this is based on preference and enjoyment rather than on health-based needs.
- Stage 3: This section links the participant to prioritised and valued activities and resources, from a pre-created database where local organisations/resources have been listed and categorised. Suggestions for activities include exercise groups, hobby groups, and volunteering and educational opportunities. Network members can be selected as potential buddies to accompany participants to new activities.
- Stage 4: The GENIE tool then presents options to the participant in a user-friendly way with clear details about location and access; locations of activities are shown on a Google-based map (an example of this is shown in **Figure 6**).

Figure 5 An example of a concentric circles diagram, which maps the personal community of support of GENIE tool users.

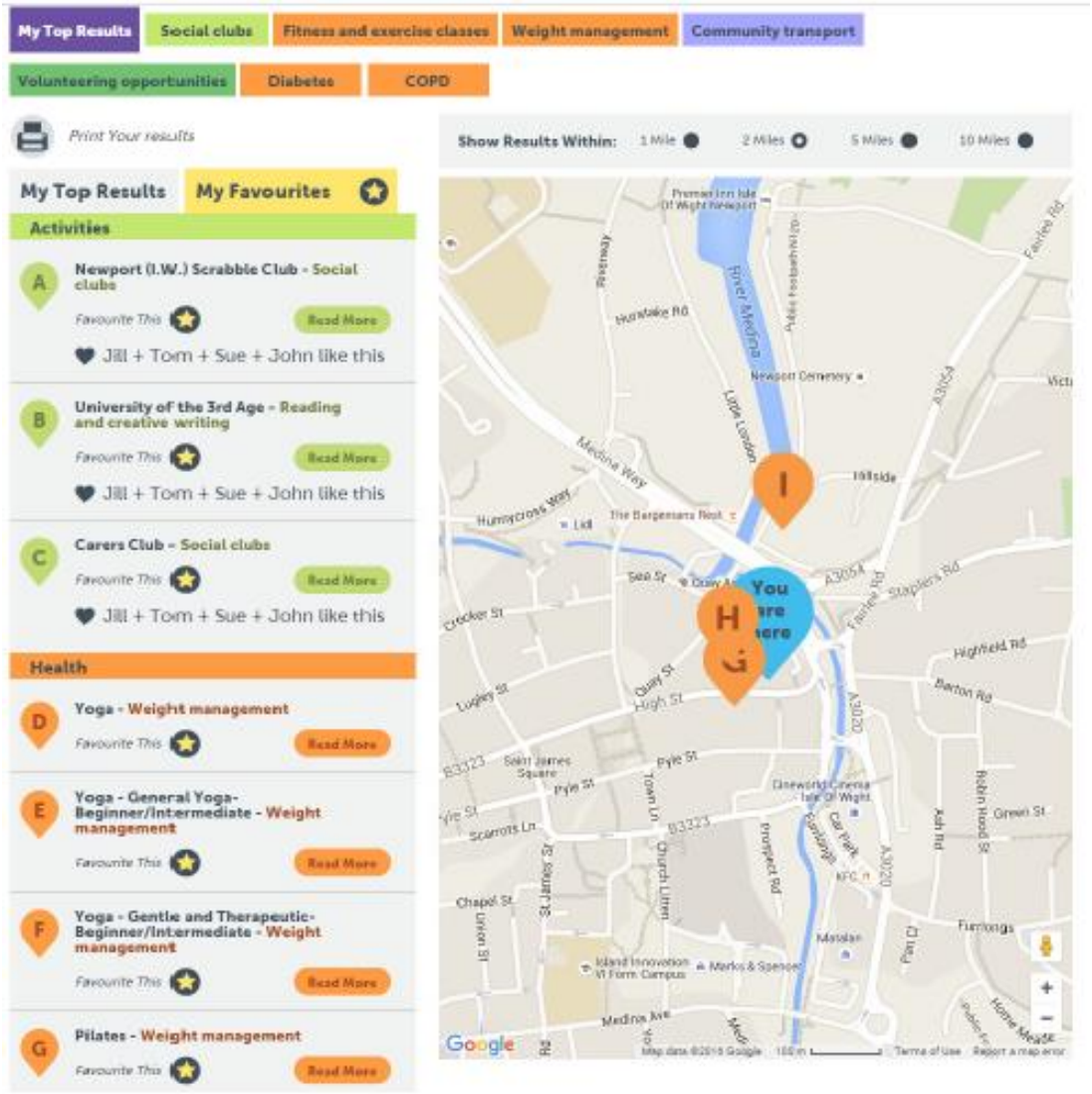


Figure 6 An example of suggestions of local activities and groups that are presented to GENIE users, based on their preferences, with location and further details.

Chapter 3: Hertfordshire Cohort Study: qualitative study of influences on diet in older age

3.1 Introduction

As indicated by the literature review in Chapter 1 of this thesis (page 10), much of the evidence regarding the determinants of food choice and diet quality in later life is cross-sectional and largely fragmented, particularly regarding how factors might interrelate to impact on diet. The lack of longitudinal evidence is particularly problematic because of the age-related physiological, psychological, and social changes that occur which may affect food consumption. Importantly, the variability in diet seen across the older population in the UK (Robinson et al., 2009) suggests that some older adults are able to adapt to these changes and maintain diet quality, while others do not (Vesnaver et al., 2012). It is important to understand which factors might predict changes in food-related behaviours and in the quality of diets in the course of ageing.

Gaining insight into what supports older adults to eat well will be important in the development of interventions to promote diet quality and enhance healthy ageing. The present chapter uses qualitative methodology to explore subjective experiences and attitudes to food and eating, to provide deeper insights into what influences older people's food-related decisions and behaviours, and ultimately the quality of their diets. Using quantitative longitudinal data on diet quality in the Hertfordshire Cohort Study (HCS), participants could be identified according to their stability of diet, to enable comparison of individuals whose diet quality declined and those whose diets remained stable over time. A sub-group of participants were invited to the Hertfordshire Qualitative Study; its primary aim was to explore influences on diet among community-dwelling older people in the UK; the secondary aims were to gain insight into gender differences and factors linked to differences in diet stability in older age.

Most of the work presented in this chapter has been published as an article (Bloom et al., 2017b). The published article has been added to this thesis as an appendix (Appendix D).

3.2 Methods

Some of the methods that were used to undertake the work in this chapter have been detailed in sections 2.1 and 2.2 of this thesis.

Hertfordshire Qualitative Study (HQS) participants were selected from the HCS. I set up the focus group data collection for this qualitative study, carried out between March and September 2014; I obtained ethical approval for the study (REC reference: 10/H0311/59), recruited 92 participants from the HCS, and organised a series of 11 focus groups to discuss influences on diet and barriers to eating healthily. The participant information sheet can be found in Appendix A. The semi-structured discussion guide that was used in the focus groups was developed in consultation with members of the research team that included nutritionists, epidemiologists and social scientists in the field, and was based on a literature review (see Appendix B for the full discussion guide). Together with another researcher (Dr Wendy Lawrence), I conducted focus groups to collect the qualitative data – each of us took turns to moderate and observe the discussions; both of us had moderator (leading discussions) and observer (monitoring the environment such as heat and timings, taking notes about the group dynamic, and prompting the moderator with any areas they may feel require extra exploration) roles throughout the discussions. Discussions were audio-recorded and I transcribed verbatim the focus group discussion audio recordings. Working with the other members of the research team, we analysed the data and discussed the results of the analysis at a number of meetings to identify main themes. I wrote this work up for publication (Appendix D).

3.2.1 Participants

Study participants were selected from the HCS, and included participants whose diets had been assessed at two time points. Of the 442 HCS participants with follow-up dietary data (diets had been assessed at baseline and at 2011 follow-up, as described in section 2.1), 408 (still alive and taking part in the study, in early 2014) were approached and invited to attend a focus group to discuss influences on diet and barriers to eating healthily. These participants were divided into three groups (initially) according to change in diet over the past decade – defined using change in prudent diet scores (as described in section 2.1.1.1). The distribution was evaluated and an interval of change in prudent diet scores was chosen (-0.02 to +0.02) to represent 'maintenance' of diet quality – the participants with change in diet scores to either side of this interval were grouped into one of two groups: 'diet-declined' or 'diet-improved'. 'Diet-declined', 'diet-improved' and 'diet-maintained' participants took part in different focus groups. As only one focus group was held with 'diet-maintained' participants (n=7), participants falling into either the 'diet-maintained' or 'diet-improved' groups were grouped together into a 'diet-stable' group, for the purposes of these analyses.

Sufficient focus groups were conducted both to reach the point of saturation, the point at which no new information or themes were observed in the data (Krueger and Casey, 2000), as well as to

ensure approximately similar numbers of participants from the groups that we aimed to compare (men vs women; 'diet-declined' vs 'diet-stable').

Of the 408 participants approached, 92 (23%) participants (43 women and 49 men; mean age=78 years) were successfully recruited into the study; the remaining 316 people did not take part for various reasons (unavailability in the study time frame, non-response to invitation letter or unwillingness; further, not all participants who were available and willing to take part, could be recruited into the study, as recruitment was stopped when the point of saturation was reached). In comparison with the 316 HCS participants who did not take part, there were no differences in terms of age, education or social class, however the 92 participants had slightly healthier diets when assessed at baseline: mean (SD) prudent diet score 0.476 (1.429), compared to 0.117 (1.205) in those who did not take part (P=0.017).

This study was carried out in line with the guidelines set out in the Declaration of Helsinki and all procedures involving human participants were approved by the NRES Committee East of England, Hatfield (REC reference: 10/H0311/59). All participants were provided with an information sheet explaining the study and the nature of the discussion (see Appendix A for the participant information sheet). Written informed consent was obtained from everyone before discussions began.

3.2.2 Procedure

Participants were contacted by post with an invitation letter, a participant information sheet detailing all important aspects of the study and a reply slip to indicate whether they would be willing to take part. If there was no response from a potential participant after two weeks, a reminder letter was sent. Thereafter, no further contact was made about this study. Willing participants were contacted by telephone to arrange a convenient time for them to attend a focus group. Focus groups were run by two investigators (myself and Wendy Lawrence) and held in a centrally-located community venue in the town of Hertford, UK in mid-March, end May/beginning June and end September 2014. Upon arrival, we introduced ourselves to participants, attendees were reimbursed for any travel costs incurred and refreshments were provided. Participants did not receive any further incentives for their participation. Wendy and I worked as a pair, each of us taking turns to moderate and observe the discussions. Both researchers were present at every focus group, except for the last one where only I was present due to practical constraints. Focus group discussions lasted anywhere between 75 and 99 minutes, with an average of approximately 1.5 hours, and were guided by a semi-structured discussion guide. Discussions were audio-recorded and transcribed verbatim.

3.2.3 Data analysis

Thematic analysis is a common approach to focus groups analysis. This involves looking for patterns or 'themes' which emerge from the data (Braun and Clarke, 2006). Transcripts were analysed thematically. The process began with identifying initial codes from transcripts to be refined into themes. Working with the other members of the research team, we independently read and reread the transcripts while coding the data; either whole segments of conversation were coded, or individual statements. A coding framework was developed to represent emergent themes, which were identified using inductive coding, a process of coding the data without attempting to incorporate it into a pre-existing coding framework, i.e. data-driven (Braun and Clarke, 2006). All transcripts were double-coded and analysed using a constant comparative approach (Boyatzis, 1998), whereby each theme was compared to the others and assessed for similarities and differences, driven by the study's central purpose, i.e. to explore influences on diet in older age, as well as any gender differences and differences between 'diet-declined' and 'diet-stable' groups. Both moderator and observer were involved in the data analysis to ensure that it was representative of the groups' views and we met regularly to discuss any disagreements, make suggestions for amendments, and agree on the coding framework. The final coding framework has been included as an appendix to this thesis (Appendix C). The themes were developed and depicted in a thematic map to illustrate how they linked to form the interpretation presented here. Analyses took place at the group level as individuals were not identifiable from the audio-recordings.

3.3 Results

3.3.1 Focus group characteristics

Eleven focus group (FG) discussions were held (see **Table 1**): six with participants whose diet quality had declined (n=41), five with participants whose diets had remained stable over time (n=51). All but one group were held separately for men and women in order to examine differences by gender. Of the 92 participants, 47% were female, the age range was 74-83 years (mean=78 years). There was a similar spread of manual social class and non-manual social class participants, both within each category of focus group, as well as within each individual group. Numbers of participants in each focus group ranged from five to twelve, and all were white British, born in Hertfordshire 1931-9.

Table 1 Characteristics of study participants by type of group interviewed (the number of participants in each focus group ranged from five to twelve).

		Women, Diet Declined	Men, Diet Declined	Women, Diet Stable	Men, Diet Stable	Men and Women, Diet Stable
Number of focus groups conducted		3	3	2	2	1
Total number of participants		20	21	21	23	7
Mean Age (years)		78	78	78	78	80
Age Left Education N (%)	**≤14**	6 (30%)	3 (14%)	1 (5%)	3 (13%)	1 (14%)
	≥15	14 (70%)	18 (86%)	20 (95%)	20 (87%)	6 (86%)
Social Class (N)	**Non-manual**	10	8 (2 missing)	9	11 (1 missing)	5
	Manual	10	11	12	11	2

3.3.2 Thematic analysis

Analysis of the data, whereby themes were identified in an inductive (data-driven) process and then thematically coded and analysed using a constant comparative approach, revealed that a number of distinct themes appeared to be important influences on diet. A thematic map was created to depict these themes, and this was developed into a hypothetical model to depict the relationships between the themes (shown in **Figure 7**). This model shows how it is proposed that the themes might interrelate to impact on diet. Four initial themes were proposed as contextual factors:

1. Historical influences on and current beliefs about food
2. Retirement and bereavement
3. Age-related conditions/symptoms
4. Food environment

Discussions with participants revealed two additional themes that appeared both to have a direct influence on diet and also potentially to mediate the influence of the four contextual factors on diet; these themes are thus hypothesised to be underlying factors in this interpretation of the data:

5. Psychological/personal factors

6. Social engagement

The relationship between the contextual factors and the two underlying factors is seen as a dynamic, and bi-directional. The result of the interrelationship between the contextual and underlying factors determines how individuals make food choices and construct their diets, captured in the final theme:

7. Food-related habits (e.g. types and quantities of foods eaten, methods used to prepare food/meals…).

These themes are set out below and illustrated with example quotes.

In addition to the primary aim, to explore influences on diet among community-dwelling older people, the study was designed to address two secondary aims, namely to explore differences between 'diet-declined' (DD) and 'diet-stable' (DS) groups, and between men (M) and women (W). However, the analysis did not reveal any obvious differences between the diet groups and revealed few gender differences. Therefore the Results section focuses on the themes (listed above) that address the primary aim. For each theme, example quotes are presented from a mix of diet-declined and diet-stable groups (indicated for each quote), as well as 'men' and 'women' groups, to illustrate the broadly similar findings among the types of groups. Where appropriate, comments on gender differences are given.

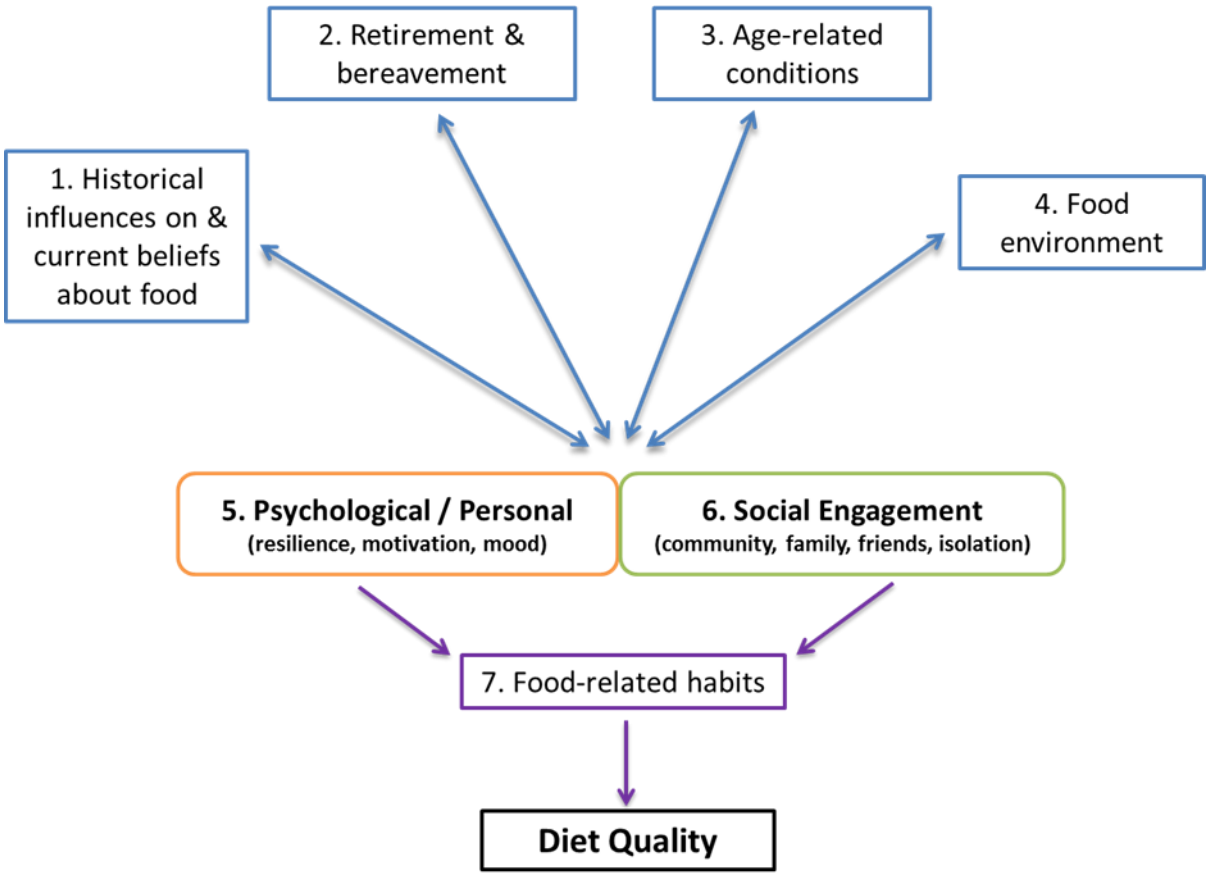


Figure 7 Hypothetical model of the relationships between the themes and potential routes to impact on diet quality in older age.

1. Historical influences on and current beliefs about food

All groups in this study described the importance of their upbringing and past experiences, including their mother's influence, on the foods they currently ate:

> "My mother was a great cook and she taught me how to skin rabbits (laughter) and pluck chickens … she taught me all sorts of things and I continue that today … we eat basic and that's what I've been brought up on" (FG1W DD)

> "Certainly in the 40s and perhaps in the 50s the standard part of everybody's diet was bread and dripping, Christmas suet puddings … all the offal that we used to eat, which we're now told we shouldn't" (FG11MW DS)

Growing up during the war was an important topic of discussion in all groups, and in particular how this shaped attitudes towards food waste:

> "During the war you even scraped the packet after the butter had come in and you got every last bit. Opened up the tea packet to get the last little bit out - sugar, everything. You

> didn't waste anything did you really, and it's hard to get out of that way, well I don't think you should really" (FG7W DS)

Many perceived food production practices today as worse than they used to be:

> M1: "A lot of the food stuff now is 'factorised' whereas the cows used to stroll in the fields, they are all sort of penned-up and the chickens are all inside and not free-range. It was more natural then; even the fish is farmed to a great extent.
>
> M2: Yes I don't like the idea of farmed fish in fact I won't eat it if I can help it" (FG3M DD)

> "I used to spend a lot of my summers on farms and we used to eat naturally produced foods and I used to drink milk straight from the cow. But nowadays everything is so processed I often wonder whether it's the process that's causing a lot of the problems. If we could go back to the old days and eat food that was fresh and eat it at the time it was fresh rather than when it's been stored and frozen etc. it would be better" (FG8M DS)

Confusion caused by conflicting messages and information in the media nowadays was discussed extensively:

> "They tell you one week that eating red meat isn't good for you or next week maybe you should never drink wine and then the next week it's … you know too much pasta is not good for you and they all make it up as they go along don't they" (FG2M DD)

> "We swapped over to having things like Flora and then you read articles that say actually butter is better for you" (FG9W DS)

Discussions conveyed that a general shift towards healthier eating habits was guided by current messages and beliefs about what constituted 'healthy', including less fat, sugar, salt:

> "The latest research comes out and you switch to something, you know. But gradually… we probably eat a much healthier diet now" (FG3M DD)

> "I know that we all eat a lot more fish than we used to, and probably more chicken, but a great deal less red meat … I think because in the media there's been quite a lot about it not being good for you" (FG9W DS)

> "Don't have fried bread now … I suppose because it was … said that it was bad for you" (FG10M DS)

These contrasting views of current messages, demonstrate the importance of messages received from the media in shaping people's dietary attitudes and behaviours.

2. Retirement and bereavement

Most spoke of the impact retirement had had on their lifestyles and in particular on their food habits. One outcome was having more time to prepare food, and another was how the new daily structure led to changes in eating patterns:

> "I think when you're retired, you've got more time … retirement's seven days a week … but you can think a bit more about what you want – if you gotta cook, what you want to cook, or organise your week" (FG2M DD)

> "We wonder how we ever found time to go to work!" (FG4W DD)

> "I've cut out the two cooked meals a day 'cos when I was in the office I had a restaurant and … had a proper meal, but when I got home in the evening my wife hadn't had anything so I'd keep her company with a cooked meal. Now … we just have a cooked lunch and then have a lighter meal" (FG10M DS)

Following bereavement there were often significant changes to cooking or eating behaviour. The impact on diet following the loss of a partner appeared to affect men and women differently. For women, the loss of their partner elicited a range of differing responses in relation to eating, both positive and negative. Women who had lost their partner felt less motivated to cook for themselves, as is described further on. Some tried different foods or went to different places to eat:

> "I have a sister-in-law … and our husbands died within six months of each other and I decided to take her out and we went to (*restaurant*) and ooh she'd never been anywhere like that, it was wonderful so we've been there several times" (FG4W DD)

Some had difficulty in accessing the shops, since it was their husband who had done most of the driving:

> "My husband died and so I haven't got the car now … I didn't drive a lot … I am lucky because if I go shopping, I've got my cousin's husband, always picks me up you know and takes me home" (FG4W DD)

For men, the primary outcome from the loss or illness of their partner appeared to relate to their ability or motivation to cook or learn to do so. Men largely spoke about having to adapt after losing the person who did most of the cooking. Some learnt to cook and found enjoyment in this; others found alternative solutions such as opting for ready-meal deliveries.

"We always ate well and I still eat well … 'cos my wife was a good cook and she taught me because the latter part of her life she wasn't able to do it, so obviously I had to do it under supervision and to be honest about it, it's stood me in good stead" (FG2M DD)

"My wife died about 18 years ago so I've been on my own for the past 18 years but I've got 3 daughters … we meet up on Wednesday, have a have a dinner 'cos I cook my own meals…" (FG10M DS)

"Well ten years ago I suddenly found myself on my own as my wife suddenly died without any warning at all … so I suddenly found I had to learn how to cook, and anyway I found that I liked to steam all my vegetables mainly because you could do it all in one pot and you only had one to wash up" (FG3M DD)

"My main meals are prepared meals you know microwave meals … I have them delivered from a frozen food company … I feel rather lazy (laughter) … I've been doing that for must be three or four years now … I didn't take much notice of what she was doing unfortunately" (FG2M DD)

3. Age-related conditions

Having a smaller appetite as a result of the natural ageing process was discussed in all groups and many considered portion sizes to be too large when eating out.

W1: "I am eating less definitely"

W2: "I think you do as you get older" (FG4W DD)

"Ten years ago I'd eat a plate full of food … several times a day, good big meal, but now well in the last two or three years I just don't want it really…" (FG5M DD)

"Just have a smaller appetite, if I go out I meet a group … and a meal just a social thing … but we often have children size portions" (FG1W DD)

"Some of the places where you go … they seem to serve up absolutely enormous helpings" (FG8M DS)

Many noticed changes to their sense of taste or smell:

"I can't taste anything much, never tastes the same" (FG7W DS)

"My sense of smell is nothing like as good as it used to be" (FG8M DS)

All groups discussed making changes to their diets, such as choosing or avoiding certain foods, due to medical conditions or medication they were taking. Furthermore, most groups spoke about how physical incapacity or decline had affected food-related activities:

> "I enjoy fruit but I don't have it because I am sure it affects arthritis" (FG4W DD)

> "I found I'd got a cholesterol problem so I had to go onto Simvastatin and therefore cut down on milks, cut down on butter and all that sort of stuff" (FG3M DD)

> "My knees are so bad now I just don't walk far … I used to drive but I had to give it up, but I wish I could drive now, it would be easy as I could go down and get my own shopping. I miss doing the shopping" (FG4W DD)

Discussions about weight were more dominant in the women's groups than the men's:

> "I've lost nearly a stone and I'm pleased … since my husband died, I watch what I eat" (FG1W DD)

> "The problem I had with my knees and my hip… I then went to Weightwatchers … and we had quite a low-fat diet, not such large quantities, a much healthier diet I think … I feel much better" (FG9W DS)

4. Food environment

Price or getting value-for-money was widely discussed, as well as availability and quality of foods.

> "… when I first started you couldn't buy hardly anything gluten-free but now you can … there's quite a lot in the supermarket, it's pricey I must admit … but you can get it" (FG1W DD)

> "Herrings, you can't get herrings now can you?" (FG5M DD)

> "Can't buy scrag-end of neck of lamb to make a good stew … taken the bones away and it's no good without the bones is it? I honestly don't think some of the food tastes like it used to but then perhaps that's all part of getting old" (FG7W DS)

> "Well I like bread and dripping but there's none around" (FG10M DS)

Many spoke about issues with accessing shops or food-related activities:

> "We've got a small Co-op shop just at the end of the road from us" (FG5M DD)

> "I only ever use long-life skimmed milk … I've always got it because it's about 7 miles to get to the supermarket, so I buy a boxful and it's in there now until October" (FG6W DD)

> "We used to walk down for tea to Hertford and catch the bus back 'cos it's uphill, but you can't rely on the buses now so we've stopped doing that" (FG7W DS)

Women who lived alone had difficulty finding smaller portions, with supermarkets not catering for the single person and a lack of availability of small shops, such as local butchers:

> "If you're on your own, supermarkets don't really cater for single portions" (FG7W DS)

> "I think villages are luckier … we don't have any small butchers or anything. My sister's got a butchers there … and the little local shops you know which cut off ham or bacon, cuts it as you want it" (FG1W DD)

It is hypothesised that there are two underlying factors (presented below), namely psychological/personal factors and social engagement, that impact on how older people respond to and cope with the influences identified above.

5. Psychological/personal characteristics

Our analyses identified a series of contextual and underlying themes that describe influences on diet in older age. One of the underlying themes identified in this study was the role of psychological and personal factors. A frequently-cited driver apparent in these discussions was the need to "keep going", by being positive and maintaining an interest in life, for fear of being a burden on others or losing their health/independence, like others (peers) have. Participants spoke of wanting to be part of the wider community and to be able to do the things that they had always done, including cooking and eating well. This, along with other explicit references to being motivated to "not give up" and to not be perceived and treated as old, as well as implicit examples of resilience and coping strategies, highlights the importance of resilience (positive adaptation despite adversity) and self-efficacy (belief in their own ability to achieve a desired outcome) for these participants in overcoming dietary setbacks, and suggests an important mediating role of psychological and personal factors on diet, in this population. These characteristics may make it easier to cope with some of the other contextual influences that were identified, such as bereavement, age-related conditions, barriers to food access, and challenges to food-related beliefs.

A consistent message from the discussions was the importance of staying positive and being motivated to keep healthy and independent to avoid having to rely on others:

W1: “You just do it.

W4: You must be positive …

W2: Motivation …

W3: I think it’s fear of having to rely on other people.

W4: Just like you’re going home tonight (you want) a meal, so you’re going to cook it aren’t you?” (FG7W DS)

“I would really like to try and do it myself and I think the art is trying to keep going as long as you can (FG1W DD)

“Still here anyway, that’s the main thing, still get up in the morning” (FG5M DD)

“W: Although I haven’t got any children I’ve got two of the little girls across the road, I mean they come and they’ve been making cakes with me or they come do things in the garden. I think it’s to have an interest in something, it doesn’t matter what it is, it’s just having an interest.

M: ... whether the interest is reading the paper or doing the crossword or doing Sudokus or running around the block … you’ve got to have something that absorbs you. (FG11MW DS)

There was an emphasis on not being regarded as old, or accepting that old age meant behaving in a certain way, and on wanting to remain part of the wider community:

“Making sure you can keep doing all the things you did all your life … and that’s only by keeping on doing exactly what you’ve always done, not suggesting that you’re too old anymore … that’s my policy” (FG8M DS)

“My daughter always says ‘Why do you like to go out shopping on a Saturday mum?’ It’s because I like to be with people of all ages (noises of agreement). If you go and have a coffee on a Saturday it is all ages (noises of agreement) children which I love to see you know … you go out in the week … it’s like an old people’s club” (laughter) (FG9W DS)

“I was told a long time ago … it was a lecture by a geriatric doctor and she said you should never look at your pension book, your birth certificate and think I can’t do that because I’m this (age) now, you use everything before you lose it, which … I thought was very good” (FG11MW DS)

For most groups, cooking and food were viewed as a priority:

> Moderator: "And what kind of priority is there for food in everybody's lives?
>
> M: Oh number one … I'm still on me own but I'm still … making meat puds and all that" (FG2M DD)
>
> Moderator: "Is it still a priority to eat well? Not just to provide for somebody else?
>
> W: Yes because you've got to keep going haven't you?" (FG4W DD)

For all groups, taste and enjoying food were significant influences on food choices and it was evident that for some this may be more important than potential health benefits:

> "I eat what I wanna eat. I know I have a fat belly as you can see. I eat butter, milk, cream, everything, you name it I'll have it. 'Cos you know life's too short, you have what you want" (FG8M DS)
>
> "I think I'm nearly 76 and how long are you going to live and why make your life miserable in the meantime. I'd rather live a bit shorter and enjoy my life" (FG9W DS)

Both genders spoke of being too lazy, not bothering to cook or not enjoying cooking, but this appeared to be more dominant for women. This seemed to be linked with the issue of eating alone and no longer having the role of providing meals for someone else (described below in the section about social engagement), and was another aspect of the interrelationship between gender and how bereavement and potentially loneliness influenced food-related behaviours:

> "I'd really love somebody to cook for me, yes I would" (FG1W DD)
>
> "I admit I'm lazy, I don't bother to cook dinners very often … I very rarely eat meat and I don't eat chicken so I find it really difficult to eat proper, so possibly I have too much things on toast … I never used to be like this I used to eat… possibly since I've been on my own I think … I used to cook dinners every day, we used to be quite big meat eaters but I can't eat much meat now ...
>
> Moderator: Do you enjoy cooking?
>
> No, not now" (FG6W DD)
>
> "Well when my husband died I mean before that I used to have to, you know you've got to cook for them haven't you … but then sometimes I don't bother … I don't cook the same as

> I used to, I don't cook a proper meal 'cos I think you know, sometimes it's not worth it … but I probably (eat) more salads and more fruit and veg" (FG9W DS)

Men appeared to need the structure of set daily routines for their meals, and this was not so apparent for women:

> "I also find that when I eat I have to eat at certain times, believe it or not … I have my dinner at half past four-five o' clock every night, even Sunday when I've been down the pub … that is the time I enjoy my meal, whether that stems from the time I used to finish work (and the) meal was on the table when you come in" (FG3M DD)

> "One thing I do insist on is regular meals … breakfast … lunch at midday, that's right like my mother used to do" (FG10M DS)

6. Social engagement

In addition, there was much discussion about social activities and isolation; of community spirit and loneliness – indicating the importance of maintaining and developing ways to ensure social engagement, the other underlying theme identified in this study. For those who have a good level of social engagement, it may be easier to cope with the process of ageing and some of the other contextual influences that we identified, such as retirement and bereavement, age-related conditions, and barriers to food access. There was recurrent discussion about taking part in various social activities and clubs. The motivation to keep going and not be perceived as old led these participants to seek opportunities for social engagement.

Eating out or with friends/family was widely spoken of as a key social activity:

> "We have a monthly pub lunch over at Watford Stone and you see people there that you probably haven't seen for donkey's years and we've got another group in Hertford ... we meet once a month, the food is dreadful (laughter) - it really is! I said to a bloke the other day 'I could never stop coming' because I only see him … when I go there … I moan about it something rotten but you go again and that is very good for socialising" (FG2M DD)

> "It's lovely if family come or you go out. I do like eating out … just for the fact that you've got company" (FG7W DS)

Friends also played an important role in facilitating engagement with a range of social activities, not necessarily food-related.

> "I have a friend who is fast approaching her 90th birthday and she's absolutely wonderful. She and I both lost our husbands in the same year and … now she will walk, she will do

> almost anything … I don't think I would've done half the things that I did if she wasn't there for company" (FG7W DS)

> "I do have one friend that we lived next door to each other when we were 3 and I'm going to see her this evening. We've known each other all that time … we went to school together she followed me to work (laughter) ... but now she's a widow, we still see each other, we go out" (FG11MW DS)

The University of the Third Age (U3A) was frequently referred to as a key source of social interaction:

> "You know every day of the week you can go on a pub lunch with the U3A" (FG10M DS)

> "Also belong to the U3A which is an absolute lifeline" (FG6W DD)

> "Quite happily go to any group in U3A as a single person, you don't have to be a couple and that's different with a lot of clubs ... they have Sunday lunch groups and things" (FG9W DS)

There was discussion of the influence of family members on eating habits; family members, such as children or grandchildren, had an important influence on participants' eating habits:

> "I do me own cooking … 'cos I'm on me own now but my daughter occasionally brings things in for me to eat" (FG5M DD)

> "I've got a grandson who's informed me that I've got to look after my health so every morning I now have to squeeze a lemon and an orange and drink it as soon as I get up every morning. 'Nan you have to have that and you've got to eat almonds' and I don't know what else. Trouble is the almonds are really hard, I have a job to bite them. So I bought the flaked ones, he said 'well they're better than nothing Nan but the whole ones are best" (FG6W DD)

> "My wife died about 18 years ago so I've been on my own for the past 18 years but I've got 3 daughters … we all meet up - my daughters and grandchildren - on Wednesday, have a dinner" (FG10M DS)

Women were more likely to speak about the loneliness of eating alone or not having a supportive community around them, particularly following bereavement. They emphasized the importance of family, friends and community in supporting them through difficult times and ensuring they did not become isolated. For women, eating alone was seen as a difficult or lonely activity; they spoke of the importance of having a partner or others to cook for:

> "I find um eating on your own, you take ages cooking a meal and you sit at the table … and within a few minutes you've eaten it and there's no one to talk to" (FG1W DD)
>
> W1: "I think if you've got a partner to do things for you or to cook for ... your life is different.
>
> W2: I think loneliness is a very big factor actually" (FG9W DS)
>
> W1: "But once you get to a certain age you stop doing things, I mean I know you're encouraging your friend and she probably wouldn't do that, would she, without (you)
>
> W2: No she wouldn't
>
> W1: Once you get lonely it's a downward spiral isn't it
>
> W2: Yes it is" (FG9W DS)

The role of friends or family in motivating and supporting women to take part in social activities, especially following the loss or illness of a partner was particularly important:

> W1: "You know if you meet people then they'll say well I'll come and pick you up.
>
> W2: Going this week … and that's the first time I've been invited and I said ... eighty-two years and I have never had an invite you know and so I got one, so I'm going there Thursday and I'm going to be taken and brought home … even though I've got a car" (FG1W DD)
>
> "People are very good ... we didn't have any children or anything like that but I've been very lucky. I've got good friends and I've got good cousins so basically if I really wanted to go somewhere special they would always take me" (FG4W DD)
>
> "Luckily I've got good family and friends, so they would rally around and say 'Oh come on go and do this'. But it is a completely different life because I find … friends … if they're all couples when you're on your own in the group … you feel more alone, you think 'Well I'd rather be at home' (FG7W DS)

Discussion about the importance of having supportive neighbours or community environment was also more prominent for women:

> "The cul-de-sac I live in, not one person has come up to me and said 'I'm ever so sorry your husband died'. I could do with somebody caring, not for me but about me, 'cos at the

> moment it's eleven months today my husband died and I am lonely … it's horrible, nobody comes up to you and says 'Want a cup of tea?' or anything" (FG1W DD)

> "I don't think there's a community spirit like there used to be … like I just know three other houses and ourselves and I very rarely see the other people … at one time you knew all your neighbours. You knew everyone was around you, there was more of a community spirit … and churches and all sorts of things, we always lived sort of in the country …people … would come to your aid or you went to somebody else and families lived together somehow" (FG7W DS)

These findings suggest that the interrelationship between contextual and underlying themes impact differently on people's food-related habits, which could underlie differences in dietary quality observed across the population.

7. Food-related habits

All participants had a great deal to say about how they prepared food and what they liked to eat. For instance preparing one-pot dinners, cooking extra and freezing were strategies to dealing with eating alone.

> "I cook for myself now and I tend to do what I call a one-pot dinner so all my vegetables go into one saucepan. I cook them all together with whatever I've decided I'm having that day ... fish or chicken" (FG4W DD)

> "Well I've lived on my own for ages and uh cooking to me is a chore so I what I tend to do is - certainly all through the winter - is I live on stews and things like that. I've got one of these wonderful slow cooker things that you just bung everything in, go off for the day and when you come back it's all done" (FG8M DS)

> "Trying to buy for one is almost impossible isn't it, you just can't hardly ever buy ... you might be able to get off the fish counter or something like that a small piece of fish, but yes it's not easy, but I say I can just freeze now and I'll just have lots of salads and vegetables and things" (FG7W DS)

All groups discussed the division of food-related tasks within the household; two main patterns emerged: the wife doing most or all of the shopping or cooking, and the husband and wife sharing the tasks.

> "You see it's difficult for me because our family are all diabetics. I'm not diabetic but my husband and his family have all been diabetics, so he's always had to be fed a diabetic meal and he doesn't cook, so I do it all" (FG4W DD)
>
> "We do it (shopping) together bit by bit; we mostly buy fresh every other day" (FG4W DD)
>
> "My wife chooses what meat we're gonna have, but I've got the stuff in the garden, vegetables, and I say we've got this and this and this. (FG2M DD)
>
> Moderator: "So what influences your choices?
>
> M: Whatever my wife puts on the table (laughs)" (FG8M DS)
>
> "We shop together … we discuss what we're gonna have" (FG8M DS)

For women, it was clear that their husbands' likes and dislikes played a major role in influencing the types of foods they cooked and hence the current family food habits. At the same time, many men appeared to prefer home-cooked meals, cooked by their wives, to meals eaten out.

> "My husband insists … meat and two veg every day at one o'clock" (FG1W DD)
>
> "I've got a husband who is very conservative about what he eats, he knows what he likes ... occasionally I try something different, but it's not worth the hassle" (FG4W DD)
>
> W1: "If you're cooking for somebody else you've got to take into consideration their likes and dislikes.
>
> W2: I did a bean hotpot one day and (husband) was looking and looking and I said if you're looking for the meat there's not any in there (laughter). I think we only had that once (laughter)" (FG7W DS)
>
> "The only time we eat out is if it's an occasion you know like Mother's Day or Father's Day or anniversary or something like that ... and the reason is I prefer her indoors' food rather than somebody else cooking it (general noises of agreement)" (FG3M DD)

3.4 Discussion

This study suggests that social and psychological factors may mediate the influence of a range of background or contextual characteristics on the diets of older people, which to my knowledge has not been demonstrated before. The study also generated testable hypotheses as to how these complex factors might interrelate to impact on diet.

The primary aim of this work was to explore what influences older people's diets. As expected, various contextual factors relating to the process of ageing had a significant impact on diet. This encompassed experiences over a long lifetime, represented as past and present food influences and beliefs, the impact of retirement, bereavement, medical conditions and symptoms, and the interrelationship between environmental and ageing factors (such as cost or access to shops, including having a means of transport to get around). All of these factors potentially constrain food choices, but there appeared to be variability in how individuals responded to these influences, indicating that other underlying factors may condition their effects on diet. Separate focus group discussions were conducted with men and women whose diets had declined in recent years and those whose diets had remained relatively stable, making it possible to explore differences between them. All but one group was single-sex, allowing an exploration of gender effects. However, surprisingly, the analysis revealed no obvious differences in influences on diet between diet-stable and unstable groups. Furthermore, despite evidence of poorer diet quality among older men compared with women in this cohort (Robinson et al., 2009), there were few differences by gender.

We developed a hypothetical model to illustrate the relationships between the themes identified through analysis of the data, suggesting how these factors might interrelate to influence diet. To my knowledge only one other model (Winter Falk et al., 1996) has sought to comprehensively synthesise the complex interrelationships between the broad range of influences on dietary choices in later life. Although the models differ in various ways, the influences on dietary choices identified in the present study are essentially similar to those set out by Winter Falk et al. in a US context. Both models emphasize the role of the life course or historical influences in shaping food choices, as well as the importance of ideals or beliefs about food and of social frameworks, linking food-related activities to companionship and social activities. The model by Winter Falk and colleagues highlights the role of personal systems in the food choice process, including value negotiations, especially involving sensory perceptions (e.g. taste, appearance) and management of social contexts (e.g. considering one's own needs as well as the needs of others). On the other hand, the model developed in the present chapter depicts more explicitly the contextual factors related to ageing, such as retirement, bereavement, and medical conditions. This model also highlights the importance of resilience as a psychological/personal factor, and suggests an important role of both psychological factors and social engagement in mediating the effects of other influences on diet.

A consistent message from the focus group discussions was the importance of staying positive and being motivated to keep healthy and independent to avoid having to rely on others, which is similar to findings by Host and colleagues in their qualitative study of dietary behaviour in

independent older Australians (Host et al., 2016b). Participants in the present study wanted to "not give up" and to be able to do the things that they had always done, including cooking and eating well. Participants discussed coping strategies to overcome barriers to achieve these goals, which highlights the importance of resilience (positive adaptation despite adversity) and self-efficacy (belief in their own ability to achieve a desired outcome) for potentially overcoming dietary setbacks. This is consistent with the findings from the qualitative study by Vesnaver and colleagues that highlighted the importance of resilience and self-efficacy as influences on diet quality (Vesnaver et al., 2012).

Participants talked about eating foods for enjoyment, as opposed to eating to maintain health. It appeared that some believed that changing unhealthy eating habits would not necessarily improve their health, whereas others were convinced that a healthy diet would keep them healthy and independent. These differing outcome expectancies – believing that one's behaviour will lead to a desired outcome – are likely to influence food behaviour in older age (Grembowski et al., 1993). According to social cognitive theory (Bandura, 1986), psychological factors such as self-efficacy and outcome expectancies can mediate the influence of environmental or situational factors on an individual's behaviour; if an individual believes they can undertake an action and that this will lead to a positive outcome, they are more likely to overcome barriers to healthy behaviours and to make changes to these (Purdie and McCrindle, 2002).

In line with previous research (Blane et al., 2003, Vesnaver et al., 2015) this study highlighted the importance of life transition points, such as retirement, loss of a partner, and onset of illness, in leading to changes in dietary habits. Previous research (McDonald et al., 2000) suggests that older men may be ill-prepared to undertake food-related activities when losing their spouse, as women traditionally carried out food-provisioning tasks; while others suggest that particularly for men, poor cooking skills may have a negative influence on diet (Hughes et al., 2004). In the present study, women who had lost their partner felt less motivated to cook for themselves, which is consistent with previous qualitative research in older community-dwelling adults (mostly female) that found that food apathy (lack of interest or enthusiasm regarding eating) influenced diet (Vesnaver et al., 2012). A recent qualitative study of widowed older women living alone (Vesnaver et al., 2015) suggests that women adopt new eating patterns in widowhood in a process that is influenced by various factors including their social network.

Previous research has found that older men and women who live alone have worse diet quality than those living with a partner (Dean et al., 2009, Irz et al., 2014a). A cross-sectional study of adults aged over 50 years in the EPIC cohort (UK) (Conklin et al., 2014) found that people who were single or widowed had decreased variety of fruit and vegetable intake in comparison to

those who were married, in men more than in women. Longitudinal evidence from the same cohort (EPIC-Norfolk cohort study) also suggests that becoming widowed, separated or divorced, could be associated with more negative impacts on diet (reduction in the quantity and variety of fruit and vegetable intakes) in men compared to women (Vinther et al., 2016). Moreover, in their study, Conklin and colleagues observed that both living alone and having less frequent contact with friends exacerbated the effect of widowhood on decreasing vegetable variety, suggesting that friends may compensate for the lack of social ties to a partner (Conklin et al., 2014, Friedman, 2014). These findings are consistent with those of the present study, where social engagement appeared to mediate the influence of bereavement (one of the proposed contextual factors) on diet.

In all of the focus groups there was recurrent discussion about taking part in various social activities or belonging to clubs, including the U3A (University of the Third Age). Among a few of the participants there was some lack of awareness about the existence of these activities and there was some discussion about differences in availability of activities according to area of residence. Research has shown that increased frequency of social contact is associated with healthier dietary habits in older people (Conklin et al., 2014). Others have found that social relationships, rather than socioeconomic status, enhance resilience in older people, when these precede, and continue throughout, the period of adversity (Blane et al., 2011). Involvement in leisure activities could become increasingly important with age and could contribute to resilience in older people (Nimrod and Shrira, 2014).

Various mechanisms have been proposed through which social isolation and loneliness might influence health, including through effects on health behaviours (Cotterell et al., 2018, Shankar et al., 2011). Social isolation and loneliness are separate concepts. While social isolation is an objective measure that indicates an absence or limitation in the quantity of social interactions, reflecting a person's lack of ties to others, such as family, friends, acquaintances and neighbours, loneliness is an emotional experience; it is a subjective measure reflecting a perceived discrepancy between an individual's desired level of social interaction and the level of social interaction achieved (Cotterell et al., 2018). There are several possible ways in which social relationships may positively influence diet; such as through increased social support, which can provide encouragement and companionship; through social influence/social comparison in relation to norms of eating behaviour; and through an increased sense of purpose, meaning in life and sense of belonging (Thoits, 2011, Higgs and Thomas, 2016). The latter pathways may promote positive psychological states that could motivate healthy behaviours, including diet (Thoits, 2011). In addition to being a source of support, social networks may also help people to make better use of the resources and services that are around them, which could impact on diet and health.

3.4.1 Strengths and limitations

Qualitative methods, focusing on subjective experiences and views, can provide insights into the influences on food choices in older community-dwelling adults that cannot be obtained by quantitative methods alone. Focus groups were selected as the method for data collection as they draw on the communication and interaction between research participants in order to generate data, and are a useful method to investigate complex behaviours, such as dietary behaviours as is the case for the present study.

Analysis of focus group data is generally conducted at the group level, increasing the likelihood of some views being weighted inaccurately. Although two researchers were present at most focus groups, one of the groups was only attended by one of them. This study presents only one possible interpretation of the data and other interpretations could be possible. However, through a rigorous approach to the analyses, including double-coding, a high level of quality control was achieved, in order to minimise misinterpretation.

A limitation of the present study is that the age range of the study population (74-83 years) was determined by the prior quantitative study, and does not represent the full age range of older adults (in the context of this thesis, 'older age' includes people ≥65 years). Only white, British older adults took part, and participants had slightly healthier diets than members of the cohort who did not take part, such that the findings may not be generalisable to all older populations. However, the HCS has been shown to be broadly representative of the wider population of older adults in England (Syddall et al., 2005), and there is no reason to believe a vastly different interpretation would be presented if others from this population were sampled. Although most qualitative research produces evidence that is not empirically generalisable (i.e. it is not possible to draw conclusions about the characteristics of a wider population from study findings), qualitative research evidence can be theoretically generalisable (i.e. the findings can be used to understand phenomena, and to develop concepts and theories that could be applicable to other settings and other populations) (Swift and Tischler, 2010). It is a strength of the present study that a good sample size was achieved, that included older adults from a range of different social backgrounds, which suggests that the findings could be of relevance to the wider population of older adults in the UK.

3.4.2 Conclusions

This study highlighted the potential importance of underlying social and psychological factors in understanding why, in the face of dietary challenges that commonly accompany ageing, some older people are able to adapt and maintain a healthy diet, while others are not. Hence, future

interventions to promote quality of diet and better health in older age may need to consider social engagement and psychological factors (such as self-efficacy and outcome expectancies, that is, the belief that one's behaviour will lead to a desired outcome) in their design, as levers for change. The development of a hypothetical model of influences on diet in older age presents the opportunity to test quantitatively the hypothetical relationships between these factors and how they could interrelate to impact on diet in later life.

Chapter 4: Hertfordshire Cohort Study: quantitative study of psychosocial correlates of diet quality and change in diet quality in older people

4.1 Introduction

Although there is evidence of decreased energy intake with older age, it remains unclear how diet quality might change with age (Nieuwenhuizen et al., 2010, Otsuka et al., 2018). Furthermore, since most of the evidence relating to factors associated with diet quality is cross-sectional, there is limited understanding of predictors of change in diet quality over time.

In a longitudinal analysis, Arabshahi and colleagues (Arabshahi et al., 2011) assessed change in diet quality and associated factors over three time points and found that diet quality improved over time in both men and women. Although diet quality improved the most in the younger age groups, in adults 55 years and older improvements in diet quality were not as pronounced in men and even decreased in women over the age of 65. A Japanese 12-year longitudinal study found that dietary diversity (an indicator of diet quality) increased in both men and women until middle age, and declined in women aged 63-79 years (Otsuka et al., 2018). There was also a trend of decreased dietary diversity from 65 years of age in men, although these findings were not statistically significant.

In the qualitative study outlined in the previous chapter, various psychological and social factors were identified as potentially important influences on the diets of older people. The present chapter builds on these findings using quantitative information about psychosocial factors that was collected as part of the baseline data survey in the Hertfordshire Cohort Study (HCS). The aim of the present chapter was to identify psychosocial correlates of diet quality in older community-dwelling HCS men and women, and determine their associations with change in diet quality over 10 years.

Much of the work presented in this chapter has been published as an article (Bloom et al., 2017a). The published article has been added to this thesis as an appendix, Appendix E.

4.2 Methods

Part of the methods that were used to undertake the work in this chapter have been described in section 2.1 of this thesis.

This was a secondary data analysis of data that had already been collected. Baseline data collection (on diet, background characteristics, and social and psychological factors) was carried out by the HCS team. Follow-up dietary data were collected by the EPOSA study team. Statistical analyses, including calculation of prudent diet scores and changes in prudent diet scores, were performed with a statistician in the MRC LEU (Karen Jameson); I developed the analysis plan and directed the analyses carried out. I interpreted the results of the statistical analyses and wrote this work up as a first draft of a paper for publication. I liaised with the other authors of the paper to finalise the manuscript for publication (Appendix E).

4.2.1 Assessment of diet quality at baseline and follow-up

Methods for dietary assessment and calculation of prudent diet scores, which were used as an indicator of diet quality, have been described in section 2.1.1. Participants of the HCS were assessed at baseline (1998-2003: 1048 men, 862 women) and 183 men and 189 women were re-assessed in 2011 (as described in section 2.1.1.1). At baseline and follow-up, the prudent diet scores of HCS participants were calculated, based on their reported frequency of consumption of 24 food items, to describe diet quality at baseline and at follow-up time points. Changes in prudent diet scores from baseline were calculated by subtracting baseline diet scores from follow-up scores, such that a positive change value indicates an increase in diet quality and a negative change value indicates a decline.

4.2.2 Assessment of social and psychological variables at baseline

At baseline (1998-2004), a social health questionnaire was self-completed by 1048 men and 862 women (n=1910) in the HCS; this assessed a range of psychosocial factors, including social support, social network, participation in social and cognitive leisure activities, and control at home, using measures that were based on those used in the Whitehall II Study (Stansfeld et al., 1998b, Stansfeld and Marmot, 1992, Singh-Manoux et al., 2003). The latter study based questions about social support originally on Schaefer et al. (Schaefer et al., 1981) and Power et al. (Power et al., 1988), and drew questions relating to social network and leisure activities from Berkman and Syme (Berkman and Syme, 1979). All 1910 HCS participants who had completed the social health questionnaire at baseline had provided baseline information on various background factors and medical history. A range of demographic factors, socioeconomic status indicators, and lifestyle factors were assessed, including age, gender, social class, age left full-time education, marital status, alcohol consumption, smoking status, and BMI. These factors were not exposures of interest in this study as they had already been the focus of previous work by Robinson and

colleagues, examining the correlates of dietary pattern scores in the HCS cohort (Robinson et al., 2009).

Of the 442 participants who had follow-up dietary data, 183 men and 189 women (372, 84%) had completed the social health questionnaire at baseline (this was not completed again at follow-up; social and psychological exposure data were available only at one time point).

4.2.2.1 Assessment of social variables at baseline

- Social support

Participants were asked about the person they felt the closest to and the support they had received from this person over the preceding 12 months. This included measures of three types of social support – confiding/emotional, practical, and negative aspects of support. Three scores were derived; the 'confiding/emotional support score' measured confiding, wanting to confide, sharing interests, boosting self-esteem and reciprocity with the closest person (Stansfeld et al., 1998b); the 'practical support score' measured the practical help received from the closest person (Stansfeld et al., 1998b); and the 'negative aspects of support score' measured negative interaction and perceived inadequacy of support from the closest person (Stansfeld et al., 1998b). Each of these three scores was assessed on a 1-4 Likert scale, with higher scores indicating more positive support.

- Social network

A composite measure of social networks, the 'social network score', was created from questions about the frequency and number of contacts with relatives (outside the household) and friends/acquaintances. This score is meant to capture the number of contacts beyond the household, giving an indication of social ties and social connectedness (Stansfeld et al., 1998b).

- Social support/network

Participants were asked how many people they felt very close to, indicating not only number of contacts (social network) but also the quality of those contacts in terms of perceived closeness/intimacy (social support). 'Number of people close' to was categorised into four categories – number of people close to <5, 5-9, 10-19, 20+.

- Leisure activities

Information on the extent of engagement in 13 leisure activities in the preceding 12 months was collected and assessed on a 4-point Likert scale (0=never, 1=rarely, 2=monthly, 3=weekly). These activities included: religious activities, positions of office (e.g. school governor, councillor etc.),

involvement in clubs and organisations, courses and education/evening classes, cultural visits (e.g. to galleries, cinema etc.), social indoor games (e.g. cards, chess etc.), visiting friends and relatives, going to pubs and social clubs, individual occupations (e.g. reading, listening to music), household tasks (e.g. maintenance, decorating), practical activities (e.g. pottery, drawing etc.), gardening, and using a home computer for leisure. Three scores were derived from these measurements, including a composite measure of all leisure activities – 'leisure activity score', and two other scores were created based on Singh-Manoux et al. (Singh-Manoux et al., 2003) to reflect participation in leisure activities that are more cognitive in nature ('score for cognitive activities') and in activities that are more social ('score for social activities').

4.2.2.2 Assessment of psychological variables at baseline

- Control at home

Participants were asked how much they agreed or disagreed with the following statement 'At home, I feel I have control over what happens in most situations' on a 6-point Likert scale (from strongly disagree to strongly agree). This was then collapsed into a binary variable of low control (those who responded strongly, moderately and slightly disagree and slightly agree) vs. high control (those who responded moderately and strongly agree), according to Chandola et al. (Chandola et al., 2004).

- Depression and Anxiety

Depressive and anxiety symptoms were measured using the Hospital Anxiety and Depression Scale (HADS) (Zigmond and Snaith, 1983). A possible case of depression or anxiety was defined as a HAD-D or HAD-A score, respectively, between 8 and 10 and a probable case as a score ≥11 (Zigmond and Snaith, 1983).

4.2.3 Statistical analysis

This was a secondary data analysis of data that had already been collected (as detailed in the previous subsections). The aim of the analyses were: 1) to identify psychosocial correlates of baseline diet quality in older community-dwelling HCS men and women, and 2) to examine the associations between psychosocial factors and change in diet quality over 10 years in this study population.

Baseline descriptive characteristics were given as mean with standard deviation (SD) for continuous normally distributed variables, median with interquartile range (IQR) for continuous variables with a skewed distribution, or counts and percentages for categorical variables, as

appropriate. Descriptive statistics were presented separately by gender. Differences between men and women in terms of baseline characteristics were assessed using, as appropriate: t-tests (for comparing 2 independent groups; normally-distributed continuous dependent variables), Mann-Whitney rank-sum tests (for comparing 2 independent groups; continuous and skewed dependent variables) or chi-squared (χ^2) tests (2 independent groups; categorical dependent variables).

Differences between the sub-group who were followed up (n=372 participants) and the baseline group of participants who were not followed up (n=1538) were also assessed using either t-tests, Mann-Whitney rank-sum tests, χ^2 tests or Fisher's exact tests, as appropriate.

For the cross-sectional analyses, the outcome of interest was baseline diet quality, expressed as baseline prudent diet score, and the exposures were the baseline social and psychological factors. Cross-sectional associations between baseline social and psychological factors and baseline prudent diet score were examined.

For the longitudinal analyses the outcome of interest was change in diet quality, expressed as change in prudent diet score per year, and the exposures were the baseline social and psychological factors. Longitudinal associations between baseline social and psychological factors and change in prudent diet score were examined.

The outcome variables, i.e. baseline prudent diet score (cross-sectional analyses) and change in prudent diet score (longitudinal analyses), were continuous and normally distributed. Univariate and multivariable linear regressions were used to explore the correlates of baseline dietary pattern scores and their changes over time.

Previous analyses of dietary patterns in the Hertfordshire Cohort Study (Robinson et al., 2009) found a significant relationship between gender and diet quality such that women had significantly better diet quality than men. In light of these findings, and given the consistent evidence from the wider literature with regard to the influence of gender on diet quality in older age (being a woman is consistently associated with better diet quality in older age), a decision was made to stratify all the present analyses by gender, so as to look at men and women separately in terms of diet quality outcomes.

The earlier analysis of dietary patterns in this cohort (Robinson et al., 2009) found associations between social class and level of education and diet quality in men and women, such that people who left full-time education at an older age and those of a higher social class had higher 'prudent' diet scores. Based on this, the potential confounding factors considered in the present cross-sectional and longitudinal analyses were baseline social class (whether a participant was in a

manual or non-manual social class, based on current or most recent occupation for men and never-married women, and the husband's occupation for ever-married women) and baseline age left education (whether a participant had left full-time education at the age of 15 or above, or below the age of 15). In addition, given the potentially important influence of illness and comorbidities on appetite and dietary intake, and likely diet quality, in older age, we also considered as a confounding factor the number of comorbidities at baseline – of bronchitis, diabetes, ischaemic heart disease, hypertension, stroke and fracture after age 45 (at baseline information had been obtained on each participant's medical history; the presence of these comorbidities was measured by self-report).

Data were analysed using Stata version 14.

4.3 Results

At baseline, participants (n=1910; 1,048 men and 862 women) were aged between 59 and 73 years (mean (SD) age 65.8 (2.8) years). Fifty-seven per cent of men and women were in manual social classes. Most men (81%) and women (84%) left full-time education at age 15 or above, and most (86% and 73% respectively) were married or living with a partner. **Table 2** shows a summary of baseline population characteristics in terms of social and psychological factors. There were differences between men and women in the social factors assessed – men had higher median scores for confiding/emotional support (median (IQR) score 76.2 (57.1 - 90.5) vs 71.4 (57.1 - 85.7), P=0.003), and for social activities (median (IQR) score 55.6 (44.4 - 66.7) vs 50 (38.9 - 61.1), P<0.001), and lower median scores for cognitive activities (median (IQR) score 28.6 (19.0 - 42.9) vs 33.3 (19.0 - 42.9), P=0.002). There were also differences in the number of people that men and women felt close to (P<0.001) – a higher proportion of men felt close to fewer than five people (25.5% vs 16.6%). With regard to psychological factors, a lower proportion of men than women had anxiety (4.5% men with a probable case of anxiety vs 10.3% women, P<0.001). At baseline, mean (SD) prudent diet score was significantly lower in men -0.245 (1.216) than women 0.388 (1.109), indicating less healthy diets (P<0.001). Over half (59%) of men and women had at least 1 comorbidity at baseline; 6% of men and 5% of women had 3 or more.

In comparison with the baseline group of HCS participants who were not followed up, the sub-group who were followed up (183 men, 189 women) were younger (mean (SD) age 64.8 (2.8) vs 66.0 (2.7) years, P<0.001), had healthier diets (mean (SD) prudent diet score 0.239 (1.270) vs -0.007 (1.190), P<0.001), and had fewer comorbidities (45.9% with none vs 40.1%, P= 0.039). In addition, their leisure activity scores and scores for 'cognitive' activities were slightly higher (median (IQR) leisure activity score 46.0 (35.1 - 54.0) vs 43.2 (32.4 - 51.3), P=0.006, and median

(IQR) score for cognitive activities 33.3 (19.0 - 42.9) vs 28.6 (19.0 - 42.9), P=0.034). The sub-group who were followed up were more likely not to have depression or anxiety (97.3% of participants who were followed up did not have depression vs 94.0% of those who were not followed up, P=0.029, and 85.5% of participants who were followed up did not have anxiety vs 80.0% of those who were not followed up, P=0.039).

Prudent diet scores at follow-up were highly correlated with baseline scores (men: r=0.696, P<0.001; women: r=0.656, P<0.001). In men, average diet quality remained stable with increasing age, but in women there was an overall decline in diet quality with age: mean (SD) change in prudent diet score per year 0.008 (0.099) in men and -0.025 (0.108) in women (P=0.003). Change in prudent diet score was expressed per year due to the fact that the follow-up period varied between participants (mean (SD) follow-up period: 10.8 (0.9) years), so it was necessary to take account of the follow-up time.

Table 2 Summary baseline characteristics (social and psychological factors) for HCS participants who had completed a baseline social health questionnaire (total n=1910; 1048 men and 862 women).

	Men			Women			
Social factors							
	N	**Median**	**IQR**	**N**	**Median**	**IQR**	**p-value[1]**
Confiding/emotional support score [a]	1012	76.2	57.1 - 90.5	823	71.4	57.1 - 85.7	0.003
Practical support score [a]	1021	55.6	44.4 - 77.8	831	55.6	33.3 - 77.8	0.019
Negative aspects of support score [a]	999	16.7	8.3 - 33.3	812	16.7	8.3 - 25.0	0.498
Social Network Score [b]	961	62.5	50.0 - 75.0	798	62.5	50.0 - 75.0	0.172
	Total N	**N**	**%**	**Total N**	**N**	**%**	**p-value[1]**
Number of people close to [c]	994			805			<0.001
<5		253	25.5		134	16.6	
5-9		282	28.4		302	37.5	
10-19		308	31.0		288	35.8	
20+		151	15.2		81	10.1	
	N	**Median**	**IQR**	**N**	**Median**	**IQR**	**p-value[1]**
Leisure activity score [d]	947	43.2	35.1 - 51.3	742	43.2	32.4 - 51.3	0.085
score for 'social' activities [d]	947	55.6	44.4 - 66.7	742	50	38.9 - 61.1	<0.001
score for 'cognitive' activities [d]	947	28.6	19.0 - 42.9	742	33.3	19.0 - 42.9	0.002
Psychological factors							
	Total N	**N**	**%**	**Total N**	**N**	**%**	**p-value[1]**

Control at home [e]	1007			835		0.171
High		917	91.1		775	92.8	
Low		90	8.9		60	7.2	
HAD-D [f]	1047			862		0.381
Non-case (score 0-7) (reference)		997	95.2		810	94.0	
Possible case (score 8-10)		42	4.0		41	4.8	
Probable case (score 11+)		8	0.8		11	1.3	
HAD-A [f]	1047			862		<0.001
Non-case (score 0-7) (reference)		901	86.1		647	75.1	
Possible case (score 8-10)		99	9.5		126	14.6	
Probable case (score 11+)		47	4.5		89	10.3	

[1] p-value for difference between men and women. For statistically significant results, p-values are shown in red. Differences between men and women were assessed using, as appropriate: t-tests, Mann-Whitney rank-sum tests or chi-squared (χ^2) tests.

[a] Three types of social support were assessed. 'Confiding/emotional support score' measured wanting to confide, confiding, sharing interests, boosting self-esteem and reciprocity with the closest person; 'practical support score' measured the practical help received from the closest person; and the 'negative aspects of support score' measured negative interaction and perceived inadequacy of support from the closest person. Higher scores indicate more positive support. [b] Devised from questions about the frequency and number of contacts with relatives (outside the household) and friends/acquaintances. [c] Indicates not only number of contacts (social network) but also the quality of those contacts in terms of perceived closeness/intimacy (social support). [d] Based on the extent of engagement in 13 leisure activities three scores were derived, including a composite measure of all leisure activities – 'leisure activity score', and two other scores that reflect participation in leisure activities that are more cognitive in nature ('score for cognitive activities') and in activities that are more social ('score for social activities'). [e] Based on how much participants agreed or disagreed with the following statement 'At home, I feel I have control over what happens in most situations'. [f] Depression and anxiety were measured using the Hospital Anxiety and Depression Scale (HADS); a possible case of depression or anxiety was defined as a HAD-D or HAD-A score, respectively, between 8 and 10 and a probable case as a score ≥11.

4.3.1 Correlates of baseline diet

Table 3 shows associations between baseline social and psychological factors and baseline prudent diet score. At baseline, diet quality was related to a range of psychosocial factors. In both men and women, diet quality was related to social support; specifically, greater confiding/emotional support was associated with a higher prudent diet score (0.006 [95% CI 0.002, 0.010], P=0.002 for men, and 0.005 [95% CI 0.001, 0.009], P=0.019 for women). In men, but not in women, greater practical support was also associated with a higher diet score (0.004 [95% CI 0.001, 0.006], P=0.014). A larger social network (0.006 [95% CI 0.001, 0.011], P=0.015) and feeling close to many people (0.241 [95% CI 0.004, 0.478], P=0.046 for 'number of people close to' between 10 and 19, and 0.418 [95% CI 0.101, 0.736], P=0.010 for 'number of people close to' ≥20) were associated with higher prudent diet scores in women only. For both men and women, greater overall participation in leisure activities was related to higher prudent diet scores (0.019 [95% CI 0.013, 0.025], P<0.001 for men, and 0.016 [95% CI 0.009, 0.022], P<0.001 for women);

furthermore, increased participation in activities of a more cognitive nature (0.017 [95% CI 0.012, 0.022], P<0.001 for men, and 0.014 [95% CI 0.009, 0.020], P<0.001 for women), as well as in activities of a more social nature (0.009 [95% CI 0.004, 0.014), P<0.001 for men, and 0.008 [95% CI 0.003, 0.013], P=0.003 for women) were both associated with higher prudent diet scores. Diet score was not related to control at home. Diet scores were lower in men who had a possible case of depression (defined as HAD-D score between 8 and 10), compared to non-cases (-0.524 [95% CI -0.924, -0.125], P=0.010), and in men who had a possible case of anxiety (defined as HAD-A score between 8 and 10), compared to non-cases (-0.289 [95% CI -0.546, -0.031], P=0.028), whereas there were no associations with depression or anxiety in women. The pattern of all associations was similar after adjusting for social class, age left education and number of comorbidities (out of bronchitis, diabetes, ischaemic heart disease, hypertension, stroke and fracture since aged 45), for both men and women separately.

Predictors of change in diet

Table 4 shows baseline social and psychological factors as predictors of change in prudent diet score in the follow-up sub-group of men and women. Overall, there were few associations between psychosocial factors at baseline and change in diet score over 10 years. However, in both men and women, baseline participation in leisure activities, as well as participation in cognitive leisure activities, were associated with smaller declines in diet scores; for a one point increase in leisure activity score, change in diet score increased by 0.002 (95% CI 0.000, 0.003, P=0.017) in men and 0.002 (95% CI 0.000, 0.003, P=0.014) in women. With the exception of women who had a possible case of anxiety, there were no associations between psychological factors and change in diet score. The pattern of associations remained robust to adjustment for social class, age left education and number of comorbidities (out of bronchitis, diabetes, ischaemic heart disease, hypertension, stroke and fracture since aged 45).

Table 3 Multivariable linear regressions between baseline social/psychological factors and baseline 24-item prudent diet score in all men and women (HCS participants who completed a baseline social health questionnaire (n=1910; 1048 men, 862 women)).[1]

	Men			Women		
	N	Regression coefficient (95% CI)	p-value	N	Regression coefficient (95% CI)	p-value
Social factors						
Confiding/emotional support score	922	0.006 (0.002, 0.010)	0.002	775	0.005 (0.001, 0.009)	0.019
Practical support score	932	0.004 (0.001, 0.006)	0.014	781	0.002 (-0.001, 0.004)	0.261
Negative aspects of support score	912	-0.001 (-0.006, 0.003)	0.601	763	-0.002 (-0.006, 0.003)	0.448
Social Network Score	878	0 (-0.004, 0.005)	0.864	749	0.006 (0.001, 0.011)	0.015
Number of people close to	907			757		
<5 (reference)		0 (0.000, 0.000)	.		0 (0.000, 0.000)	.
5-9		-0.042 (-0.252, 0.168)	0.693		0.140 (-0.095, 0.375)	0.243
10-19		0.066 (-0.141, 0.274)	0.531		0.241 (0.004, 0.478)	0.046
20+		-0.006 (-0.258, 0.245)	0.960		0.418 (0.101, 0.736)	0.010
Leisure activity score	861	0.019 (0.013, 0.025)	<0.001	696	0.016 (0.009, 0.022)	<0.001
score for 'social' activities	861	0.009 (0.004, 0.014)	<0.001	696	0.008 (0.003, 0.013)	0.003
score for 'cognitive' activities	861	0.017 (0.012, 0.022)	<0.001	696	0.014 (0.009, 0.020)	<0.001
Psychological factors						
Control at home	919			784		
High (reference)		0 (0.000, 0.000)	.		0 (0.000, 0.000)	.
Low		-0.194 (-0.466, 0.079)	0.163		0.032 (-0.268, 0.332)	0.835
HAD-D	957			810		
Non-case (score 0-7) (reference)		0 (0.000, 0.000)	.		0 (0.000, 0.000)	.
Possible case (score 8-10)		-0.524 (-0.924, -0.125)	0.010		-0.165 (-0.528, 0.198)	0.371
Probable case (score 11+)		0.331 (-0.547, 1.210)	0.460		-0.411 (-1.106, 0.284)	0.246
HAD-A	957			810		
Non-case (score 0-7) (reference)		0 (0.000, 0.000)	.		0 (0.000, 0.000)	.
Possible case (score 8-10)		-0.289 (-0.546, -0.031)	0.028		-0.187 (-0.404, 0.029)	0.090
Probable case (score 11+)		-0.198 (-0.578, 0.182)	0.306		0.031 (-0.232, 0.295)	0.816

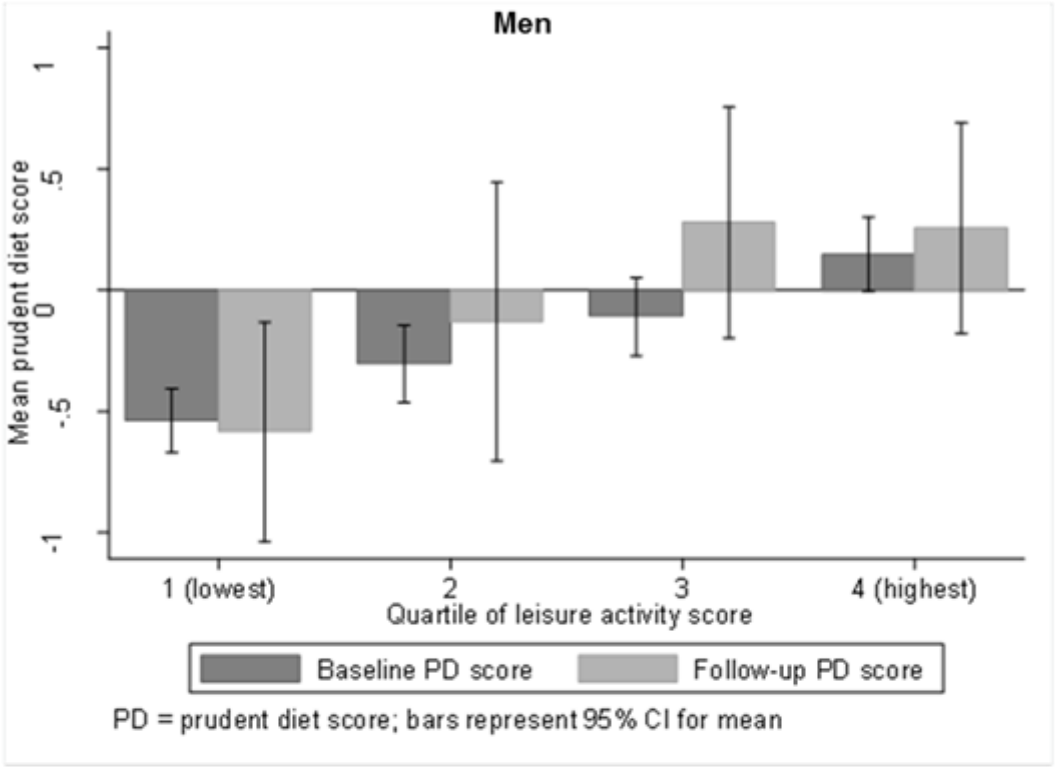
[1] Analyses were adjusted for social class, age left education and number of comorbidities (out of bronchitis, diabetes, ischaemic heart disease, hypertension, stroke and fracture since aged 45). For statistically significant results, p-values are shown in red.

Table 4 Multivariable linear regressions between baseline social/psychological factors and change in 24-item prudent diet score in men and women subgroups (HCS participants who completed a baseline social health questionnaire and had follow-up dietary data (n=372; 183 men, 189 women)).[1]

	Men			Women		
	N	**Regression coefficient (95% CI)**	**p-value**	**N**	**Regression coefficient (95% CI)**	**p-value**
Social factors						
Confiding/emotional support score	160	-0.001 (-0.001, -0.000)	0.040	179	-0.001 (-0.001, 0.000)	0.187
Practical support score	163	-0.001 (-0.001, 0.000)	0.076	179	0.000 (-0.001, 0.000)	0.493
Negative aspects of support score	158	0.000 (-0.001, 0.001)	0.718	174	0.001 (-0.000, 0.001)	0.288
Social Network Score	153	0.000 (-0.001, 0.001)	0.847	173	0.000 (-0.001, 0.001)	0.844
Number of people close to	157			178		
<5 (reference)		0 (0.000, 0.000)	.		0 (0.000, 0.000)	.
5-9		-0.018 (-0.060, 0.025)	0.414		0.007 (-0.042, 0.056)	0.781
10-19		-0.039 (-0.081, 0.004)	0.074		-0.003 (-0.050, 0.044)	0.899
20+		0.009 (-0.043, 0.060)	0.733		0.003 (-0.060, 0.067)	0.922
Leisure activity score	149	0.002 (0.000, 0.003)	0.017	169	0.002 (0.000, 0.003)	0.014
score for 'social' activities	149	0.001 (-0.000, 0.002)	0.070	169	0.001 (-0.000, 0.002)	0.238
score for 'cognitive' activities	149	0.001 (0.000, 0.002)	0.041	169	0.001 (0.000, 0.002)	0.023
Psychological factors						
Control at home	161			178		
High (reference)		0 (0.000, 0.000)	.		0 (0.000, 0.000)	.
Low		-0.036 (-0.095, 0.023)	0.226		-0.044 (-0.104, 0.016)	0.149
HAD-D	165			182		
Non-case (score 0-7) (reference)		0 (0.000, 0.000)	.		0 (0.000, 0.000)	.
Possible case (score 8-10)		0.001 (-0.116, 0.118)	0.987		-0.075 (-0.164, 0.014)	0.097
Probable case (score 11+)		0.073 (-0.126, 0.272)	0.471		-	-
HAD-A	165			182		
Non-case (score 0-7) (reference)		0 (0.000, 0.000)	.		0 (0.000, 0.000)	.
Possible case (score 8-10)		-0.030 (-0.102, 0.043)	0.415		-0.051 (-0.099, -0.003)	0.038
Probable case (score 11+)		-0.015 (-0.092, 0.062)	0.701		-0.035 (-0.098, 0.027)	0.261

[1] Analyses were adjusted for social class, age left education and number of comorbidities (out of bronchitis, diabetes, ischaemic heart disease, hypertension, stroke and fracture since aged 45). For statistically significant results, p-values are shown in red.

The relationship between the leisure activity score and prudent diet score at baseline and follow-up is illustrated in **Figure 8**. There were graded increases in prudent diet score across the range of leisure activity. As an example, in the highest quarter of leisure activity score, 81% of men and 84% of women were involved in clubs and organisations weekly or monthly, compared to around 12% of men and women in the lowest quarter. To illustrate the nature of differences in diet quality across the range of leisure activity scores at baseline, green salad was consumed more frequently in the highest quarter (men and women: median 3 times per week (IQR 1-3)) than the lowest (men: 1 (0.2-3), women: 1 (0.5-3)); the equivalent figures for wholemeal bread consumption were men: 3.5 (0.1-8.8), women: 3.5 (0.5-8.8) vs men: 1.5 (0-8.8), women: 2.8 (0.1-8.8).



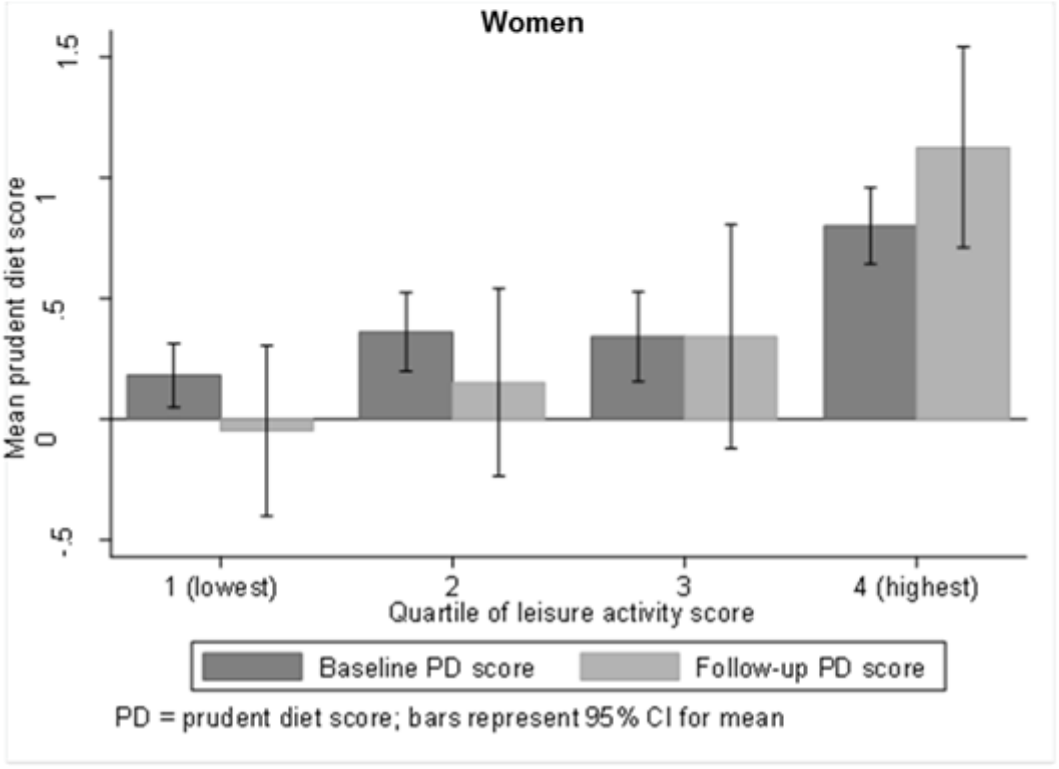


Figure 8 Mean prudent diet score by quartile of leisure activity score for men and women.

4.4 Discussion

The analyses presented in this chapter identified psychosocial correlates of diet quality in a cohort of community-dwelling older men and women, and described relationships with change in diet quality over 10 years in a sub-group. Baseline diet quality was positively related to a range of psychosocial factors; a consistent finding for both men and women was that greater participation in leisure activities, as well as in cognitive and social activities, was related to higher diet scores. There were few associations between psychosocial factors at baseline and change in diet score over 10 years in the follow-up sub-group of men and women. However, baseline participation in leisure activities, as well as participation in cognitive leisure activities, was associated with smaller declines in diet quality over time. These associations were not explained by social class, education or number of comorbidities. To my knowledge these findings have not been described before in a UK population.

There were some differences in the pattern of associations between social and psychological factors and diet quality between men and women. One consistent finding at baseline was that for men and women diet quality was positively related to having greater confiding/emotional support. This may be explained by a greater level of confiding, sharing interests, and reciprocity with a person someone feels very close to, contributing to increased self-esteem, sense of mattering to others, and mastery over activities (Thoits, 2011). Although this includes tasks such as cooking, which might increase motivation to cook and eat healthier meals, confiding/emotional support was not related to change in diet quality in men and women followed up at 10 years. At baseline, greater practical support was also associated with better diet quality among men. Poor cooking skills have been identified as a barrier to a healthy diet in older men (Hughes et al., 2004), and these skills may be poorer in older men than in older women (Blane et al., 2003). A greater level of practical support might reflect greater help received with shopping for food and cooking but, consistent with associations with emotional support, it was not related to changes in diet quality over the follow-up period. In a recent Canadian study, Rugel and Carpiano found that higher emotional support was positively associated with adequate fruit and vegetable consumption in older women, whereas for older men, there was no association with emotional support nor practical (or tangible) support (Rugel and Carpiano, 2015). The differences in findings could in part reflect the different measures used to assess social support; for example in the Canadian study participants were asked about social support availability, rather that the support received, as in the present study (Rugel and Carpiano, 2015). A large cross-sectional study that examined data from US adults aged 40 years and older, also found that the association between social support and diet quality varied between genders (Pieroth et al., 2017). In this case, higher social support, which was assessed by five components (including availability of emotional

support and financial support, marital status, number of close friends, and frequency of attending religious services) as a 'social support index', was associated with higher diet quality (assessed by adherence to the Healthy Eating Index-2010) in men, but there was no significant association for women. For the present study, there was data on marital status at the follow-up time point (the only social factor for which this was the case), and in earlier analyses that were conducted prior to this thesis, marital status had been considered as an exposure. However, these previous analyses found, surprisingly, that change in marital status over the follow-up period was not related to change in diet (unpublished data). For this reason marital status was not looked at as an exposure of interest in this study.

In women, a large social network and feeling close to many people were associated with better quality diets at baseline, although not with change over follow-up. Older women may lose motivation to cook for themselves when alone (Vesnaver and Keller, 2011) and may regard social aspects of meals to be of great importance for maintaining an adequate diet (Rugel and Carpiano, 2015), which could explain the benefits of a larger social network. Positive effects of maintaining social contact have also been reported by Conklin and colleagues, although in this case an association was evident in both genders (Conklin et al., 2014). Although 'number of people close to' was higher in HCS women (see **Table 2**), there was no difference in social network scores between men and women and it is not clear why their associations with social network differed.

Previous research that has linked personal control (the extent to which someone feels they can run their life the way they want) to health outcomes, has assessed sense of control by using related aspects such as powerlessness and self-efficacy (someone's belief in their own ability to achieve a desired outcome) (Chandola et al., 2004). In the present study, control at home was not found to be associated with diet quality, which contrasts with the findings from the previous chapter of this thesis, where the role of self-efficacy was highlighted as a potentially important influence on the diets of older people. However, although self-efficacy is likely to be related to general sense of control (Chandola et al., 2004), it is not clear how well the question used to assess control at home in this study captures the concept of self-efficacy.

A key finding was that higher overall participation in leisure activities, including both social and cognitive activities, was related to better quality diets at baseline. Furthermore, greater participation in leisure activities at baseline was associated with smaller declines in diet quality over time, in the follow-up sub-group; this was a consistent finding for both men and women although the effect size was modest. The significance in practical terms of the modest statistical changes in prudent diet score is difficult to interpret. The prudent diet score is a composite measure that reflects variations in a range of foods – and differences in scores and/or changes in

scores can be achieved both by increases in positive-scoring foods and decreases in negative-scoring foods. Thus, it is not possible to isolate effects on individual foods from the composite measure of diet quality.

Differently, the qualitative study of older people from the Hertfordshire cohort, described in the previous chapter (Chapter 3), revealed no obvious differences in social engagement as an influence on diet, between diet-stable and diet-declined groups.

A previous study from the US found that high social contact, including meeting with family and friends and engaging in leisure activities, namely attending religious services and club meetings, was related to better diet quality (increased fruit and vegetable consumption) in older adults (Sahyoun and Zhang, 2005). In addition, a longitudinal study of community-living older disabled women in the US found that attending more activities predicted an increase in diet quality over a 1-year period (Nicklett et al., 2012b). As discussed in the previous chapter, there are various possible pathways through which participation in leisure activities, and indeed other social relationships, might impact upon diet, such as increased social support, social influence, an increased sense of purpose, meaning in life and sense of belonging (Thoits, 2011). These pathways may promote positive psychological states that could motivate healthy behaviours, including diet (Thoits, 2011).

A meta-analytic review (Holt-Lunstad et al., 2010) found that participants (average age of 64 years) with adequate social ties and relationships had a lower risk of mortality than people without such connections – this includes not only factors such as being married and having contact with friends and relatives, but also involvement in leisure activities (e.g. being a church member or belonging to group associations) (Berkman and Syme, 1979). Social factors have also been linked to musculoskeletal outcomes in older people. Poor social support and increased level of negative social interactions have been associated with poorer health, including physical function (Stansfeld et al., 1998a). In addition, the risk of frailty in women was found to increase with a greater level of negative social interactions at baseline (Gale et al., 2012). Differences in diet quality may contribute to the higher risk of mortality observed in people who have poor social connections (Holt-Lunstad et al., 2010), although the mechanisms that underlie this association are not fully understood (Holt-Lunstad et al., 2010). A more recent scoping review found a negative effect of social isolation or loneliness on various health outcomes, such as depression, cardiovascular disease, quality of life, general health, cognitive function and mortality (Courtin and Knapp, 2015). The mechanisms through which social relationships influence health remain unclear, but are thought to include influences on health behaviours (Cotterell et al., 2018).

4.4.1 Strengths and limitations

This study is based on a secondary analysis of data from a large well-characterised cohort. As baseline participants' characteristics were comparable with those of the wider population (Syddall et al., 2005), the cross-sectional findings should have relevance to older adults in other parts of the country.

A strength of the present study is the longitudinal data, this study is one of the few studies to examine dietary patterns over a long follow-up period in an older population. Longitudinal data were however only available for a subsection of the HCS, who were slightly younger and healthier than the remainder of the cohort, which may have implications for the generalisability of the findings, and the interpretation of the changes in diet quality described.

Additionally, I cannot exclude the possibility of residual confounding by factors that were not considered in the analyses, such as the general health status of participants. A limited number of comorbidities were considered, and other linked health behaviours that may be relevant, such as levels of physical activity, were not considered. A further limitation is that there was no exposure assessment at follow-up; social factors were not re-assessed at follow-up and it is unknown if there were changes that could have affected diet quality over time. I did not include both social and psychological factors (and indeed marital status) in same model (adjusting for each other) because of the risk of over adjusting. The social and psychological exposure variables are likely to be highly correlated, which could result in multicollinearity if the regression model included these factors. Furthermore, I did not adjust for baseline prudent diet score in the models analysing change as outcome. There is some discussion about not adjusting for baseline values in analyses of change, and it has been argued that adjustment for baseline values may introduce bias, which could exceed the bias eliminated (Glymour et al., 2005). In discussion with my supervisors and statisticians we decided not to adjust for baseline values in these analyses.

Self-report measures were used to collect the social and psychological exposure data, which increases the likelihood of measurement error. Only some of these exposure measures have been validated. The Close Persons Questionnaire, on which the measures used to assess social network and social support were based, had been validated against the Self Evaluation and Social Support Interview and against more objective indices of contact with close persons in a community-based population (Stansfeld and Marmot, 1992). However, there was difficulty in establishing the validity of these measures due to the lack of universally accepted criteria against which to assess validity (Stansfeld and Marmot, 1992). To my knowledge, the measures used to assess participation in social and cognitive leisure activities, and the question used to assess control at home, have not been validated; for the latter, a validated measure was not available for use at

the time of data collection (Chandola et al., 2004). The Hospital Anxiety and Depression Scale (HADS) questionnaire, which was used to measure anxiety and depression, has been validated for use in community settings and also in older people (Snaith, 2003). Self-reported diet may also be affected by measurement error. However, the short questionnaire that was used has been shown to describe diet quality well (Robinson et al., 2017). Diet quality scores assessed using the questionnaire in this study have been shown to be correlated with blood biomarker concentrations and compared to a full FFQ, show comparable associations with nutrient intake (Robinson et al., 2017). It is unlikely that measurement error explains the associations described. The short FFQ that was used in this study is based only on a small number of indicator foods, some of which may never be consumed by respondents, which may discourage completion. Although this questionnaire has been shown to describe diet quality well in community-dwelling older adults from the HCS (Robinson et al., 2017), the suitability of this questionnaire in other older populations warrants further exploration.

The issue of multiple statistical testing should be considered regarding the analyses of the correlates of baseline diet quality and predictors of change in diet quality presented in this work. As statistical testing was run multiple times (multiple exposure variables, more than one time-point, and two outcomes) on the dataset, there is an increased likelihood of a false-positive finding (Type 1 error, or a chance finding). However, it could be that reducing the significance value (instead of setting the P level for significance to 0.05, using a lower P cut-off value) for multiple comparisons might increase the chances of a Type 2 error (false-negative error; falsely accepting the null hypothesis) (Ranganathan et al., 2016).

4.4.2 Conclusions

In community-dwelling older adults in their mid-sixties, a range of social factors, that included greater participation in social and cognitive leisure activities, were associated with diets of better quality in cross-sectional analyses. In longitudinal analyses, there were few associations between psychosocial factors at baseline and change in diet quality over the 10-year follow-up period. However, greater baseline participation in leisure activities, as well as greater participation in cognitive leisure activities, was associated with smaller declines in diet quality over time. The study findings, particularly those from the cross-sectional analyses, are consistent with some of the themes identified from focus group discussions with older adults, as outlined in Chapter 3 (page 38), and highlight the need to consider the influence of social factors on diet in later life. In this context, community-based services that might promote engagement with social activities and enhance social support may be of great importance for supporting older community-living adults

to maintain a healthy diet. A consideration of available local community support for older adults is the focus of next chapter.

Chapter 5: Mapping of local Southampton services to support diet quality in older people

5.1 Background

The literature review in Chapter 1 of this thesis highlighted the usefulness of an ecological approach for conceptualizing and integrating the multiple levels of influence that impact on health behaviours; Story and colleagues' ecological framework applies this approach to dietary behaviour, with a range of factors influencing food choices on different levels (Story et al., 2008). Part of such a broad array of influences on diet are the community and social environment, including neighbourhoods and organizations, social networks and social support systems, as well as the content of public policies. Indeed, the role of social factors as potentially important influences on diet in later life has been highlighted in the previous two thesis chapters.

The mapping study described in this chapter forms part of the process evaluation for the development of the GENIE pilot intervention study, which is described in the next chapter (Chapter 6). The mapping study comprises the contextual component of the process evaluation and seeks to understand the local context into which the intervention will be introduced. As the focus of the present chapter is the local Southampton context in terms of services to support the diets of older people, it begins with a brief overview of the national policy context and the role of community services.

5.1.1 National policy context

The National Service Framework for Older People (Department of Health, 2001) included an aim of extending the healthy life expectancy of older people. The framework incorporated the evidence base for a variety of health promotion activities for older people, and found the strongest evidence for increased physical activity, improved diet and nutrition, and immunisation programmes for influenza.

Key public health functions were transferred to local authorities in April 2013, providing an opportunity locally for greater partnership working between local authorities and social services on issues such as fuel poverty, good nutrition/malnutrition prevention, falls prevention and physical activity. At a national level, the implementation of The Care Act 2014 started in April 2015. The Act emphasizes strengthening local authorities' duties to provide good quality information about care, support and community facilities, to help people maintain their

independence for longer. It also centres on the promotion of wellbeing and provision of support to increase the resilience of individuals and communities. The Care Act 2014 amended the NHS Act 2006 to provide the legislative basis for the Better Care Fund, a nationwide initiative that provides financial support for councils and NHS organisations to jointly plan and deliver local services. The Better Care Fund (BCF) is the largest ever financial incentive for the integration of health and social care, requiring collaboration between NHS England, Department for Communities and Local Government, Department of Health and the Local Government Association. From 1st April 2015, local authorities and Clinical Commissioning Groups (CCGs) were required to establish a pooled fund for health and social care services to work more closely together in local areas, based on a plan agreed between the NHS and local authorities. Greater integration of health and social care could mean that resources are used more efficiently, reducing avoidable hospital admissions and facilitating early discharge (Department of Health and Department for Communities and Local Government, 2016). Policy guidance was published for the BCF in 2016-17, which states that the Government committed £3.9 billion to the BCF in this period, with many local areas contributing additional funds (Department of Health and Department for Communities and Local Government, 2016). In the context of these policies, the planning and delivery of services for the promotion of diet and health is likely to require increasing partnership working between various agencies, including local authorities and health and social services.

5.1.2 Role of community services

Community services could be important for promoting diet and preventing malnutrition (Wilson, 2013); these services might promote engagement with social activities and improve social support, which could support older community-living adults to maintain a healthy diet. However, little is known about the nature of services that are available locally to older adults living in the community and what services or interventions could best support them to maintain a healthy diet.

Few studies have specifically evaluated the impact of community food-related services for older people, including their impact on diet. A report by Wilson from the Caroline Walker Trust about local community food projects found that such projects can provide vital support to vulnerable older people to eat well and funding of these projects should be a priority for local authorities (Wilson, 2009). Initiatives such as lunch clubs, transport provision, social activities, cooking classes or food co-ops could be effective in not only promoting good health and access to food, but also providing opportunities for social interaction and promoting general well-being (Wilson, 2009). An Age UK briefing on the effectiveness of day services describes how various types of services can

address older people's needs for social contact, exercise, to engage in and contribute to society and to be involved in productive activities (Age UK, 2011). The briefing suggests that these services can greatly improve quality of life of older adults, promote health and prevent or delay the requirement for more costly interventions, such as a move to expensive care homes (Age UK, 2011). Furthermore, day services could be key for reducing social isolation and loneliness and could provide people with important opportunities to connect with the wider community, and it is suggested that these activities could foster a sense of self-efficacy, which has been linked to improved health and wellbeing outcomes in later life (Age UK, 2011).

5.1.3 Southampton: a local case study

As in the UK, at a local level in Southampton, average life expectancy has been increasing. In Southampton, the populations over 65 years and 85 years of age are estimated to increase by over 15% and by over 20% respectively, between 2015 and 2021 (Southampton City Council, 2016b). In the longer-term, between 2010 and 2035, it is estimated that there will be a 42% increase in the number of people aged over 65 years in Southampton (Public Health Southampton - Southampton City Council, 2013). In 2011, there were 11,283 households in Southampton consisting of older people living alone (Southampton City Council, 2016b). Social isolation and loneliness have been identified as growing problems in Southampton. A survey carried out in 2016 by the Southampton City Council estimated that there are around 29,552 people aged over 16 (15%) and 5,482 people aged over 65 (16%) who are experiencing loneliness (Southampton City Council, 2016a).

The health of the Southampton population is generally worse than the England average. Deprivation is higher than average and life expectancy for both genders is lower than the England average (Public Health England, 2015). There is much poverty among older people living in Southampton; for example, there are seven areas in the city where Income Deprivation Affecting Older People is in the worst 10% for England (Public Health Southampton - Southampton City Council, 2013). There is a greater level of need for support for older people in Southampton, compared to the national level; in 2011/12, 213 older people per 1,000 were receiving social services in Southampton, compared to a national average of 113.5 per 1,000 (Public Health Southampton - Southampton City Council, 2013). It is expected that the prevalence of conditions such as diabetes and stroke will increase by 2030, as well as the number of adults over 65 years of age who are unable to manage at least one activity alone (Public Health Southampton - Southampton City Council, 2013).

The aim of this chapter was to determine what services or interventions are available to community-dwelling older people in Southampton that might support their diets. It forms part of the process evaluation for the development of the GENIE pilot intervention study (Chapter 6), by assessing the context into which the intervention will be introduced. The area studied consisted of the six wards in Southampton that the Southampton City CCG defined as clusters for community service delivery, a map of which is shown in **Figure 9**. The chapter also provides an example of the situation facing older people in the UK in an age of austerity cuts.

5.2 Methods

The background to the methods used for this piece of work has been described in section 2.3. There were three main approaches to mapping local services in Southampton:

1. Describing the local policy context of services, including identifying strategies that inform the services provided. I achieved this by performing online searches of local websites, and also through discussions with local policymakers and commissioners.

2. Development of a network of contacts from the Southampton City Council, the NHS Southampton City Clinical Commissioning Group (CCG) and the voluntary sector within Southampton to provide information relating to the range of services available. This was started when one of my supervisors (Janis Baird) and I contacted the Public Health Team at Southampton City Council who then directed us to contacts within to the NHS Southampton CCG, who we met with and then signposted us to contacts in various voluntary organisations. I stopped contacting people once the information received overlapped with information already collected.

3. Searching online databases for relevant services in the Southampton area. I searched various databases, including Google and local websites and directories, including the Age UK Southampton website, the Age Concern Hampshire website, the Carers in Southampton website, and the Southampton Information Directory (SID). The SID, coordinated by Southampton City Council, provides access to information on various topics, including activities and support for older adults and those who are caring for them.

All services that older people had contact with and that had the potential to influence their diets were included. Community settings were considered including local authority, voluntary sector and private sector services. For each service/activity that could influence the diet of older adults,

the following information was collated: name of service/activity; how the service was identified; type of service: statutory/voluntary; provider/organiser; features of the service; target audience.

Most of the networking and searches were carried out from March to July 2015. For any networking activities or searches performed after this period, the dates are specified in the relevant description below. Some updates were subsequently performed regarding stakeholder discussions and online searches. In 2017, elements of the online database search were rerun to provide an update on the availability of relevant services in the Southampton area. Also, in 2017, I met with a contact within the NHS Southampton CCG to obtain an update on the services available in Southampton. In 2018, I attended various meetings and engaged with relevant stakeholders, some of whom I had not engaged with previously, to gain a better understanding of the services provided in Southampton and surrounding areas.

5.3 Results

5.3.1 Local policy context: summary of strategy document content related to nutrition / older adults in Southampton and Hampshire

In 2015, four local policies related to health and/or nutrition of older people were identified that were relevant in terms of the services provided in Southampton and the wider Hampshire area.

1. Southampton City Council, NHS England and NHS Southampton City Clinical Commissioning Group (CCG) had a Joint Health and Wellbeing Strategy for Southampton (Southampton Health and Wellbeing Board, 2013), which set out the approach for addressing the main health and care needs over a three-year period (from 2013/14), informing commissioning plans for the City Council and the CCG. The strategy was informed by a Joint Strategic Needs Assessment (JSNA) and through discussions with stakeholders and the public. 'Living and Ageing Well' was one of three key themes set out in the strategy. The actions set out for this theme included:

- To tackle poverty;
- To focus on prevention and earlier intervention (including revision of tele-care and tele-health services to help people retain their independence, extension of re-ablement services to help people recover after being unwell, and promotion of healthy lifestyles with Activity Coordinators);
- To have a person-centred and not disease-centred approach (including integration of health and social care services to reduce the number of assessments that a person needed to undergo, facilitation of their movement between professionals and services, and development of knowledge and support for people to retain their independence);

- To care for long-term conditions, including cancer and dementia.

2. The NHS Southampton City Clinical Commissioning Group (CCG) had a 5-year strategic plan (2014-2019) (NHS Southampton City Clinical Commissioning Group (CCG), 2014) that tied in with the aforementioned strategy. Better Care was a vital part of this strategy. Better Care is a nationwide initiative and the Better Care Fund provides financial support for councils and NHS organisations to jointly plan and deliver local services. It was envisaged that Better Care Southampton would lead to integration of services for frail and older people into integrated cluster based teams, based on GP practice populations. In November 2013, the CCG and City Council jointly established an Integrated Commissioning Unit (ICU) that used an evidence-based approach to commissioning to plan and buy health and social care services, with integration of these services to ensure a more streamlined experience for service users. The ICU supported the Better Care Southampton programme.

3. Hampshire County Council had a Community Nutrition Strategy for Older People (2011-2014) (Hampshire County Council, 2011). This strategy focused on older people who were not intensively using health or social care services and recognised adequate nutrition for older people as an essential part of the prevention and early intervention work stream of Adult Services. The social and economic value of supporting older people to live independently, with a good nutritional status, was also acknowledged. The strategy supported a series of locally based activities and services for older people, including:

- Countywide Meals on Wheels service;
- Volunteer led community cookery demonstration courses;
- Food and Friendship befriending visits;
- Closer joint working between Health and Adult Services to identify more easily signs of malnutrition and dehydration in older people living at home and support appropriate actions;
- Awareness raising of the importance of eating well, and developing, with statutory and voluntary sector partners, ways of expanding the range of opportunities for social eating, e.g. pie and pint clubs or buddying with neighbours.

Some projects including Food and Friendship, run by Age Concern Hampshire, had shown an increase in life satisfaction for recipients and an increase in their ability to cope and problem solve (Hampshire County Council, 2014). This community nutrition strategy has been superseded by a more general strategy on ageing, with less of a nutrition focus (detailed in the following paragraph).

4. Together with partners from public sector organisations, the voluntary and community sector, local businesses and older people themselves, Hampshire County Council developed a strategy that served as a framework for improving the well-being of the ageing population in Hampshire (Hampshire County Council, 2014). The strategy focused on the 84% (423,095, in 2013) of older people, over 55 years of age (and those who self-defined as older), who were not intensively using health and social care services. Through co-ordinated "light touch" prevention and early intervention activities and support, the goal was to enable them to continue to be independent and maintain a good quality of life. This strategy took 'crisis points' such as bereavement, retirement, diagnosis of a long-term illness and moving home into account and looked to offer timely and relevant support. Hampshire County Council and the five Hampshire Clinical Commissioning Groups (CCGs) were working on integrating care within community-based settings, to help people maintain or return to independent living. Age Action Alliance, of which Hampshire County Council and several other strategy partners were members, was established to link organisations, to build communities where older people felt secure and valued.

In the area of Southampton, and also the wider Hampshire area, there was a considerable amount of policy focus on older adults and ageing. Although there was also some focus on nutrition, this was to a lesser extent. In 2017 and 2018, update searches regarding the local policy context, as well as further stakeholder discussions and online searches, revealed a similar local policy context (this is discussed later on in section 5.4.2).

5.3.2 Services in Southampton identified through discussion with local stakeholders

Discussions with a network of contacts from the Southampton City Council, the NHS Southampton City Clinical Commissioning Group (CCG) and the voluntary sector (see **Table 5**) provided insight into the type and range of services available. In March 2015, Janis Baird and I contacted the Public Health Team at the Southampton City Council, who then directed us to contacts (three in total) within the NHS Southampton CCG, who we then met with and in turn signposted us to contacts (total of four) in various, mainly voluntary, organisations. Stakeholders identified groups of services and this informed the online search process. Discussions also provided background information about the commissioning context of service provision in the city, which is described below.

Table 5 Stakeholders involved in the mapping exercise.

Agency	Type of role
Public Health Southampton, Southampton City Council	surveillance and provision
NHS Southampton City Clinical Commissioning Group	commissioning
SCA (Social Care in Action) Group	provision
Age UK Southampton	provision
Southampton Voluntary Services (SVS)	provision
Chaplaincy for Older People in Southampton	provision

The Southampton City Council and the NHS Southampton City CCG were working together to pool budgets and agree on an integrated spending plan for how to use their Better Care Fund (BCF) allocation, in order to comply with the Better Care Fund national requirement. The goal in Southampton was to go over and above the national minimum requirement, and completely transform the delivery of health and social care services so that they would be better integrated, delivered as locally as possible and person-centred. In January 2015, the Southampton City Council Cabinet and the Southampton City CCG Governing Body agreed to bring together health and social care community resources to deliver three schemes, namely support to carers, cluster teams, and rehabilitation and supported discharge.

The BCF plan led to the integration of services for frail and older people clustered around six neighbourhood areas (see **Figure 9**). These services include community nursing and therapy, community mental health, adult social care and housing.

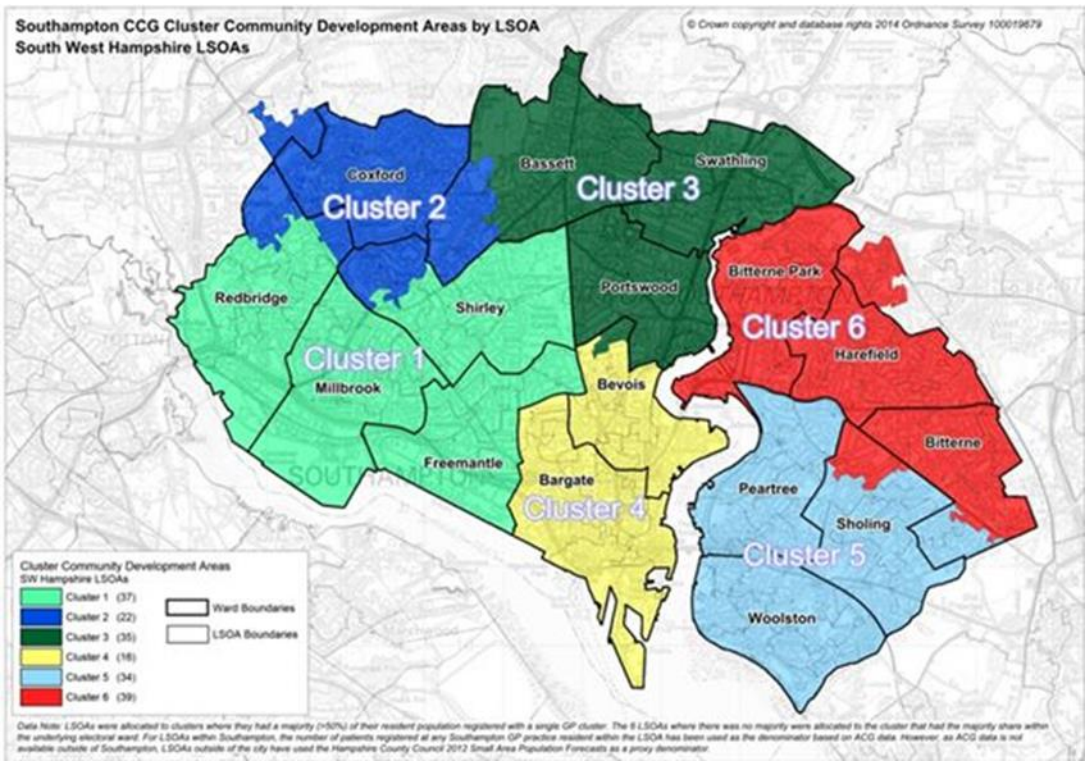


Figure 9 Southampton City CCG clusters for community service delivery (available online at http://spectrumcil.co.uk/services/community-navigation/).

The Community Solutions Group, set up in 2015, was a new Better Care Southampton initiative run by the Southampton City CCG and the City Council, local voluntary organisations and faith groups, to develop support for health and wellbeing in the community. It comprised organisations and individuals from across city communities, from resident groups to local charities providing services, support groups and clubs to enhance health and wellbeing. A Community Navigator role was set up together with Spectrum Centre for Independent Living (a voluntary organisation) and was trialled in two areas – Shirley/Freemantle (Cluster 1) and Woolston/Weston (Cluster 5). Spectrum worked with other local community organisations and the cluster leadership groups. Community Navigators provided information to help people locate and access local community resources and services (e.g. sports and leisure, employment, education, welfare rights, housing, volunteering opportunities), including directly linking people to activities/community resources. Community Navigators also received and made referrals from/to health and cluster teams, and worked directly with individuals and their families to identify solutions and develop action plans, follow them up and identify whether additional support was required. It was envisaged that the role of Community Navigators would also include mapping community resources to upload to an information directory and identifying gaps in resources required by the community.

At that time, day services in the city (commissioned by the Integrated Commissioning Group) were being restructured, and SCA (Social Care in Action) and Age UK were the main providers of day services for older people in Southampton. Day centre users were predominantly identified or referred through social services. The main criteria for council funding for a place at a day centre were isolation, physical frailty and/or respite for carers; some centres also focused on memory problems and dementia. Five SCA Day Care Clubs and one Age UK Day Centre were identified in the Southampton area. Day centres aimed to support people who required extra daily care due to their physical or mental health needs. The centres were run by professional care staff and volunteers and offered opportunities for social interaction, mental stimulation, physical activity, and arts and crafts activities, among others. With a limited number of day care centres available, it was unclear how these centres were meeting the local need.

Use of Meals on Wheels services was declining and these services were being reviewed; use of Meals on Wheels services in Southampton was limited and there was a transition to providing less support and investment for these services. In 2015, all lunch clubs around Southampton were privately run and paid for by users. There was an organisation called Communicare, belonging to the SVS and run by a group of volunteers from the local churches, which provided services such as shopping for or with older/disabled people, transport, visiting people who are lonely or housebound, and befriending. At that time, there were plans for Communicare to set up further social activities and clubs.

In 2015, the Southampton Information Directory (SID) was a recently developed online database coordinated by Southampton City Council (and accessed through the city council website) to provide details about local services, for any age.

5.3.2.1 Update in 2017

In March 2017, I met with a contact within the NHS Southampton CCG to get an update on the current situation in Southampton and to get a picture of what, if anything, had changed since our first meeting in March 2015. The aim of the NHS Southampton City CCG was still to integrate services between health and social care and support a wider group of people, with the development of a greater range of activities in the local community and a change in the way that people managed their personal budget to increase flexibility and choice. There were proposals to review forms of support provision for promoting health and independence in older people. The proposals for an 'Older Persons Offer' were expected to change the way the Council provided day care for older people in the future, and sought to deliver greater independence, wellbeing and choice for older people in local communities across the city. Combating loneliness in Southampton was identified as a priority. At that time, the SID was being revamped and was to be updated over following 18 months. There were plans to implement the GENIE social networking tool across Southampton using trained volunteers and the improved SID, with SID anticipated to establish a regular data exchange to share available community resources with the GENIE tool.

In 2017, there were six integrated cluster teams and Local Solutions Groups (which included elements from the city council, CCG, police and fire service, councillors) that were established in all Better Care cluster areas. Cluster 5 was mapping out local services and resources, and this information was meant to feed into the SID. The Community Navigation Scheme was being rolled out across Southampton, to support residents to find the most appropriate support (utilising and updating the SID) and to act as a link between lonely residents, local Community Solutions Groups and statutory services, including GPs. In 2017, around 700 people were using this service, however there were no data at that stage on the impact of it.

There were plans for a hub or community wellbeing centres to be developed in each of the cluster areas across the city, these would consist of various services and activities (such as growing food or cooking meals) as well as transport. It was envisaged that these hubs would complement existing services and would likely work at no cost to users. The aim was for the service to start in April 2018. Hubs would be aimed largely at older people but could follow an intergenerational model and would possibly be funded by a Social Impact Bond scheme. In this type of system, investors pay for a series of services or interventions to improve a social outcome that is of interest to government commissioners. If the social outcome improves, the government

commissioner repays the investors for their initial investment plus a return for the financial risks they took. If the social outcomes are not achieved, the investors could lose their investment. Social Impact Bonds provide investment to address social problems and look to fund preventive interventions. Similar strategies were being adopted in Hampshire but not at the same scale and pace.

5.3.2.2 Update in 2018

In May 2018, I attended the Public Health England South East Ageing Well Network meeting and follow on workshop. This meeting was attended by various stakeholders in the South East of the UK, from various backgrounds including clinical leads (e.g. oral health and GPs), and public health professionals from city/county councils. The discussion centred on current services and interventions to support ageing well in the South East, including examples of integrated health care systems and models for older people's prevention services.

In June 2018, I attended a stakeholder engagement event and workshop about nutrition and hydration support to vulnerable people in the city, organised by the Southampton City Council (SCC)/CCG Integrated Commissioning Unit. The NHS Southampton CCG was trying to provide joined up services, such as advice and community navigation and had recommissioned older people's day services. Current services on offer included Meals on Wheels, home-delivered meals, online shopping, luncheon clubs, extra care restaurants, older people's day services, food banks, domiciliary care, homeless schemes, and the Dietetic Team in the hospital and community. The GENIE tool was being implemented in Southampton, with a focus on self-management; SID was to provide links to the GENIE database of services. For the City Council, there was a shift away from residential care, towards extra care, for people aged 55 and over with care and support needs. For example, one extra care facility, established in 2016, had 24-hour on-site care staff as well as a restaurant/café (owned by SCC, City Catering Southampton had the catering contract). Meals on Wheels, provided by City Catering, were provided to around 150 people per week; they provided a more holistic service than the national provision, including a health check. Communicare aimed to provide an extended service in Southampton and was creating hubs. Austerity measures, including budget cuts and reduced funding from central government for local governments, had led to reduced funding for local services. There was discussion that with less time and less money for social care, services needed to be better coordinated and people needed to be made more aware of available services. A major concern was how to identify people in the community who were at risk before they lost weight or before they had a clinical need, and how to reach people who were most in need.

Major issues that were identified and discussed at the meeting included:

- How to better meet the nutritional and hydration needs of vulnerable people?
- What is important for supporting people to eat and drink well? What would success look like and how to measure it?
- How to bring services together to help people meet their nutritional and hydration needs?

Discussion around these topics prompted various suggestions for the future, including to have someone with an overarching networking role – a 'nutrition champion' – to identify links between organisations and bring all the parts together, for the SID to have online pop-up windows to prompt users about nutrition and malnutrition, and to deal with transport issues in Southampton for older people. There was agreement that a variety of services were available, but services were not joined up. The CCG was trying to set up a coordinating group and aimed to work to develop the ideas shared during the workshop.

I also contacted the dietitians that covered the city to gain a better understanding of the services that they provided. In June 2018, I met the Community Lead for Dietetics, from the Southern Health NHS Foundation Trust. There were approximately 15 community dietitians (some were based at the West Hants Enteral Nutrition Service). Dietitians were involved in numerous areas. If housebound individuals were identified to be at risk of malnutrition (either by their GP, community nurse or in hospital), then dietitians visited them at home for assessment. The visits would generally happen once per month or once every 3 months. A 'food first' approach was always taken. Dietitians ran clinics in the Royal South Hants hospital (for people with diabetes, general weight loss, among others). Dietitians provided support for adult patients with feeding tubes in the community and also provided training to care homes, about ONS (oral nutritional supplements) and healthy eating. Various dietitians/speech and language therapists were also involved in research. Dietitians also provided support to optimize the prescription of ONS to people in the community, ensuring the most cost-effective and best options were being prescribed by GPs. People were usually referred to the dietetic service through GPs or community nurses, not through voluntary organisations. Dietitians did provide some signposting information to people in the community who needed it (e.g. Wiltshire Farm foods etc.) but did not have access to information about what was available in terms of community organizations, lunch clubs etc., which could be useful to give to people. There was a lack of linking up between the dietetic team and other local services. Dietitians recognised that they were not aware of many services (e.g. extra care lunch facilities, lunch clubs etc.) that were at the time available to older people living in the community. Dietitians observed that they would welcome a resource (e.g. pamphlet,

website…) that they could use to access information on available services in the community, so that they would be able to signpost people to these.

Overall, a range of services that could support the diets of community-living older people were available locally, and services appeared to have an increasing emphasis on the promotion of health and independence and on combating loneliness. However, it became apparent that services were not adequately joined up, and stakeholders expressed a need for better links between the various agencies and services, to be able to support the nutritional wellbeing of older people living in the community.

5.3.3 Services in the Southampton area identified through online searches

Discussions with local stakeholders (mentioned in the previous section) helped to identify groups of services and service databases, which informed the online searches for services that were provided in the city that could support the diets of older people. **Table 6** shows a summary of the results of the online search of databases such as Google and local databases (such as the SID) for services in the Southampton area; specifically, a tally of services/activities that could support the diets of older people (the search was performed in 2015). Services were grouped based on whether their primary focus was considered to be nutrition, physical activity or social support/activities. Within these groupings, services were then further subdivided into types of activity/service. In the nutrition category, services were divided into Meals on Wheels, lunch clubs/community meals, or tea/coffee groups. Within the physical activity category, services were divided into circuits/dance classes, or aerobic classes/chair/water-based/falls prevention exercises. Finally, within the social support/activities category, services were divided into those that provided general support (e.g. befriending/transport/DIY/signposting), social groups/activities, or day centres. Services were also subdivided into statutory or voluntary and categorised according to the method used to identify them (using the SID, performing a manual search of websites, or as part of information provided by a local charity).

A total of 60 services were identified, 26 (43%) of which were nutrition-related services, 13 (22%) of which were physical activity-related services and 21 (35%) of which were services related to social support/social activities. Within the nutrition-focused services, only one service (4%) was Meals on Wheels, five (19%) were tea/coffee groups; the remaining 20 were lunch clubs/community meal services, which comprised most of the nutrition-focused services (77%). Of the physical activity-related services, 46% were circuits/dance classes and 54% were aerobic classes/chair/water-based/falls prevention exercises. Within the social support category, 43% of the identified services provided general support (e.g. befriending/transport/DIY/signposting), 47%

were social groups/activities and 10% were day centres. The overwhelming majority (95%) of all services identified were provided by the voluntary sector, including churches. Only 23% of the services were identified using the SID, the remainder were identified using manual searches of websites and through information sent by a local charity.

5.3.3.1 Update in 2017

In March 2017 I searched the SID to identify which nutrition-focused services were still available in Southampton, and to provide an update on the current situation. In this follow-up search I managed to find all of the nutrition-focused services that had previously been identified, except for three – all three were lunch clubs provided by the voluntary sector. On the other hand, in the follow-up search, I identified two additional services that had not been identified in 2015. These were also lunch clubs provided by the voluntary sector.

Table 6 Results from an online search for services in the Southampton area: tally of services/activities that could support the diets of older people.

Main focus of activity	Type of activity	Statutory/Voluntary	Identification Method
Nutrition	Meals on Wheels – 1	Voluntary – 0 Statutory – 1	SID – 1 Manual search of websites – 0 Information sent by local charity – 0
	Lunch Clubs/ Community meals (lunch/breakfast/dinner) – 20	Voluntary – 20 Statutory – 0	SID – 5 Manual search of websites – 15 Information sent by local charity – 0
	Tea/coffee group – 5	Voluntary – 5 Statutory – 0	SID – 2 Manual search of websites – 3 Information sent by local charity – 0
Physical Activity	Circuits and dance classes – 6	Voluntary – 6 Statutory – 0	SID – 1 Manual search of websites – 3 Information sent by local charity – 2
	Chair or water-based exercise, aerobic classes and falls prevention exercise – 7	Voluntary – 7 Statutory – 0	SID – 0 Manual search of websites – 3 Information sent by local charity – 4
Social Support/Activities	General support (e.g. befriending/transport/DIY/signposting) – 9	Voluntary – 8 Statutory – 1	SID – 2 Manual search of websites – 6 Information sent by local charity – 1
	Social groups/activities – 10	Voluntary – 10 Statutory – 0	SID – 2 Manual search of websites – 8 Information sent by local charity – 0
	Day Centres – 2	Voluntary – 1 Statutory (Private/publicly commissioned service) – 1	SID – 1 Manual search of websites – 1 Information sent by local charity – 0
Totals	Nutrition – 26 Physical Activity – 13 Social Support/Activities – 21	Voluntary – 57 Statutory – 3	SID – 14 Manual search of websites – 39 Information sent by local charity – 7
	All services identified – 60	**% of services provided by the voluntary sector – 95%**	**% of services not identified by SID – 77%**

5.4 Discussion

The aim of this work was to map community services, in the Southampton area, that older people could use and that have relevance when developing interventions to promote their diets. The purpose of this was to inform the GENIE pilot study, by assessing the context into which the intervention was to be introduced, and to inform the development of process evaluation for a future full-scale study. Furthermore, this work is an in-depth study of services in one area, providing an example of the current UK situation in an austerity era, where measures adopted by the national government since 2010, such as budget cuts and reduced funding for local governments, has led to reduced funding for local publicly-funded services.

Through engagement with local stakeholders from the Southampton City Council and the voluntary sector, as well as the online database search, it was possible to gain insight into the range of services available to older people as well as into the policy context. I found that Southampton and Hampshire had health-related strategies in place, which focused on the health of older adults, although there was less emphasis on nutrition-related aspects. The one local community nutrition strategy for older people with a specific focus on disease and disability prevention through support for healthy diets, has since been replaced by another strategy with little nutrition focus. Although a range of services, which could support the diets of community-living older people, were available in Southampton, these did not appear to be adequately joined up. There was also limited statutory or publicly-funded service provision in terms of nutrition-focused services, as most of the services identified that could support the diets of older people were provided by the voluntary sector.

Public sector services for older people in Southampton have been eroded and become fragmented, with most services identified (95%) being delivered by voluntary organisations and churches. This reflects the national picture where public spending on older people's social care has been found to have dropped drastically (Franklin, 2015, Mortimer and Green, 2015). This has meant that the number of older people receiving social care organised and/or funded by local authority social care services has declined, and there are rising levels of people whose care needs are not being met (Mortimer and Green, 2015, Franklin, 2015). In 2015, it was estimated that there were around 1.86 million people over 50 years of age in England (1 in 10) with unmet care needs – an increase of 120,000 people (7%) since 2008/9 (Franklin, 2015). A 2015 report published by Age UK notes that overall, primary and community-based services, on which many older people rely to remain independent, have been most affected by funding cuts (Mortimer and Green, 2015). Community-based services are in drastic decline at a national level; in the three

years preceding the report, spending on Meals on Wheels had been cut by 47%, and there had been a 61% drop in the numbers of people receiving these services, from 2010/11 to 2013/14 (Mortimer and Green, 2015). At the same time, spending on day care services had dropped by 30% over the same period, with the number of older people accessing day care services commissioned or provided by the local authority falling markedly (Mortimer and Green, 2015). The reduction in community-based services could seriously hinder prevention efforts and the capacity for older people to maintain their independence. A report by International Longevity Centre – UK (ILC-UK) notes that a lack of investment in social care funding will lead to increasing dependence on informal care, which could have significant economic and social implications (Franklin, 2015). Furthermore, there is evidence that cuts to local government budgets are disproportionately affecting areas that are more deprived (Hastings et al., 2015). Thus, there are likely to be implications of these cuts for a city like Southampton, where deprivation is higher than the national average.

A 2016 joint report published by The King's Fund and the Nuffield Trust found that social care services for older people in England are under enormous pressure, with increasing numbers of people not receiving the help they need, which is compromising the policy objective of keeping people independent and out of residential care (Humphries et al., 2016). Recent opinion pieces have highlighted the plight of the social care system and of the support that is provided to older people (Humphries, 2016, Oliver, 2015, McKeon, 2014). In the current political and economic climate of uncertainty, there are serious and underlying inadequacies in the funding and provision of care for older people that have not been tackled and are likely to get worse. Concerns have been raised that although the Better Care Fund helps, it is not nearly enough to make up for the gap in social care funding (Humphries, 2016). Furthermore, it may be unrealistic to expect that merging health and social care budgets will bring efficiencies and service gains and that this alone will overcome the deficiencies in NHS and social care expenditure (McKeon, 2014). The Care Act 2014 has created expectations of local authorities that they are hard-pressed to fulfil due to the decline in social care spending. There is little that local authorities can do to make further savings, and soon most might be unable to meet even basic statutory duties (Humphries et al., 2016). As Richard Humphries from The King's Fund wrote in July 2016 ‘The gap between policy rhetoric and service reality has never been starker’ (Humphries, 2016).

5.4.1 Strengths and limitations

This study provides information about the context into which the GENIE pilot study intervention would be introduced and serves to inform the development of methods for assessing context within the process evaluation for a future full-scale study. This study is unique in providing a

comprehensive overview of service availability and policy context in a specific geographical area, with a focus on older people's diets and nutritional wellbeing.

The methods used to assess context in this mapping study could be further developed in the process evaluation of a wider intervention study. Along with further interviews/engagement with local stakeholders, and continued examination of the local policy context, it would be important to collect further quantitative information on local service availability/usage, to understand how service availability is faring over time; whether it is remaining stable, increasing or declining. Furthermore, interviews could be conducted with providers/organisers of available services, and potentially with users themselves, to examine how many people in fact use the services, how people find the services, how regularly do users who access a particular service actually attend it, and for how long do services tend to be operational (e.g. are most services temporary or are they long-standing/embedded in the community), to better understand whether there are adequate services to satisfy the local need or whether these are oversubscribed or not sufficient.

A limitation is that this study provides only a snapshot of the state and availability of services over a brief period; the specific services on offer are likely to fluctuate greatly over time. Attempts were made to assess whether findings changed over time by updating the information obtained from stakeholder discussions and re-running some of the online searches. This provided some idea of change in commissioning/provision and availability of relevant community services in Southampton over time, which suggested little change in the local policy context over the period examined, and that the nature of the services available (mainly voluntary), is likely set to remain for the time being (as described in sections 5.3.1, 5.3.2 and 5.3.3).

Another limitation is that the mapping study was driven by engagement with a limited number of local stakeholders, and it is unclear if the information collected and findings would be the same if other stakeholders had been contacted and interviewed.

There were several services being provided within Southampton that had the potential to influence the diets of older people living in the community. Many services, identified mainly through online databases, were aimed at the wider community, rather than specifically at older people. The services/initiatives did not appear to have been evaluated, so it is not known how they affect the diets of older people. More research is needed in this area to determine what is working and what could be improved.

Multiple different databases/sources were used to identify all relevant services shown in this work. Information about available services that support the diets of community-dwelling older people was not readily or centrally accessible, with only 23% of the services having been

identified using the SID, the remainder having been identified using manual searches of websites and through information sent by local charities. The SID was not always intuitive/user-friendly when performing searches, especially when selecting search categories. Furthermore, in the 2017 follow-up search for additional for nutrition-focused services, I identified services that I had not found in 2015, also using the SID. It is not clear whether these were new services or whether I had simply not been able to find them in my previous search of the database, which could reflect an issue with the database. In view of the difficulties found in identifying initiatives, a more coordinated approach to collating this data would be helpful to allow easy access to this information by older people and their families, by relevant organisations and health practitioners for signposting and referral, and also by policy-makers and practitioners in general, to encourage and enable sharing of good practice.

5.4.2 Future local directions

Policy guidance for 2016/17 (Department of Health and Department for Communities and Local Government, 2016) built on the requirement for health and social care services to work more closely together in local areas and overall direction of travel towards whole system integration. A 2016 update by the Southampton Health and Wellbeing Board on the Southampton Better Care plan (Southampton Health and Wellbeing Board, 2016) highlighted recommendations for the future, which included:

- A stronger focus on prevention and early intervention;
- A greater shift in the balance of care out of hospital and into the community, with development of cluster working and integrated rehabilitation and re-ablement and hospital discharge;
- Significant growth in the community and voluntary sector to divert people away from publicly funded services by promoting health and independence.

The new Southampton 'Health and Wellbeing Strategy 2017-2025' (Southampton Health and Wellbeing Board, 2017) has identified four key priorities, namely:

- For people in Southampton to live active, safe and independent lives and manage their own health and wellbeing;
- For inequalities in health outcomes to be reduced;
- For Southampton to be a healthy place to live and work with strong, active communities;
- For people in Southampton to have improved health experiences as a result of high quality, integrated services.

The delivery of this strategy is supported by various city-wide strategies including Better Care Southampton. The most recent Southampton City Better Care Plan 2017-19 (Southampton City CCG and Southampton City Council, 2017) builds on previous plans and sets out a programme of activities aimed at achieving total service integration by 2020. The plan focuses on six priorities, including the following:

- Stronger focus on prevention and early intervention, which includes City-wide procurement of community navigation; development and implementation of the Older Person's offer to support more people to maintain their health, wellbeing and independence into their later years, transforming more traditional models of care, e.g. day centres; and implementation of the Tackling Loneliness Plan;
- A shift in the balance of care away from hospitals/care homes and into the community;
- Significant growth in the community and voluntary sector; through a community development model, continue to work with the community and voluntary sector to support the prevention and early intervention agenda; to work with cluster teams to raise awareness of local provision, jointly identify gaps and stimulate new community activities;
- Development of new models of care which better support the delivery of integrated care and support, joined up patient/client record systems, and greater use of technology solutions.

A potential area that warrants exploration is social prescribing and how GPs or other health practitioners could have an important role in advising people to participate in social/community activities. In 2015, NICE issued a new guideline covering planning and delivering social care and support for older people who have multiple long-term conditions (National Institute for Health and Care Excellence (NICE), 2015). This encourages an integrated and person-centred approach to delivering effective health and social care services. The guideline also contains recommendations on preventing social isolation; health and social care practitioners should support older people to maintain links with their friends, family and community, and should identify whether people are lonely or isolated; in addition, practitioners should give older people information about social activities and opportunities that could help them maintain or build their social contacts (National Institute for Health and Care Excellence (NICE), 2015).

5.4.3 Conclusions

The mapping study described in the present chapter comprises the contextual component of the process evaluation of the GENIE pilot intervention study. I assessed the context into which the intervention would be introduced and identified contextual issues for the pilot study; also,

findings will help to inform the development of process evaluation for a future full-scale study. It is likely that the implementation of this intervention, and its effects, will be affected by the existing context in Southampton. One of the stages of delivering the GENIE intervention consists of linking participants to valued activities and resources that feature in a pre-created database, where local organisations and resources have been listed and categorised. This mapping study found that there are plans for links to be created between the SID and the GENIE database of community resources; however, if SID is not updated and/or if the GENIE database is not sufficiently populated, it could be difficult to link participants to appropriate activities and resources, which could potentially counteract the effects of the GENIE intervention.

Information from different sources about services that support the diets of community-dwelling older people should be made more readily and centrally available to relevant community organisations, health practitioners, and to older people themselves. Bearing in mind that publicly funded services for older people have eroded and fragmented, any intervention to support older people in Southampton to improve diet would need to link up with the voluntary/community sector. Future research should focus on developing and evaluating community-based services and interventions that have the potential to support the diets of older people living in the community.

Given the findings from earlier chapters of the potential importance of social and psychological factors for promoting diet quality and health in older age, there is the potential for community-based services and interventions to promote social engagement and aspects such as resilience and self-efficacy, which could support older community-living adults to maintain a healthy diet. There should be greater policy focus specifically on nutrition-related issues for older people in Southampton, and improved joined-up nutrition-focused service provision, in order to promote the nutrition and health of older residents in the area.

Chapter 6: A Social Network Intervention to Promote Diet Quality in Older Adults: A Pilot Study

6.1 Introduction

Chapters 3 and 4 of this thesis describe how social factors, such as social support, social networks and participation in activities, were linked with higher diet quality in older people. Social factors may help to promote, or conversely to undermine when inadequate, diet quality in older people. However social factors, such as social networks and engagement with community-based institutions, are not usually included in the design of interventions to promote healthy eating among older people (Zhou et al., 2018). There is also a lack of research on the impact of community engagement activities on health-related behaviours (Jones et al., 2013). Thus, little is known about how interventions aimed at supporting social networks and engagement with community activities might impact on the promotion of healthy diets and other health behaviours in later life. To my knowledge, no studies have evaluated the impact of social engagement interventions on diet quality specifically in older people.

While Chapter 5 assessed the context into which a local Southampton-based intervention could be introduced, the present chapter assesses the nature of an intervention to increase social engagement, describing a pilot study that assessed the feasibility of collection of health behaviour data before and after the intervention, and evaluates its potential impact on change in diet quality (primary outcome) and other behaviours, lifestyle factors and physical function. It describes the implementation and evaluation of a social networking tool (GENIE—Generating Engagement in Network Involvement), which facilitates engagement with local support resources and activities.

Using a randomised controlled trial design, the aims of this pilot study were: 1) to develop data collection methods and process evaluation methods that could be used in a larger study, 2) to assess the feasibility of scaling this study up into a larger future study, and 3) to assess the potential impact of GENIE on diet quality, and other lifestyle and health outcomes, in a group of older community-dwelling adults with Chronic Obstructive Pulmonary Disease (COPD) and to compare changes in the outcomes of interest with those in a control group.

6.2 Methods

Some of the methods for this pilot study have been described in section 2.4 of this thesis. I set up a collaboration with researchers in the National Institute for Health Research Collaboration for Leadership in Applied Health Research and Care (NIHR CLAHRC) Wessex (Theme 5), who were implementing and evaluating the GENIE social network intervention tool in a local Southampton COPD clinic. The GENIE (Generating Engagement in Network Involvement) tool maps a person's social networks, takes their preferences and needs into account and facilitates engagement with local support resources (Kennedy et al., 2016). It was hypothesized that the GENIE intervention could have a positive impact on diet through improving engagement with existing networks and by extending networks, and this pilot study aimed to provide further insight into whether improving social engagement can influence dietary behaviour change and diet quality in older adults.

To develop the pilot study described in this chapter, I designed the data collection methods for a sub-study that could be embedded in a larger randomised controlled trial that aimed to implement and evaluate the use of the GENIE intervention tool in a Southampton Integrated COPD Service, to ascertain cost effectiveness and patient benefit. The main outcomes of this larger study were healthcare utilisation, burden of disease, psychological outcomes and quality of life. Ethical approval for this study was obtained from the Health Research Authority – NRES South Central – Hampshire Research Ethics Committee (REC reference: 17/SC/0044). Participation in the sub-study that assessed diet and lifestyle (the focus of this pilot study) was optional.

I developed a questionnaire that could be used to collect data on various health behaviours, lifestyle factors and physical function, at baseline and at follow-up. The full 'Health Behaviour Tool' questionnaire can be found in Appendix F. I drafted the amendment to enable collection of data on health behaviours and obtained ethical approval for the amended protocol on 22nd June 2017.

Participants were recruited from a local COPD Service at Bitterne Health Centre (Solent NHS Trust), and data collection began in June 2017. I trained researchers to administer the Health Behaviour Tool questionnaire and supervised data collection. I worked with the IT team to clean the data; I performed the statistical analyses and interpreted the results of the analyses.

6.2.1 Participants and setting

Within the COPD Service at Bitterne Health Centre, patients usually enter the pulmonary rehabilitation (PR) section of the service after an acute episode or by GP referral. The PR service

includes an exercise component. At the post-PR review, patients are usually offered maintenance exercise therapy, delivered by the COPD team, and are reviewed yearly. For recruitment into the present study, patients already referred into PR groups were approached at assessment and at the end of PR, in their post-PR review appointment (usually after 12 sessions by the clinical team), and asked if they wished to participate in the study and were provided with study information. At yearly maintenance review, patients were also offered the opportunity to participate in the GENIE study.

The option to participate in the study was offered to every patient in pulmonary rehabilitation or maintenance exercise programs in the east of Southampton, provided they fulfilled the following inclusion criteria: (1) they were an adult aged between 18 and 95 years with a predominant diagnosis of COPD; (2) they had the ability to understand spoken English; (3) they were enrolled in PR or maintenance therapy; (4) they had the ability and capacity to make their own decisions and consent freely. The exclusion criteria included: (1) the absence of a clear COPD diagnosis; (2) the inability to give informed consent.

If patients were interested in participating in the study they provided their names to the clinical staff to keep on a secure Solent NHS database. Participant information sheets and invitation letters were provided to the interested patients at their clinical visits to minimise the need for extra visits. Once patients received the participant information sheet (see Appendix G), including the information that they would be given the option of completing a questionnaire about their health behaviours, they were allowed at least 72 hours to read and process the information. Participants were invited in person, via letter, text and/or phone call, to attend a baseline appointment, at Bitterne Health Centre. If patients were returning for clinical visits then appointments for research were amalgamated with usual clinical visits, in order to reduce extra visits.

At the baseline visit, informed consent was obtained from participants, and they were then randomised using the block randomisation technique. Pre-prepared envelopes containing the random combinations of group allocation (A or B), were stored in a locked drawer in Bitterne Health Centre. Randomisation was in blocks of four to complement the clinic structure. Therefore, each envelope contained a pre-determined allocation pattern for a particular clinic (AABB, ABAB, BABA etc.). A random number sequence was generated, to ensure that each envelope was selected at random. Participants in both the control and the intervention group received normal clinical care (discharge planning with suggested activities, usually exercise therapy), and those in the intervention group received the GENIE tool intervention (in addition to usual clinical care). Baseline questionnaires were also administered at this visit.

The follow-up visit took place approximately 3 months (12 weeks) from the day of the baseline visit. Participants were invited back, via letter and/or phone call to attend the three-month follow-up visit at Bitterne Health Centre. For the wider study, the aim was to recruit a minimum of 30 participants in each group, and up to 60 in each group, to ensure meaningful analysis. For the sub-study the aim was to collect diet and lifestyle data for up to 30 of these participants.

The baseline visit (including intervention delivery and baseline data collection) was delivered by one of two researchers (Lindsay Welch or Chris Allen), and the follow-up visit (including follow-up data collection) was led by either one of two researchers (Lindsay Welch or Liz James).

6.2.2 Delivery of the GENIE intervention

Each participant in the intervention group of the present study completed the GENIE tool online, with the researcher's help. Both the participant and the researcher sat in front of a computer in the clinic. Participants had the option either to complete the online tool themselves, with prompts from the researcher, or the researcher could talk the participant through the online process, asking them the questions and completing the online system for them. The process of delivering the GENIE intervention consisted of the stages set out in section 2.4.

Researchers who delivered the intervention had received training in how to deliver GENIE. The GENIE intervention took researchers between 45 minutes and one hour to deliver. In order to maintain privacy, participants were given the option for pseudonyms to be used on the GENIE website (including pseudonyms of friends and relatives), however most participants chose to use their real names. At baseline, the mapping of the participant's current social support network on a concentric circles diagram was printed out, and the printed copies were stored in a locked drawer on Solent NHS premises. At follow-up, uptake of social activities and/or changes to social networks by participants in the intervention group were recorded using the GENIE concentric circles diagram and this was printed out.

6.2.3 Assessment of background characteristics at baseline

At baseline, background data were collected from participants in both the control (usual care) group and the intervention group on age, gender, age left school, highest level of qualification attained, job or occupation, the number of people living in the participant's household, and the number of regular visitors received. Data were also collected on COPD disease severity (based on spirometry measurements (forced expiratory volume in one second – FEV_1), and categorised as mild, moderate, severe or very severe, according to the GOLD classification of airflow limitation severity (Global Initiative for Chronic Obstructive Lung Disease, 2018)).

6.2.4 Outcome evaluation for the present sub-study

6.2.4.1 Assessment of lifestyle and health factors, at baseline and follow-up

At baseline, data on health behaviours, lifestyle factors and physical function were collected by administering a questionnaire (called the 'Health Behaviour Tool') to participants in both the control group and the intervention group. The following subsections describe the separate components of this questionnaire – Appendix F includes the full questionnaire.

At the three-month follow-up, the same health behaviour questionnaire was administered again, and follow-up data were collected.

6.2.4.1.1 Diet Quality

The primary outcome in this pilot study was change in diet quality, represented by change in prudent diet scores.

Diet was assessed using the short food frequency questionnaire (FFQ) described in section 2.1.1, which has been validated to assess diet quality in older adults (Robinson et al., 2017). A 'prudent' diet score can be calculated from a small number of discriminating foods. In this pilot study, prudent diet scores were calculated for each participant based on their consumption of 19 indicator foods, indicating the participant's compliance with the prudent pattern, and were used as an indicator of diet quality (Robinson et al., 2017). High prudent diet scores indicate diets characterised by frequent consumption of fruit, vegetables, wholegrain cereals and oily fish but low consumption of white bread, added sugar, full-fat dairy products, chips and processed meat (Robinson et al., 2017). Prudent diet scores were calculated to describe diet quality at baseline and follow-up. Change in prudent diet scores (representing change in diet quality) were expressed per month, from baseline to follow-up.

6.2.4.1.2 Other lifestyle and health factors

Secondary outcomes that were considered in this pilot study were change in current alcohol consumption status, change in current smoking status, change in BMI, change in appetite score, change in physical function score, and change in total physical activity. Change was expressed per month, from baseline to follow-up; change in status for alcohol consumption and smoking was expressed over the entire follow-up period.

Alcohol consumption status was assessed by asking whether the participant currently consumed alcohol.

Smoking status was assessed by asking whether the participant currently smoked and whether they had ever been a smoker, i.e. whether they had ever smoked at least once a day for a year or more.

Height (cm) and weight (kg) were obtained from participants' most recent clinical records (where this was not possible, participants were weighed by researchers), and BMI (kg/m^2) was calculated for each participant.

Appetite was assessed using the Simplified Nutritional Appetite Questionnaire (SNAQ), which is validated to predict weight loss in community-dwelling older people (Wilson et al., 2005). The SNAQ is a 4-item questionnaire that includes questions about appetite and issues around food intake. Results were presented as a total SNAQ score (continuous) and also categorised into two categories, with a total SNAQ score <14 indicating low appetite.

Data were collected on physical function using self-reported assessment of physical function (SF-36 physical functioning (PF) domain – SF-36 PF), which involved asking participants questions about ten activities that they might typically perform, specifically how much their health limits them in carrying out these activities (Syddall et al., 2009). This was presented as a continuous physical function score (SF-36) and participants' scores were also categorised to reflect whether they had 'poor physical function' (if their physical function score was in the sex-specific bottom fifth of the distribution).

Physical activity was assessed using a series of questions that were derived from the International Physical Activity Questionnaire (IPAQ) Short Form. The IPAQ short form has been validated for use in 15-69 year olds (IPAQ group, 2005). It includes questions about the time spent walking, in vigorous- and moderate-intensity activity and in sedentary activity. Physical activity scores were categorised into three categories (low activity, moderate activity or high activity) based on the protocol for the IPAQ Short Form (IPAQ group, 2005). To be classified as 'moderate activity' a participant's pattern of physical activity met one of the following criteria: a) 3 or more days of vigorous-intensity activity of at least 20 minutes per day; or b) 5 or more days of moderate-intensity activity and/or walking of at least 30 minutes per day; or c) 5 or more days of any combination of walking, moderate-intensity or vigorous intensity activities achieving a minimum 'total physical activity' of at least 600 MET-minutes/week. For 'high activity', the two criteria for classification were: a) vigorous-intensity activity on at least 3 days achieving a minimum 'total physical activity' of at least 1500 MET-minutes/week; or b) 7 or more days of any combination of walking, moderate-intensity or vigorous-intensity activities achieving a minimum 'total physical activity' of at least 3000 MET-minutes/week. Participants who did not meet criteria for the above categories were considered to have a 'low' physical activity level.

6.2.4.2 Statistical Analysis

Baseline and follow-up descriptive characteristics were reported as mean with standard deviation (SD) for continuous normally distributed variables, median with interquartile range (IQR) for continuous variables with a skewed distribution, or counts and percentages for categorical variables, as appropriate. Descriptive statistics for lifestyle and health characteristics were presented separately by participant group (intervention and control). Baseline differences between participant groups (intervention vs. control), in terms of background, lifestyle and health characteristics, were assessed using, as appropriate: Mann-Whitney rank-sum tests (for comparing 2 independent groups; continuous and skewed dependent variables), or two-sided Fisher's exact tests (for comparing 2 independent groups with small numbers; categorical dependent variables).

The primary outcome of interest was change in diet quality, represented by change in prudent diet scores. For this analysis the exposure and outcome were as follows:

- Exposure: two independent groups (intervention and control groups)
- Outcome: Change in prudent diet score was expressed per month, from baseline to follow-up (Change in diet (per month)). Differences between participant groups (intervention vs. control) were assessed; a Mann-Whitney rank-sum test was used for comparing the groups.

Wilcoxon signed-rank tests were used to statistically test whether follow-up prudent diet scores differed from baseline prudent diet scores, for participants in each of the groups (intervention and control).

Secondary outcomes were change in lifestyle and health factors. For this analysis the exposure and outcomes were as follows:

- Exposure: two independent groups (intervention and control groups)
- Outcomes: change in current alcohol consumption, change in current smoking status, change in BMI, change in appetite score, change in physical function score, and change in total physical activity. Change was expressed per month, from baseline to follow-up. Differences between participant groups (intervention vs. control) were assessed using Mann-Whitney rank-sum tests or two-sided Fisher's exact tests, as appropriate.

A significance level of $P<0.05$ was used. Data were analysed using Stata version 14.2.

6.2.5 Process evaluation

In terms of the process evaluation, this section focuses mostly on the implementation of the GENIE tool intervention and, to a lesser extent, aspects relating to its mechanisms of impact; aspects related to context are addressed in the previous chapter of this thesis (Chapter 5).

Information was collected on the implementation process of this intervention through implementer/researcher (Lindsay Welch) field notes (self-report). These field notes derived from observations by the researcher delivering the intervention of the implementation process of the intervention, discussions at baseline and follow-up with participants who received the intervention, an informal interview with one of the clinicians at Bitterne Health Centre, as well as informal discussions with a group of participants who had received the GENIE intervention and were part of a COPD support group.

In order to facilitate an understanding of the mechanisms of impact of this intervention, participant uptake of social activities was recorded, by the researcher delivering the intervention, on paper using the GENIE tool, for comparison between baseline and follow-up. At follow-up, for those in the intervention arm, feedback and reflection discussions were initiated using the network diagrams. My collaborators have gone on to do further work on comparing participants' social networks at baseline to those at follow-up, so as to examine the changes to social activities/social networks that participants might have made as a result of the intervention.

6.3 Results

Twenty-two men and women were recruited from a local COPD Service; 11 participants were randomised to each group. Participants of the wider study were offered participation in the present sub-study on a first come first serve basis; there was only one participant who did not agree to respond to the extra questionnaire on diet and lifestyle, and therefore did not take part in this sub-study. The aim of this study was to recruit around 30 participants, to understand feasibility of the study and usability of the questionnaires. However, due to the large amount of detailed data collection required for the wider study, after 22 participants had been interviewed, and in discussion with other members of the study team, it was deemed that sufficient data had been gathered. One participant was lost to follow-up in the control arm, and for a small number of participants in the control group there was missing data at follow-up, due to participant time constraints and questionnaire fatigue. Some participants were unable to attend for a follow-up appointment, and therefore questionnaires were posted to them; in some cases not all the pages of the questionnaires were completed and some were missed. However, for all participants dietary data was collected that enabled calculation of the prudent diet scores.

Table 7 and

Table 8 show a summary of baseline descriptive characteristics of the study population (for ease of presentation

Table 8 shows characteristics of study participants by group, but there is a description of baseline lifestyle and health characteristics, for the whole study population combined, in the text below). At baseline, participants (13 men and 9 women) were aged between 61 and 82 years (median age (IQR): 70 (67 – 77) years). Most participants were from a relatively disadvantaged background; fifty-two per cent of participants had a manual job or occupation, and most participants (86%) had left school at age 15 years or above (the majority at either 15 or 16 years of age). Forty-one per cent of participants lived alone. In terms of their COPD disease severity, for half of participants this was moderate, while for 36% it was severe.

While all participants had smoked at some stage during their lives, only 9% smoked at the time of baseline data collection. At baseline, most study participants (82%) consumed alcohol, median BMI was 25.7 kg/m^2 (IQR 21.7 – 29.5), and over a third (36%) of participants had poor appetite (SNAQ score <14). At baseline, prudent diet score ranged between -2.23 and 2.72, and median prudent diet score was 0.58 (IQR 0.26 –1.26). Almost a quarter (23%) of participants had poor physical function and 27% of participants had low physical activity at baseline.

In this small group, there were no statistically significant differences between intervention and control groups at baseline. However, given the sample size, statistical power was limited.

Table 7 Baseline descriptive characteristics of participants – background characteristics.

	All			**Intervention**			**Control**			
	N	**Median**	**IQR**	**N**	**Median**	**IQR**	**N**	**Median**	**IQR**	**p-value[1]**
Age	22	70	67 - 77	11	70	68 - 71	11	77	66 - 82	0.306
	Total N	**N**	**%**	**Total N**	**N**	**%**	**Total N**	**N**	**%**	**p-value[1]**
Gender	22			11			11			0.387
Male		13	59.1		8	72.7		5	45.5	
Female		9	40.9		3	27.3		6	54.6	
Age left school – category	22			11			11			0.214
<15		3	13.6		0	0		3	27.3	
≥15		19	86.4		11	100		8	72.7	
Highest Qualification – category	21			10			11			0.192
None		4	19.1		1	10		3	27.3	

	All			Intervention			Control			
O/A levels/Vocational qualifications		14	66.7		6	60		8	72.7	
Degree or higher		3	14.3		3	30		0	0	
Job/occupation – category	21			10			11			1.000
Manual		11	52.4		5	50		6	54.6	
Non-manual		10	47.6		5	50		5	45.5	
Number of people in household	22			11			11			1.000
1		9	40.9		4	36.4		5	45.5	
2		13	59.1		7	63.6		6	54.6	
	N	**Median**	**IQR**	**N**	**Median**	**IQR**	**N**	**Median**	**IQR**	**p-value[1]**
Regular visitors	22	4	2 - 6	11	4	3 - 6	11	4	2 - 7	0.895
	Total N	**N**	**%**	**Total N**	**N**	**%**	**Total N**	**N**	**%**	**p-value[1]**
Disease severity [a]	22			11			11			0.473
Mild		2	9.1		2	18.2		0	0	
Moderate		11	50		6	54.6		5	45.5	
Severe		8	36.4		3	27.3		5	45.5	
Very severe		1	4.6		0	0		1	9.1	

[1] p-value for the difference between intervention and control groups at baseline. Differences between participant groups (intervention vs. control) were assessed using, as appropriate, Mann-Whitney rank-sum tests or two-sided Fisher's exact tests.

[a] Disease severity (categorised as mild, moderate, severe or very severe based on the GOLD classification (Global Initiative for Chronic Obstructive Lung Disease, 2018)).

Table 8 Lifestyle and health characteristics of participants, by group, at baseline and at follow-up.

	Intervention group						Control group					
	Baseline			Follow-up			Baseline			Follow-up		
	Total N	**N**	**%**	**Total N**	**N**	**%**	**Total N**	**N**	**%**	**Total N**	**N**	**%**
Currently drink alcohol	11			11			11			8		
No		3	27.3		4	36.4		1	9.1		2	25.0
Yes		8	72.7		7	63.6		10	90.9		6	75.0
Currently smoke	11			11			11			8		
No		10	90.9		10	90.9		10	90.9		7	87.5
Yes		1	9.1		1	9.1		1	9.1		1	12.5
	N	**Median**	**IQR**	**N**	**Median**	**IQR**	**N**	**Median**	**IQR**	**N**	**Median**	**IQR**
BMI (kg/m^2)	11	26.5	21.7 - 29.5	11	26.3	21.9 - 29.4	11	24.2	20.7 - 30.1	8	23.0	21.3 - 29.7

	Intervention group						Control group					
	Baseline			Follow-up			Baseline			Follow-up		
Prudent diet score	11	0.31	-0.61 – 1.26	11	0.47	-0.04 – 0.70	11	0.96	0.26 – 1.71	10	0.39	-0.16 – 0.97
Total SNAQ score	11	16	13 - 18	11	14	11 - 16	11	14	12 -16	7	13	11 -16
	Total N	**N**	**%**	**Total N**	**N**	**%**	**Total N**	**N**	**%**	**Total N**	**N**	**%**
SNAQ category [a]	11			11			11			7		
SNAQ score <14		3	27.3		4	36.4		5	45.5		4	57.1
SNAQ score ≥14		8	72.7		7	63.6		6	54.6		3	42.9
Physical activity category [b]	11			11			11			10		
Low activity		3	27.3		5	45.5		3	27.3		4	40.0
Moderate activity		4	36.4		2	18.2		3	27.3		3	30.0
High activity		4	36.4		4	36.4		5	45.5		3	30.0
	N	**Median**	**IQR**	**N**	**Median**	**IQR**	**N**	**Median**	**IQR**	**N**	**Median**	**IQR**
Total physical activity [c]	11	520	240 - 1500	11	280	60 - 1680	11	920	210 - 1560	9	245	150 - 440
Physical function score (SF-36)	11	30	15 - 55	10	40	15 - 55	11	25	20 - 50	8	30	15 - 40
	Total N	**N**	**%**	**Total N**	**N**	**%**	**Total N**	**N**	**%**	**Total N**	**N**	**%**
Poor physical function [d]	11			10			11			**8**		
Yes		3	27.3		3	30.0		2	18.2		2	25.0
No		8	72.7		7	70.0		9	81.8		6	75.0

[a] Total SNAQ (Simplified Nutritional Appetite Questionnaire) score <14 (low appetite). [b] Physical activity scores were categorised into three categories (low, moderate or high activity). [c] Total physical activity performed, in minutes, per week. [d] Physical function scores (SF-36) were categorised to reflect whether participants had 'poor physical function' (if their physical function score was in the sex-specific bottom fifth of the distribution).

6.3.1 Effects of the GENIE intervention on diet and lifestyle outcomes

Median time from baseline to follow-up was 3.2 months (IQR 3.0 – 4.4). In the intervention group, median time from baseline to follow-up was 3.2 months (IQR 3.0 – 4.6), and in the control group it was 3.1 months (IQR 3.0 – 4.4). There was no statistically significant difference in follow-up time between intervention and control groups (P=0.570).

The primary outcome in this pilot study was change in diet quality, represented by change in prudent diet scores, expressed per month, from baseline to follow-up. Median change in prudent diet score (per month) in the whole cohort was -0.09 (IQR -0.24 – 0.06). There was no significant change in diet quality in the intervention group over the period of follow-up (median change in

prudent diet score per month (IQR): 0.03, (-0.24 – 0.07)); whereas an overall fall in diet quality was observed in the control group (median change in prudent diet score per month (IQR): -0.15, (-0.24 – 0.03)) – **Figure 10** depicts this graphically. Although this is suggestive of beneficial effects of the intervention on diet quality, the difference between intervention and control groups, in terms of change in prudent diet score per month, was not statistically significant (P=0.260).

Within the participants of the intervention group, there was no statistically significant difference between their prudent diet scores at baseline and their prudent diet scores at follow-up (P=0.790). In the control group participants, however, the difference in their prudent diet scores, between baseline and follow-up, approached statistical significance (P=0.047), suggesting that there was a meaningful drop in diet quality for control group participants, during the study.

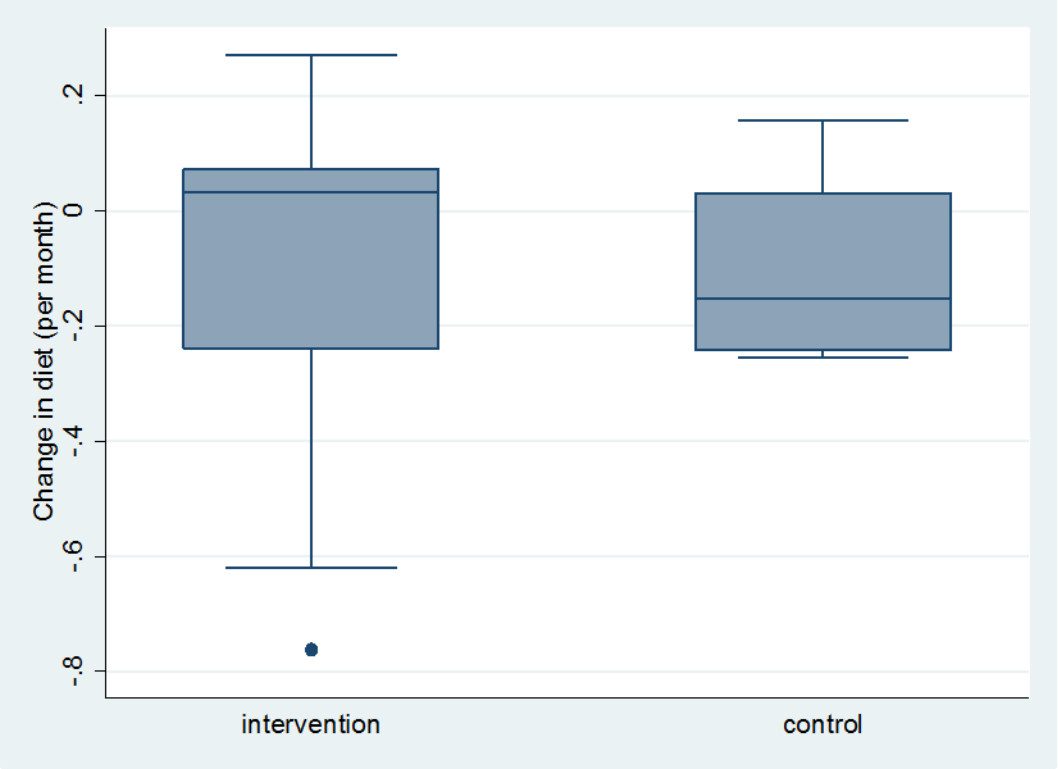


Figure 10 Box plot displaying change in prudent diet score per month, in the intervention and the control groups, separately.

Secondary outcomes that were considered in this study were change in alcohol status, change in smoking status, change in BMI, change in appetite score, change in physical function score, and change in total physical activity. Change was expressed per month, from baseline to follow-up; change in status for alcohol consumption and smoking was expressed over the entire follow-up period.

There was no change in smoking status from baseline to follow-up, in either of the groups, and little change in alcohol consumption status (only two participants, one in each of the groups,

stopped drinking alcohol over the follow-up period, and the remaining participants' alcohol consumption status stayed the same), which was not statistically significant.

Table 9 shows the change in outcome variables between baseline and follow-up for the primary and secondary outcomes, and compares the changes between the intervention and control groups.

Table 9 Assessment of the change in outcome variables, between baseline and follow-up, in the intervention and control groups.

Outcome[1]	**Intervention group**	**Control group**	**p-value**[2]
Change in prudent diet score	0.03 (-0.24 – 0.07)	-0.15 (-0.24 – 0.03)	0.260
Change in BMI	-0.02 (-0.42 – 0.24)	0.18 (-0.13 – 0.20)	0.457
Change in appetite score [a]	-0.23 (-0.89 – 0)	0 (0 – 0.45)	0.084
Change in physical function score [b]	0 (-2.16 – 3.71)	-2.46 (-3.38 – 0.55)	0.212
Change in total physical activity [c]	-51.81 (-66.81 – 54.91)	-167 (-365.62 – -29.53)	0.053

[1] All change outcomes are expressed per month, from baseline to follow-up, as median (IQR).

[2] p-value for the difference between intervention and control groups. Differences between groups (intervention vs. control) were assessed using Mann-Whitney rank-sum tests or two-sided Fisher's exact tests, as appropriate.

[a] Change in total SNAQ (Simplified Nutritional Appetite Questionnaire) score. [b] Change in physical function score (SF-36). [c] Change in total physical activity performed, in minutes, per week.

There was little change in BMI in either the intervention or control groups over the follow-up period. In the intervention group, there was an overall decline in appetite over the follow-up period, whereas in the control group there was no change in appetite (**Table 9**). There was no change in physical function in the intervention group over the period of follow-up, while an overall decline in physical function was observed in the control group. Over the follow-up period, there was an overall fall in total physical activity performed by participants, in both the intervention and the control groups, however the fall was most pronounced in the control group, as shown in **Figure 11**. No statistically significant differences were found for these outcomes, when comparing the intervention group to the control group (**Table 9**). However, the difference between intervention and control groups in terms of change in total physical activity approached statistical significance (P=0.053).

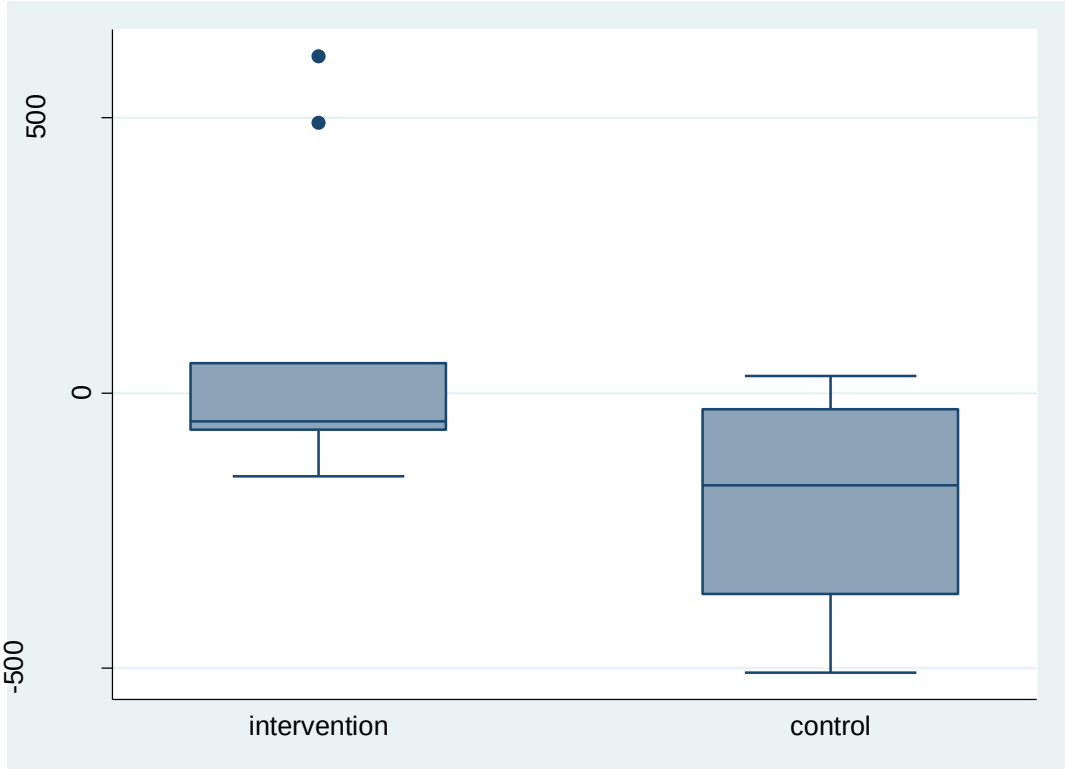


Figure 11 Box plot displaying change in total physical activity (per month), in the intervention and the control groups, separately.

6.3.2 Findings from the process evaluation

Implementation of the GENIE tool intervention

The implementation of the GENIE intervention was assessed during the pilot study. Participants in the intervention group with severe disease (n=3, 27.3%) or experiencing frequent exacerbations reported that the intervention was hard to engage with, as their main goal was to 'feel better'. An example quote from a clinician who spoke to the researchers delivering the intervention, at the time of participant recruitment:

> "I have just seen a person who is beyond GENIE. It is so desperately sad that his social world is so confined. He only sees one person, he has no friends and his ex-wife recently died. He feels he no longer has a reason to live. He used to feel comforted to know that his ex-wife was there and alive, even though they didn't interact. I think GENIE is too much, how can we support this man socially?''

This highlighted the potential need to ensure patients using GENIE are at a stage in their clinical care where they are not in such regular contact with health services, when moving away from statutory services, to support themselves through voluntary services.

Nevertheless, most participants appeared uplifted by the options of choice offered by GENIE and the recognition of the importance of their social world; participants enjoyed discussing their social world rather than constantly focusing on their condition. Participants in the intervention group with less severe disease (n=8, 72.8%, with mild or moderate disease severity) were pleased to be almost given permission to socialise more.

The following are some example quotes from participants who used the GENIE tool, when asked about their experience with GENIE:

> "I got all these forms of all different places that I can go in the area which are free … walking and knitting … the GENIE, the idea is for people on their own that don't go out and don't go nowhere, and meet up with people … it's a social circle, the bullseye of the social circle gets bigger…"

> "If you're not feeling very well who do you turn to? My mates. … Well family and that are all working…"

> "Often people are told they've got COPD they go home just sit in the chair and do nothing, therefore the illness takes over, and you just become worse and worse, just wallow in your own self-pity…"

In some cases, it seemed that mapping the social world and talking through the concentric circle diagrams could be enough to change existing habits of socialisation, breaking routines, and encouraging participants to take a step further into friendships. The concentric circle approach to 'map' social networks proved to be insightful for participants.

Barriers to implementation

The observations and the discussions with participants showed that there were issues around poor literacy of the study participants and the language used by GENIE was difficult for many to understand alone. Researchers had to read aloud a lot of the GENIE tool's online aspects, which made intervention delivery more difficult and time-consuming. Some of the participants found it tiring to complete the baseline questionnaires (including the short FFQ), as well as the online GENIE tool. Researchers found that using lay language to explain the tool's approach (e.g. using the expression 'circle of friends') proved more successful. The digital literacy of participants was also poor; most requested for everything to be printed on paper, and declined to have the option to log on and use GENIE for themselves online and to interact with any form of technology. However, the facilitation of GENIE overcame this for the majority of participants and talking through the process appeared to be cathartic for many of them.

6.4 Discussion

This chapter described a pilot study of the implementation and evaluation of the GENIE social networking tool to achieve change in diet and other health behaviours. The study developed data collection methods and contributed to the development of the process evaluation methods, both of which could be used in a wider intervention study; using a randomised controlled trial design, the study also assessed the feasibility of scaling this study up into a larger future study, and assessed the impact of GENIE on diet quality, and other lifestyle and health factors, in a group of community-dwelling older adults with COPD and compared changes with those in a control group.

While in the intervention group there was no change in diet quality over the period of follow-up, an overall decline in diet quality was observed in the control group. The magnitude of differences in prudent diet scores was modest and these are difficult to interpret in practical terms. The prudent diet score is a composite measure that reflects variations in a range of foods – and differences in scores and/or changes in scores can be achieved both by increases in positive-scoring foods and decreases in negative-scoring foods. There was no change in smoking status, and little change in alcohol consumption status, and in BMI, over the follow-up period. In the intervention group, there was an overall decline in appetite over the follow-up period, while in the control group there was no change in appetite. On the other hand, in the intervention group there was no change in physical function over the period of follow-up, while an overall decline in physical function was observed in the control group. While there was an overall fall in total physical activity in both groups over the follow-up period, this fall was most pronounced in the control group. Although this is suggestive of beneficial effects of the GENIE intervention on diet quality, physical function, and physical activity, the differences between intervention and control groups were not statistically significant, though the difference approached statistical significance for change in physical activity. Overall, the GENIE intervention was found to be acceptable and appropriate for older people with COPD, especially for those with less severe disease, when delivered by trained researchers.

While there is some evidence to suggest that social involvement (e.g. links to community groups or organisations) may be associated with the maintenance of healthy behaviours over time in older people (Reeves et al., 2014), to my knowledge, there have been few intervention studies with a focus on social components and community engagement that assessed impact on lifestyle or health behaviours, including diet, in older age, and none of them focused specifically on diet quality in older people.

One study evaluated the South West Well-being (SWWB) programme in the UK, which involved ten organisations delivering leisure, exercise, cooking, befriending, arts and crafts activities (Jones

et al., 2013). The study examined the associations between participation in community activities and psychosocial wellbeing and health-related behaviours in adults. The evaluation was a before-and-after study with 687 adults, from a range of age groups, who participated in the SWWB project activities. Overall, the study found that participation in community-based activities was associated with improvements in health and wellbeing. Results showed that participation in the SWWB programme was associated with statistically significant changes for improved general health, social well-being, and mental well-being, as well as improvements in enjoyment and importance of healthy eating, general physical activity, and enjoyment and importance of physical activity. There was a significant reduction in self-reported mental ill health. Contrary to these overall positive changes, there was a reduction in self-reported fruit and vegetable consumption at follow-up. However, sub-analysis showed that this did not apply to individuals who participated in activities with a specific focus on healthy eating; activities that focused on healthy eating were more strongly associated with positive changes in self-reported fruit and vegetable consumption, compared to project activities with no specific healthy eating focus. Of note is the fact that the programme aimed to embed activities in participants' everyday lives, setting the activities out in the context of fun, leisure, creativity and socialising, rather than as disease prevention. Another study, this one a US randomised trial, examined whether a clinic-based behavioural intervention that emphasized use of community resources would increase physical activity and improve dietary intake in women (n=236, aged 40–64) (Keyserling et al., 2008). Participants were randomised to receive an Enhanced Intervention (EI) or Minimal Intervention (MI). The EI included individual counselling sessions, group sessions, and phone calls, which aimed to increase participants' use of community resources to promote positive lifestyle changes. Objectively measured (by accelerometer) moderate intensity physical activity increased in the EI and decreased in the MI, although the difference between groups was not statistically significant; moderate intensity physical activity assessed by questionnaire was significantly greater in the EI group. Dietary intake (assessed using a brief, validated food frequency questionnaire and serum carotenoids) improved more (healthier dietary intake) in the EI compared to the MI. These two studies suggest potential for interventions that consider social engagement/participation in community activities in their design, although the study populations consisted mostly of younger adults, and it is not clear whether these findings could also apply to older adults.

A study that systematically reviewed the published literature on the effectiveness of nutrition-based interventions in community-dwelling older adults, found that comprehensive nutrition education or counselling interventions involving active participation, in developing a personalised health plan, goal setting, and self-efficacy, can be effective in improving nutrition-related outcomes in community-dwelling older adults (Bandayrel and Wong, 2011). The interventions

included in the review involved either didactic nutrition education programs, dietary advice/nutrition counselling interventions, or nutrition supplement interventions, and had little focus on social aspects. The authors acknowledged that since the majority of studies that reported significant, positive effects had been conducted with highly motivated, well-educated community-dwelling older adults, it was not clear which types of nutrition interventions may have a positive effect on diet and nutrition-related outcomes in community-dwelling older adults with less active participation. Another systematic review of diet interventions for older people included studies that covered only three types of interventions, namely dietary educational interventions (dietary education sessions and counselling, focusing on the benefits of a healthy diet), meal service interventions, and multicomponent interventions that provided both healthy meals and additional dietary advice (Zhou et al., 2018). Once again, there was limited consideration of social engagement in the design of any of the included interventions aimed at promoting healthy eating among older people.

In the present study, while there was no change in diet quality in the intervention group over the period of follow-up, an overall decline in diet quality was observed in the control group, although in this small pilot these differences were not statistically significant. However, it is not clear why diet quality declined among control participants during the study. It is also not clear why changes occurred in some of the secondary outcomes (appetite, physical function, and physical activity) over the course of the study. The study was underpowered to detect differences that might exist between participants in the intervention group and those in the control group, at baseline. Despite this, there did appear to be some differences between participants in the intervention group and those in the control group at baseline. Participants in the control group appeared older than those in the intervention group (median age 77 vs. 70 years), and they had a lower level of education (27.3% vs. 0% left school <15 years; 27.3% vs. 10% had no qualification; 0% vs. 30% had a degree or higher qualification). At baseline, participants in the control group appeared more likely than those in the intervention group to live alone (45.5% vs. 36.4%), and were also more likely to have poor appetite (45.5% vs. 27.3%). Furthermore, participants in the control group appeared more likely than those in the intervention group to have severe or very severe disease at baseline (54.6% vs. 27.3%). It is possible that these differences could potentially account for the decline in diet quality, physical function, and the greater decline in physical activity that were observed among control participants during the study, compared to the maintenance of diet quality and physical function, and overall smaller decline in physical activity, in intervention group participants. Given these findings, a future wider intervention study should examine the effects of these factors, perhaps especially those of living alone, poor appetite and disease severity, on change in diet quality and other outcomes. Other factors such as income, access to food/shops

and nutrition knowledge were not considered in this pilot study; these should be assessed in a future intervention, due to their potential as confounding factors, given their potential influence on diet quality in older adults.

Research has suggested that the GENIE intervention might work through increasing links to and uptake of social activities (Kennedy et al., 2016). Previous implementation of the GENIE tool led to an increase in the diversity of participants' social networks, greater engagement with community activities and adoption of GENIE by facilitators as part of routine user assessment (Kennedy et al., 2016).

The process evaluation findings of this study suggest that the intervention is acceptable to older participants, especially those with less severe disease, when facilitated. The findings also suggest that the questionnaire used to assess the lifestyle and health outcomes is feasible; however, to minimise participant burden in a future larger future study, attention should be given to limiting the extent of additional data collection. Overall, the present study suggests that the GENIE tool can help people to think about the links they have with others (local groups, friends, family members, professionals) and to reflect on their involvement in social activities. By using GENIE, and thinking or talking through the GENIE mapping tool, participants were able to visualize their network and reflect on connections and understand where there might be gaps in social support.

GENIE is an evidence-based intervention which provides an avenue for changing behaviour patterns in everyday life (Kennedy et al., 2016). The intervention raises awareness of social networks and improves engagement with resources through strengthening existing individual and community networks. Previous research found that the intervention integrated well with community service delivery environments, fitting in with the work of community-based health workers, which indicates that GENIE could show promise for future integration into healthcare policy and practice (Kennedy et al., 2016). In early 2018, Southampton City Council and NHS Southampton CCG signed up to use the GENIE tool for a year. Southampton City Council would work with the NIHR researchers, and training and technical support would be provided to volunteers to help people who may be lonely, including older people, to improve their social networks, with the aim of reducing loneliness and improving health.

6.4.1 Strengths and limitations

The RCT design is a strength of this study, with the presence of the comparison group helping to clarify what the intervention effects were. Researchers collecting the baseline and follow-up data also delivered the intervention, so they could not be blinded to the intervention status of participants. In a future larger intervention with a similar design, we would expect baseline

characteristics to be similar in participants in the intervention group and those in the control group, since random allocation should ensure no systematic differences between the groups in terms of factors, known and unknown, that may affect the outcome (Sibbald and Roland, 1998).

The measures that were used to assess the primary and secondary outcomes were based on self-reported data (except for BMI, for which height and weight were obtained from participants' clinical records or participants were weighed). However, despite their self-reported nature, the measures used to assess diet quality, appetite, physical activity and physical function have been shown to be valid measures within older populations (Robinson et al., 2017, Wilson et al., 2005, IPAQ group, 2005, Syddall et al., 2009).

The sample size achieved in this pilot study was small; there was a lack of power, so it was less likely to detect differences that might exist between intervention and control groups. It is also possible that the follow-up period was too short to capture significant changes in diet and other lifestyle factors; further data collection, in a larger sample with a longer follow-up period would help to explore longer term behavioural changes.

It is possible that the outcome measure values might have been observed with random error, for example random measurement error, or random fluctuations in a participant; thus, it cannot be discounted that the changes in outcomes that were observed in this study were due to regression to the mean, rather than representing actual changes in behaviours (Barnett et al., 2005). In a larger future study, if participants are randomly allocated to study groups (intervention or control) the results for both groups should be equally affected by regression to the mean (Barnett et al., 2005).

All study participants had COPD and were attending a local COPD Service, therefore, it is unclear whether the findings would be valid in relation to individuals with other chronic illnesses or without long-term health conditions. In addition, all participants were white British. Results are therefore not generalisable to all populations of community-living older people. Further evaluation is warranted in a non-clinical setting, e.g. by trained facilitators in a community setting, and in older populations with diverse ethnicities and medical conditions.

In terms of the process evaluation of this pilot intervention study, this assessed the three key components of a process evaluation of a complex intervention, i.e. implementation, mechanisms of impact, and context, as set out in the MRC process evaluation framework (Moore et al., 2015). At this pilot stage, mainly qualitative methods were used for the process evaluation, with only basic quantitative measures having been used to assess implementation and context. These methods could be expanded upon for the process evaluation of a larger intervention study, to

provide a more in-depth understanding of intervention functioning on a large scale. For the process evaluation of a wider intervention, quantitative measures that include structured observations of audio recordings of the intervention delivery could be used to assess implementation. Also, in addition to implementer self-report, semi-structured qualitative interviews could be conducted with participants, and implementers (e.g. health professionals, researchers). These methods could help to understand whether the intervention is being delivered as intended in practice, according to the theory of the intervention, whether it is delivered consistently (e.g. duration of delivery), and to examine any barriers to implementation. In terms of the mechanisms of impact of the intervention, in addition to recording participant uptake of social activities using the GENIE tool (for comparison between baseline and follow-up), in the wider study it would be important to collect quantitative data on potential mediating social and psychological factors (e.g. measures of social networks, participation in social activities, social support, self-efficacy and motivation), to test hypothesised pathways. Qualitative interviews could also be conducted with participants, at follow-up, to gain insight into any changes that they might have made as a result of the intervention. Regarding the assessment of the context of a wider intervention, in addition to interviews with stakeholders, and examination of the local policy context, it could be useful to collect further quantitative information on local service availability/usage (as discussed in section 5.4.1).

The mapping study described in the previous chapter (Chapter 5) comprised the contextual component of the process evaluation and assessed the context into which the GENIE pilot intervention would be introduced. The success of the GENIE intervention delivery depends on the nature of services that are available locally; the database of activities and services needs to be updated regularly and maintained. This does require community ownership, which could be a long-term issue for the sustainability of the tool.

In terms of the information that was collected about the implementation of this intervention, findings indicated that the implementation of the GENIE tool, by including the clinical teams in the research process, ensured acceptance and a place for the tool within the COPD service. GENIE will continue to be used for some patients in the COPD service. The GENIE tool took time to deliver; in a clinical service context it could perhaps work well if it could be accessed in sections, the mapping model and then the signposting to services.

The GENIE tool and the social network maps could be useful for clinicians, to understand the social networks and support around the patient they are treating, and to ensure patients are supported in the community. However, a lay person or health care assistant role may be better placed to deliver to tool, rather than the clinical team, due to the use of lay language, the removal

of the clinical interface, and the perception of the role of the health care professional as a provider of medical treatment.

The process evaluation of the intervention raised questions about the suitability of the GENIE tool for individuals with more severe COPD and those with a poor prognosis. There was also evidence that poor literacy of the study participants made intervention delivery more difficult and time-consuming. In order to reduce the time taken for the baseline visit, as well as the burden on participants, fewer questionnaires could be administered for data collection, or these could be shortened (e.g. there could be scope to reduce the number of items in the Health Behaviour Tool). Researchers found that using lay language to explain the tool's approach proved more successful. The digital literacy of participants was also poor, with most participants reluctant to interact with technology. However, the facilitation of GENIE by a researcher overcame these issues for the majority of participants.

Lastly, in terms of the final component of the process evaluation, the mechanisms of impact, it is not possible to reach any firm conclusions about how the effects of this intervention might have occurred; it is not clear why there was no change in diet quality in the intervention group, while diet quality declined among control participants during the study. It is unclear what the effect of the intervention was on participants' social networks, or to what extent it led to an increase in the diversity of participants' networks and greater engagement with community resources and activities. Even though at follow-up any uptake of social activities or changes to social networks by participants were recorded, these data were still to be analysed by the researchers with whom I collaborated. As such, it was not possible to identify the nature of the changes that participants might have made as a result of the intervention that might account for the results. Further information on mechanisms of impact, including testing hypothesised causal pathways, should be collected and analysed in the process evaluation of a wider intervention. And further work should evaluate whether the GENIE tool can in fact effectively signpost to resources online and offline to initiate peer and social support.

6.4.2 Conclusions

The findings of this study suggest potential for beneficial effects of GENIE on quality of diet among older adults given that diet quality did not change in the intervention group at a time when it declined in the control group. However, it is not clear why diet quality declined among control participants during the study. Further evaluation is needed in a non-clinical setting, in a larger, more diverse group of community-dwelling older adults, with a longer follow-up period. This work has contributed to the development of the process evaluation methods that might be used in a

wider intervention. Implemented in a local COPD service, GENIE was found to be acceptable and appropriate for older people with COPD, especially for those with less severe disease, when delivered by trained researchers.

Further research is needed to understand the benefits of interventions that adopt this type of social networks/community engagement approach. Future research should evaluate how social network interventions could be used to improve diet in older age and to prevent a decline in nutritional status and associated health consequences.

Chapter 7: Discussion

Chapters 3 to 6 of this thesis each include discussion sections that are relevant to each of the individual pieces of work. This final chapter provides an overall conclusion to the PhD thesis, while considering how the proposed research questions were addressed.

7.1 Addressing the research questions

7.1.1 Research questions one and two

- Research question 1: What factors are associated with food choice and diet quality in UK community-dwelling older adults?
- Research question 2: What is the interrelationship between the various factors related to food choice and diet quality in community-dwelling older people and what is the role of psychosocial factors?

These questions were formulated following the literature review in the Introduction Chapter, which found that, while there is a broad literature that examines factors that are associated with community-dwelling older people's food choices and diets, there is limited longitudinal evidence, and limited evidence from a UK context. Furthermore, many of these studies only reported a small number of the potential determinants of diet and did not consider how the various factors may interrelate to affect diet quality in older age.

For this PhD project, a qualitative study (Chapter 3) was conducted to explore influences on diet among community-dwelling older people in the UK and to further examine how these factors might interrelate to impact on diet quality. Based on the findings from the qualitative study, I went on to further explore, quantitatively, the role of psychosocial factors as influences on diet quality in community-dwelling older adults (Chapter 4). Both studies were conducted with participants of the Hertfordshire Cohort Study.

The qualitative study (Chapter 3) suggested for the first time, to the best of my knowledge, that social and psychological factors could mediate the influence of a range of background or contextual ageing-related factors (past and present food influences and beliefs, retirement, bereavement, medical conditions and symptoms, and environmental factors, such as access to shops) on the diets of older people. It could be that social engagement and stronger social relationships, as well as psychological factors, such as resilience, self-efficacy and outcome

expectancies, may offset the effects of some of the barriers to eating a healthy diet that often come with the ageing process.

A hypothetical model (**Figure 7** on page 44) was developed to depict the relationships between the themes identified during the data analysis process. This model sets out how it is proposed that the potential influences on diet might relate to each other; it sets out four themes as contextual factors, namely 'historical influences on and current beliefs about food', 'retirement and bereavement', 'age-related conditions/symptoms' and 'food environment'. Two additional themes, namely 'psychological/personal factors' and 'social engagement', are proposed to have a direct influence on diet and also to mediate the influence of the four contextual factors on diet.

Previously, in the Introduction Chapter of this thesis, I had set out a theoretical model depicting the multiple potential influences on older people's diets, and how they might work in combination to affect diet quality (**Figure 3** on page 24). The basis for the different levels of influence on food choice and diet quality that I considered in this model was an ecological framework of eating behaviour (Story et al., 2008), which I then adapted and developed according to the review of the literature around the factors that are associated with food choice and diet quality in community-dwelling older people, especially to show what I theorised could be the potential relationships between the various factors.

There are differences, but also some overlap, between the hypothetical model, developed in the process of the inductive (or data-driven) analysis of the qualitative data, and the theoretical model, presented previously in the Introduction. I have now integrated the two models into a new model by modifying the initial theoretical model to reflect the findings from the qualitative study. In this new conceptual model (shown in **Figure 12**), the factors and relationships identified in the focus group discussions, which had not been depicted previously in the initial theoretical model, are highlighted in blue, whereas the aspects in the theoretical model that were not borne out by the qualitative study findings were removed to simplify presentation. It should be noted that it is likely that some of these factors, although not identified in the qualitative study, e.g. social class, level of education, income, and oral health, are nevertheless likely to affect the diets of older people. Food poverty, in terms the inability to afford a healthy diet, is also likely to play an important role in affecting the food choices, and also the diet quality, of community-dwelling older adults. Although the contextual factors that were identified in the qualitative study (as well as nutrition knowledge and cooking skills) are also likely to have direct effects on diet quality, in accordance with the focus group findings and the resulting hypothetical model, the new model highlights the mediation effects of social and psychological factors to influence diet in older people. **Figure 12** shows proposed directions of associations, with a focus on how the various

factors might influence diet quality; however, it is likely that the different factors are themselves interrelated, and some of the associations between the factors themselves could be bi-directional.

This model of influences on diet in older age offers the opportunity to further explore the role and importance of psychosocial factors as determinants of diet quality in later life, by testing quantitatively the hypothetical relationships between these factors and how they could interrelate to impact on diet in later life. This could contribute to our understanding of the causal pathways by which specific influences might influence diet in older age and of which factors are more influential than others.

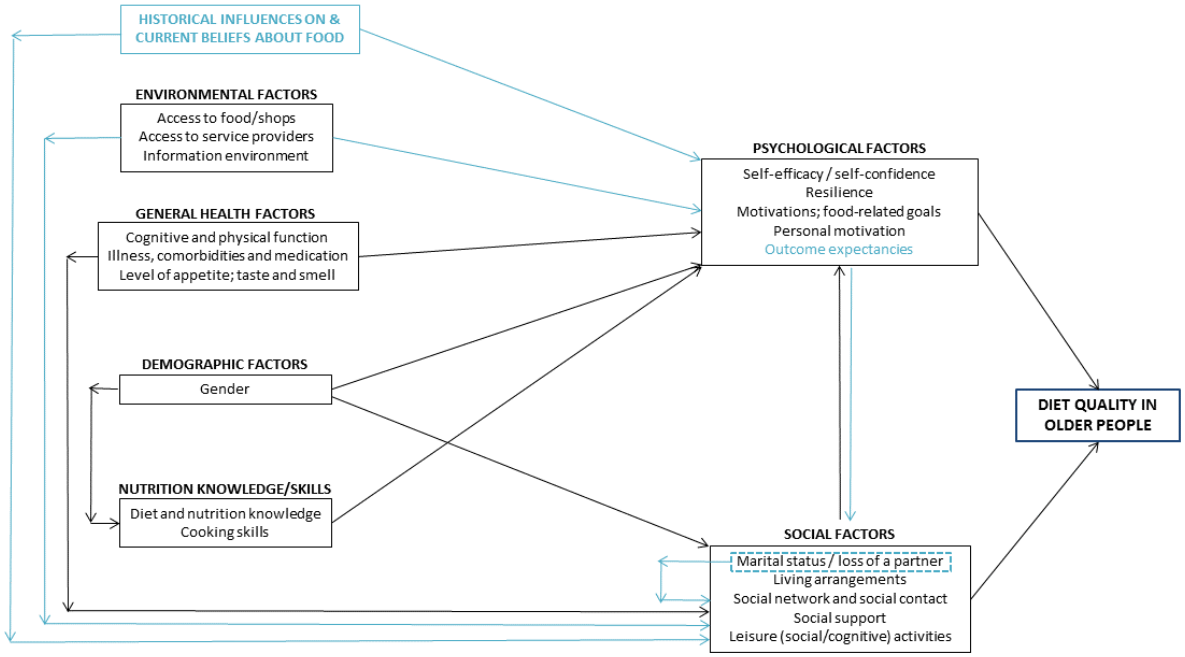


Figure 12 Conceptual model building on the theoretical model from the Introduction of this thesis and the hypothetical model resulting from the qualitative study, to depict potential influences on food choices and diet quality in community-dwelling older adults, and how these could interrelate to impact on diet quality in older age. Factors and relationships identified in the qualitative study, which had not been depicted previously in the initial theoretical model, are highlighted in blue.

The 'age-related conditions/symptoms' theme from the hypothetical model mapped onto the 'general health factors' level of influence in the theoretical model, and these are proposed to either impact directly on diet, or their influence could be mediated by a range of social and psychological factors. For example, a decline in mobility could lead to difficulties for an older person to shop for food and prepare meals; however, help from a family member with these tasks could mitigate the effects of limited mobility on their food-related activities, and ultimately on the quality of their diet.

The ‘food environment’ theme in the hypothetical model captured similar aspects to those covered by the ‘environmental factors’ aspect of the theoretical model, however the former model posited that the influence that these factors on the diets of older people might also be mediated by social and psychological factors. For instance, if an older person has difficulty accessing shops due to lack of public transportation they might be motivated to find strategies to overcome this (thus demonstrating resilience), for example, by buying store-cupboard foods or ingredients in larger quantities when they do go to the shop, or by shopping online.

In the hypothetical model ‘retirement and bereavement’, while also being social factors, were set out as separate theme. This theme, particularly regarding the impact on diet following the loss of a partner, was strongly linked to background factors such as gender and cooking skills. Again, the effects of these factors on diet appeared to be mediated by psychological factors, such as motivation, and social factors such as social network. For example, an older woman who loses her partner might start going out to eat more frequently with members of her social network, e.g. friends or family; a recently bereaved older man who did not used to do the shopping or cooking, may or may not have the motivation to learn how to cook for himself.

Finally, regarding the ‘historical influences on and current beliefs about food’ theme of the hypothetical model, aspects such as the importance of upbringing and past experiences, had not been represented in the theoretical model of the Introduction chapter. Other aspects of this theme, such as the messages and information received through the media, had been captured in the theoretical model as part of the information environment (included in ‘environmental factors’). To give an example how these types of factors might interrelate with psychosocial factors to potentially influence diet, an older person might change their beliefs about the benefits of particular ‘healthier’ foods for their health, due to discussions with family or friends, and could then start eating these foods due to their belief that this will keep them healthy, i.e. due to their outcome expectancies.

In accordance with the qualitative work, the cross-sectional findings of the quantitative study (Chapter 4) reinforced some of the focus group findings, also highlighting the importance of a range of social factors for better diets in older age, including increased social support, larger social network, and greater participation in social and cognitive leisure activities. A consistent finding from the quantitative study, for both men and women, was that greater participation in leisure activities, as well as in cognitive and social activities, was related to higher baseline diet quality. Moreover, baseline participation in leisure activities, as well as participation in cognitive leisure activities, was associated with smaller declines in diet quality over the 10-year follow-up period. None of these associations were explained by social class, education or number of comorbidities.

As far as I am aware, this is the first time such findings have been described in a UK older population.

It is possible that poor diet quality and associated health issues could lead to poorer social engagement and poorer psychological outcomes, such as poorer mental health, poorer resilience, and lower self-efficacy, rather than the other way around, i.e. there could be reverse causality. However, the prevalence of malnutrition in older adults is high; in fact, older people are particularly at risk of becoming malnourished due to a range of medical, physical, psychological and social reasons that are unique to ageing. The fact that malnutrition is a particular problem in later life, points to underlying issues (e.g. illness, poor physical function, poor self-efficacy and social isolation) that may explain why older people could be at risk of declining diet quality and of becoming undernourished; this suggests that the present findings might not explained by reverse causality. There is, however, little understanding of how diet quality changes with age. Furthermore, the relationship between diet quality and nutritional status, and how poor diet quality might ultimately lead to overt malnutrition, is not clear.

Key themes from both the qualitative and quantitative pieces of work centre on the importance of engaging in social activities, the value of the local community spirit and on the potentially distressing effects of being socially isolated or lonely, together with the associated negative effects on diet and health. The quantitative study built on the qualitative findings, and findings from both these pieces of work were integrated to provide a stronger basis for drawing conclusions about intervention development. In the context of these findings, it was concluded that non-diet interventions that focus less directly on improving diet itself, but rather on acting on the social and psychological context in which foods are chosen and eaten could be valuable for improving the diets in older people living in the community, or preventing their decline.

7.1.2 Research question three

- Research question 3: What local services are currently provided to community-dwelling older adults that support their diets?

Before an intervention could be implemented in the local Southampton area, it was necessary to understand the local Southampton context, which was the focus of Chapter 5. The mapping study that was undertaken formed the contextual component of the process evaluation for the development of the GENIE pilot intervention study, which is set out in Chapter 6.

Findings from the mapping study paint a fractured picture of services for older people in Southampton which, given its mixed demographic make-up, could reflect the national picture.

Although a variety of services are on offer, they are largely provided by the voluntary sector and services are not adequately joined up. It is difficult for older people, as well as for community organisations and healthcare professionals, to access up-to-date and complete information about what services are available to them locally; my conclusion, in line with the opinions expressed by local stakeholders, is that information sources should be streamlined and centralised to make this process easier. The importance of linking any intervention to support older people's diets in Southampton with the voluntary/community sector was highlighted, given the erosion of publicly funded services for older people.

In addition to developing and funding more community-based services/interventions that have the potential to support the diets of older people, it is essential that providers evaluate the services that exist as well as the new ones that are potentially created, to demonstrate the effectiveness of these services, to inform future policy and practice.

7.1.3 Research question four

- Research question 4: What is the potential of a local intervention to promote diet quality in an older population?

Findings from both Chapters 3 and 4 highlighted the potential importance of social factors as influences on older people's quality of diet. It was hypothesised, therefore, that an intervention to improve the social engagement of older people could also lead to an improvement of their diet quality. Chapter 6 described a pilot study that evaluated the influence of such an intervention – the GENIE tool – on change in diet quality in a small group of older people in a local Southampton COPD service.

Previous research has indicated that the GENIE intervention, a social network intervention, might lead to an increase in the diversity of participants' social networks, and to greater engagement with social activities (Kennedy et al., 2016). The present pilot study posited that greater social engagement and stronger social relationships may counteract the effects of some of the barriers to a healthy diet that frequently occur with ageing (e.g. bereavement and medical conditions). As discussed in section 3.4, there are various possible mechanisms through which social relationships may positively influence diet. For example, increased social support can provide encouragement and companionship, and greater social engagement could lead to an increased sense of purpose, meaning in life and sense of belonging (Thoits, 2011, Higgs and Thomas, 2016); these pathways might promote positive psychological states that could motivate healthy behaviours, including improving diet quality (Thoits, 2011).

While the study was based on a relatively small sample of participants, its findings suggested that the GENIE intervention might have impacted on the diet quality of participants, in the sense that the diet quality of participants who received the intervention did not decline, at a time when it did in control group participants. Therefore, it could be that the effects of the GENIE intervention somehow protected participants against this decline in quality of diet over the three-month follow-up period. Also, in the intervention group there was no change in physical function over the period of follow-up, while an overall decline in physical function was observed in the control group. Additionally, the overall fall in total physical activity that was observed in both groups over the follow-up period was most pronounced in the control group. Although this is suggestive of beneficial effects of the GENIE intervention on diet quality, physical function, and physical activity, it is not clear why diet quality declined among control participants, or why changes occurred in physical function and physical activity, during the study, and it is possible that unintended baseline differences between participants in the intervention group and those in the control group could explain these findings.

Further evaluation is needed in a larger, more diverse group of community-dwelling older adults, with a longer follow-up period. This pilot study also contributed to the development of the data collection and process evaluation methods that could be used in a wider intervention.

Overall, the study found that there might be beneficial effects of the GENIE intervention on diet quality in older adults, and that the intervention was acceptable and appropriate for older people with less severe disease, when delivered by trained facilitators. These results are promising given that the GENIE intervention could integrate well with community service delivery environments, and could potentially be integrated into healthcare policy and practice in the future (Kennedy et al., 2016).

This pilot study is a starting point that could be used to inform the development of interventions that adopt this type of social networks/community engagement approach to promote healthy diets and lifestyles in older adults. The insights gained from this pilot intervention study should be considered, together with those from Chapter 5, in the development of future interventions.

7.2 Strengths and limitations of this project

Chapters 3, 4, 5 and 6 contain individual discussion sections that include strengths and limitations for each piece of work. In this section I briefly discuss some of the main limitations of this thesis as a whole.

The use of self-report measures to collect the dietary outcome data (Chapters 4 and 6), lifestyle and health outcome data (Chapter 6), and social and psychological exposure data (Chapter 4), increases the likelihood of measurement error. However, diet was assessed using a short food frequency questionnaire, which has been shown to describe diet quality well in older people, as discussed in section 4.4.1 (Robinson et al., 2017). Also, in Chapter 6, the measures used to assess appetite, physical activity and physical function have been shown to be valid measures within older populations (Wilson et al., 2005, IPAQ group, 2005, Syddall et al., 2009). In contrast, only some of the social and psychological exposure measures used in Chapter 4 have been validated. The Close Persons Questionnaire, on which the measures used to assess social network and social support were based, had been validated against the Self Evaluation and Social Support Interview and against more objective indices of contact with close persons in a community-based population (Stansfeld and Marmot, 1992). However, it had been difficult to establish the validity of these measures given the lack of universally accepted criteria against which to assess validity (Stansfeld and Marmot, 1992). To the best of my knowledge, the measures used to assess participation in social and cognitive leisure activities have not been validated. Also, to my knowledge, the question used to assess control at home has not been validated; a validated measure was not available for use at the time of data collection (Chandola et al., 2004). The Hospital Anxiety and Depression Scale (HADS) questionnaire, which was used to measure anxiety and depression, has been validated for use in community settings and also in older people (Snaith, 2003).

Both approaches that are commonly used to define dietary patterns, i.e. *a posteriori* methods and *a priori* methods, possess certain limitations when attempting to assess diet quality. However, the *a posteriori* method used in this project assessed adherence to an empirically derived pattern that fits with a health-promoting diet (the prudent dietary pattern) and has been shown to predict expected differences in blood biomarkers. Furthermore, whilst there are concerns about measurement error associated with FFQs, the prudent pattern is evident as the most important dietary pattern irrespective of dietary assessment method. Principal component analysis (PCA) of dietary data was used to define baseline dietary patterns in HCS participants. Previous dietary patterns analyses had indicated that the way in which the foods items were grouped into food groups for the PCA was unlikely to have an impact on the results of the PCA (Crozier et al., 2006). It is a limitation that data-driven methods are context-specific and may not be transferable, making it challenging to compare descriptions of diet quality and results across studies.

With the exception of the pilot study presented in Chapter 6, the studies described in this thesis are observational in nature. A limitation of this observational data, is that it is not possible to

reach any conclusions about causality in terms of effects of factors, especially social and psychological ones, on diet quality.

One of the issues arising from this PhD thesis is the representativeness of the participants that were studied. The studies in this thesis focused on community-dwelling older adults in their mid-sixties, namely the participants at baseline in the analyses described in Chapter 4, and in their seventies, namely the focus group participants (Chapter 3), and the participants in the pilot study described in Chapter 6. The study populations were relatively healthy and independent, and it is unclear whether the findings could be generalised to frailer populations and older age groups, e.g. those aged 85 years and over. Another limitation of the work presented in this thesis is that the studies include largely white British participants, so it is unclear whether the findings would be valid for older people of other ethnicities. Nevertheless, in terms of the Hertfordshire Cohort Study (HCS), the participants' baseline characteristics have been shown to be broadly comparable with participants in the nationally representative Health Survey for England (Syddall et al., 2005). Therefore, although the results are not generalisable to all populations of community-living older people, the findings presented in Chapters 3 and 4 should have relevance to older adults in other parts of the country.

A strength of this thesis is that it integrated qualitative and quantitative findings in terms of their interpretation, by discussing the separate results of the quantitative and qualitative analyses and interpreting them together. The integration of these findings has value in that it enriched the interpretation of the findings, and strengthened the rationale for translating the findings into a relevant intervention.

Generally, measures of diet quality reflect how well an individual's diet conforms to dietary recommendations for a 'healthy' diet. However, these recommendations are often designed for the general population, including a wide range of age groups, with the aim of preventing chronic diseases (Hengeveld et al., 2018, Gil et al., 2015). In this project, prudent diet scores, used as an indicator of diet quality, assessed adherence to the prudent dietary pattern, which reflects adherence to UK government food-based recommendations for a healthy diet (Public Health England, 2016a). These recommendations are aimed at the national population aged two years and over. To give an example, the recommendation to eat at least 5 portions of fruit and vegetables per day is based on advice from the World Health Organization for reducing the risk of chronic diseases, such as coronary heart disease, stroke and some cancers (World Health Organization, 2003).

Although there are clear links between diets of poor quality in older adults and poorer health, including an increased risk of age-related diseases and conditions (e.g. poor physical function), it

is not clear whether diet quality, as it is currently assessed, is the most favourable measure to assess the quality of older people's diets. Indeed, it has been suggested that for older adults, the development of a new measure of diet quality, with greater focus on prevention of malnutrition and ageing-related decline, might be valuable (Hengeveld et al., 2018).

The current UK nutritional requirements and resulting recommendations for nutrients, for example protein and vitamin D, are largely the same across adult age groups (younger and older adults) and disability levels (Public Health England, 2016b). It could be that other aspects need to be considered in the development of dietary recommendations for older adults, in order to reduce the risk of age-related conditions, such as malnutrition and functional decline. For example, it may be important to give further consideration to the role of specific nutrients, for instance, omega-3 fatty acids, vitamin D, B vitamins (folate, B12 and B6), and protein, for the prevention of functional decline and disease with increasing age (Granic et al., 2018). Although it is acknowledged that the ageing process affects nutrient needs, e.g. requirements for some nutrients may indeed increase in later life, the nutritional requirements of older people are still not well defined (World Health Organization). As a result, the WHO has highlighted the urgent need for a revision of the current dietary (nutrient) recommendations for older adults (World Health Organization).

7.3 Implications for policy and practice

At a national level, the identification and treatment of malnutrition have been recognised as important preventive measures, which ties in with a wider shift towards a focus on prevention in healthcare in general. In terms of national government nutrition policy for older people, the focus is currently principally on malnutrition or poor nutrition (these terms, along with undernutrition, are often used interchangeably to identify nutrition problems associated with loss of weight). There is little policy focus on overall diet quality in later life, which is the focus of this PhD thesis. In the following paragraph, a brief overview of malnutrition is given in the context of current national nutrition-related policy.

Malnutrition or undernutrition has been defined as a deficiency of energy, protein, and other nutrients that causes measurable adverse effects on the body (shape, size and composition), the way it functions and clinical outcomes (Stratton et al., 2003). In the UK, it is estimated that over a million older people (over 65 years) are either malnourished or at risk of malnutrition (BAPEN, 2016). Malnutrition in older people increases the risk of disease and has a negative effect on associated outcomes, including increased complications after surgery, delayed recovery from illness with prolonged length of hospital stay, and compromised body function, with negative

consequences for well-being and activities of daily living (Elia, 2015). Malnutrition also increases healthcare use and represents a significant economic burden on the NHS; in 2011–12 it was estimated that the total health and social care expenditure (mostly healthcare expenditure) associated with malnutrition in England was £19.6 billion, or approximately 15% of the total expenditure on health and social care (Elia, 2015), and about half of this expenditure was for older people over the age of 65 years. With regard to malnutrition, preventive efforts taken at as early a stage as possible are key to ensuring better health outcomes for older people. Malnutrition is often identified using criteria such as low BMI (usually defined as BMI <20 kg/m^2) and unintentional weight loss (Stratton et al., 2007). The recent consensus report on the definition of malnutrition proposes several criteria for a diagnosis, including; one of the following three phenotypic criteria: non-volitional weight loss, low BMI, and reduced muscle mass; and one of the following two etiologic criteria: reduced food intake or food assimilation, and inflammation or disease burden (Jensen et al., 2019). The criterion of reduced food intake is assessed according to reduced energy intake (≤50% of energy requirements >1 week, or any reduction for >2 weeks). It is likely that declines in diet quality and nutrient intakes take place before significant weight loss occurs; however, currently there is a lack of evidence for the link between poor diet quality and development of overt malnutrition, and it is unclear whether changes in diet quality precede this onset (Hengeveld et al., 2018).

In February 2017, Public Health England (PHE) published a report that reviewed the evidence of 'what works' in terms of projects across the country that support older people to maintain a healthy diet and reduce the risk of malnutrition (Public Health England, 2017). The findings were aimed at helping those working in older people's health, particularly nutrition, and local decision makers. Most of the examples of emerging practice given in the report focus on reducing the prevalence of malnutrition in older people, especially by early identification and intervention. The report found that various initiatives were underway and stressed the need for appropriate evaluation of these programmes to develop the evidence base of what works and what doesn't work for preventing malnutrition.

Following a review of the literature, the PHE report sets out four main areas to consider when developing future interventions to improve older people's nutrition, namely; access to healthier food and drink options and food poverty, the ability to prepare healthier food, functional and cognitive impairment and ability to eat healthier food, and food and dietary resilience (Public Health England, 2017). This is consistent with the findings of the focus group study in this thesis, in that access to shops as well as availability and quality of foods were important issues that affected participants' diets. In addition, one of the main findings of this qualitative work was linked to how resilience, and other psychological factors, appeared to influence how participants

responded to various contextual barriers to a healthy diet, and to determine whether or not they would overcome these and manage to eat well, despite adverse circumstances. Conversely, while in the focus group study there was discussion about how physical impairment or decline affected some participants' ability to obtain and prepare food, the study population were relatively healthy and independent older adults, which might explain why physical difficulties in preparing and eating food (such as poor oral health), and cognitive impairment (such as dementia), featured less prominently in the focus group discussions. Another issue highlighted in the PHE report that was not found in the work presented in this thesis was food poverty. Although focus group participants did discuss issues such as the price of foods and getting value for money, this did not emerge as a central finding of the study. Nonetheless, as highlighted by the report, food poverty and food insecurity are potentially important issues for community-living older adults, which could be compounded by limited mobility, leading to difficulties in getting to, and around, supermarkets to find the most reasonably priced food options.

In January 2018, the All Party Parliamentary Group (APPG) on Hunger published a report titled 'Hidden hunger and malnutrition in the elderly', highlighting the growing problem of malnutrition in older people (All-Party Parliamentary Group on Hunger, 2018). The report found the main causes of malnutrition in older people in the UK to be social isolation and loneliness, and reduced access to food (triggered by issues such as bereavement, illness, limited mobility). The report highlights that malnutrition is worsened by cutbacks to social care packages, cuts to Meals on Wheels services and bus services, and local shop closures. This is consistent with the messages from this PhD thesis; both the qualitative and quantitative studies (Chapters 3 and 4) emphasized the role of social factors, such as social support and social networks, as potentially important for supporting better diets in older people; and findings from the mapping study (Chapter 5) highlighted some of the reductions in services that were found in the APPG report to affect nutrition in older people in the community.

These findings are a cause for considerable concern, not least given that social isolation and chronic loneliness are widespread amongst older people in the UK. The prevalence of social isolation in older adults is estimated to be between 7% and 17% (Dickens et al., 2011), and it has been suggested that as many as 1.2 million older people in England (10% of older people) are chronically lonely, with 500 000 older people spending at least five or six days a week without seeing or speaking to anyone (Campaign to End Loneliness). In fact, the public health consequences of social isolation and loneliness are increasingly recognised at a national level. The UK Government has appointed a ministerial lead for loneliness, and has recently launched a pioneering strategy to tackle loneliness – 'A Connected Society' (Department for Digital Culture Media and Sport, 2018). This sets out numerous commitments of varying detail from many

Government departments. The strategy outlines three overarching goals, namely, to help improve the evidence base around loneliness (what causes it, its impacts and what works to tackle it); to embed loneliness as a consideration across government policy; and to build a national conversation around loneliness. The Government will work with local authorities, health bodies, businesses and the voluntary sector on various commitments, which include support for a range of projects and pilots and expanding 'social prescribing' or 'connector' schemes across the country. By 2023, it is envisaged that all local health and care systems will be supported to implement social prescribing connector schemes across the country, with an aim to have a universal national offer available in GP practices. This will allow GPs to adopt a less medical approach by directing patients to community workers, who will connect them to activities and support within their local area, such as arts participation, befriending and exercise, and also advice services. Examples of some of the other commitments set out in the strategy include making the sharing of information more efficient, accurate and sustainable to help people find relevant local activities, services and support; and the piloting of a scheme working with Royal Mail, private enterprise, local authorities and the voluntary sector, to help identify and support older people experiencing loneliness.

Despite the support for social prescribing in the new Government strategy there are evidence gaps in the social prescribing literature, in terms of effectiveness or value for money (Bickerdike et al., 2017). A systematic review that summarised the evidence for the effectiveness of social prescribing programmes relevant to the UK NHS setting (Bickerdike et al., 2017) concluded that despite most of the evaluations of social prescribing activity that they found presenting positive conclusions (the primary outcomes of interest were measures of health and well-being, e.g. levels of physical activity or depression scores, and/or measure of usage of health services), overall the evidence base was of low quality with a high risk of bias. Consequently, while the negative health impacts of social isolation are increasingly well known, more evidence is needed regarding effective interventions to prevent isolation in later life (Cotterell et al., 2018). The authors of an overview of systematic reviews on the public health consequences of social isolation and loneliness have suggested that further well-designed studies are required to provide more information on causality, notably regarding the association with health behaviours and the impact across the life course (Leigh-Hunt et al., 2017). Nonetheless, the authors conclude that policy makers and health and local government commissioners should consider social isolation and loneliness as influential factors on health and mortality, and their possible effects on health behaviours should also be considered (Leigh-Hunt et al., 2017).

The APPG report on malnutrition in older people proposes that increased investment in social care and the social networks that support older people could lead to cost savings in terms of the

management of malnutrition, including by reducing the number of hospital admissions and the number of days older people spend in hospital (All-Party Parliamentary Group on Hunger, 2018). As discussed in the first chapter of this PhD thesis, poor diets, as well as multiple unhealthy lifestyle behaviours, are more common among older adults of lower socio-economic status (Robinson et al., 2009, Irz et al., 2014a, Maynard et al., 2006, Shankar et al., 2010a). In an apparent attempt to address these diet-related inequalities, the APPG report has called for a reallocation of existing expenditure on pensioners, in which winter fuel payments are withdrawn from the richest pensioners and invested in local services aimed at reducing isolation and malnutrition by providing, or making it easier to access, hot and fresh food. The APPG also calls on supermarkets to facilitate shopping for older people, by providing community transport, offering lunch clubs in store cafes and offering 'slow' checkout lanes for less mobile customers. It is hoped that the Government will seek to urgently address the recommendations from the APPG's report, so that malnutrition, and risk of malnutrition, in older people can be identified and treated as early on as possible.

It is of importance to note that if malnutrition is present, then nutritional deficiencies (of energy, protein, and other nutrients) have already led to measurable negative consequences on the body, for instance unintended weight loss. As discussed above, it is of paramount importance to address malnutrition, and risk of malnutrition, in older people as early on as possible. Hence, it could be of great value for preventive efforts that seek to promote good nutrition in older age to intervene ahead of changes in weight and other physical consequences (such as reduced muscle mass and changes in function), at the level of people's diets and diet quality. The APPG report recommends that screening tools should be used at all levels of care, to identify and treat malnutrition in the community (All-Party Parliamentary Group on Hunger, 2018). It is, however, important to identify older people who are at higher risk of becoming malnourished before they lose weight and become thin, which are both signs that they could already be malnourished. It could be that the identification of declines in diet quality and food consumption in older independent adults, which likely take place before significant changes in nutrient status and weight loss occur, might be crucial to effective preventive approaches (Robinson, 2017). Furthermore, preventive interventions to promote healthier diets and good nutrition might be most effective if implemented ahead of any changes to function, around the time of transition to retirement, for example (Lara et al., 2014).

The importance of diet quality in older age is increasingly recognised and there is a need for effective interventions to promote healthy eating among older people living in the community. Interventions to improve diets and nutrition-related outcomes in community-dwelling older people have largely focused on nutrition education or counselling (Bandayrel and Wong, 2011,

Zhou et al., 2018). Thus, the majority of interventions appear to focus on individual-level behaviour and do not address the potentially important role of individuals' social systems and environments. In order to provide policy makers with an evidence-based knowledge to implement appropriate public health strategies and interventions aimed at promoting diets in older people living in the community, the most important factors that influence dietary behaviour in this population group need to be identified and the reasons for these associations better understood. The findings from the present research project have highlighted the importance of adopting a more holistic approach by applying an ecological perspective for understanding diet quality in older age. This PhD thesis has sought to further the evidence-base regarding what might influence the diets of community-living older people, by examining how the various factors related to food choice and diet quality interrelate and by further expanding the evidence to clarify the role of psychological and social factors. Findings from this research project have pointed to the potential for interventions that address the effect of social contexts, and psychological aspects, for promoting the diets in older people living in the community. It is hoped that this work will inform the development of policies and future interventions aimed at promoting diet quality and health in the older population.

7.3.1 Future areas of research

Based on the findings of this thesis and on the evidence gaps identified, the work of this research project has served to highlight some areas of study that should be the subject of further epidemiological and interventional research:

- What are the causal pathways by which specific factors might interrelate with others to influence food choice and diet quality in older age? Which factors are most influential?
- What is the trajectory of diet quality, from early old age to 'oldest' old age? Which factors predict change in diet quality in the course of ageing?
- What is the relationship between diet quality and change in diet quality, and the development of malnutrition?
- Can interventions that adopt a social networks/community engagement approach improve, or prevent a decline in, diet quality in older age? Could such interventions also have an impact on other health behaviours, such as physical activity?

The pilot study described in Chapter 6 of this thesis lays the groundwork in preparation for a future randomised controlled trial designed to assess the effects of the GENIE intervention on diet quality, and other lifestyle and health outcomes, in community-dwelling older adults. As described in section 7.1.3, the findings from Chapter 6 suggest that there might be beneficial

effects of the GENIE intervention on diet quality, physical function, and physical activity, in older adults. Moreover, the intervention was found to be acceptable to most participants, when delivered by trained facilitators.

It is envisaged that a future intervention would adopt a RCT design similar to that of the pilot study, and would aim to recruit a larger, more diverse group of community-dwelling older adults, as its study population. Sample size calculations would be carried out; a larger sample size may provide greater statistical power to show evidence of the effects of the GENIE intervention. The aim would also be for a longer follow-up period, of at least one year, to allow time for any changes in diet and lifestyle outcomes to be detected. The intervention could be delivered in a community-setting, by researchers with skills in areas such as public health, nutrition, or geriatrics, in collaboration with local stakeholders (e.g. local government, voluntary sector, or local health care agencies).

It is hypothesised that such an intervention would expand social networks, increase participation in leisure activities, increase levels of social support, and by doing so also improve personal motivation and self-efficacy, and enable older people to be more supported to eat healthy diets, have healthy lifestyles, and promote their health and independence. Outcomes would include changes in diet quality, and in other lifestyle and health outcomes, similar to those assessed in the pilot study. Changes in mediating social and psychological factors would also be assessed, including social networks, social support, participation in activities, and motivation and self-efficacy. In terms of the evaluation plan, this would be based on the methods developed in the pilot study, including the tools and measures used for the outcome evaluation, as well as the methods that were developed for the process evaluation.

7.4 Conclusion

This thesis began by describing that there is limited understanding of how a transition between relatively good diets in early old age, to poorer diets and greater risk of malnutrition observed in older adults, especially at older ages, might occur.

It is important to understand what factors affect patterns of food choice and diet and might lead to a change in quality of diet with advancing age. This understanding will be critical to the design of future interventions to promote healthy diets in older community-dwelling adults. Numerous studies have focused on factors linked to older people's food choices and quality of diet; however, these commonly reported cross-sectional associations of a limited number of potentially influential factors.

The present thesis has examined what interrelationship there might be between the various factors related to food choice and diet quality in community-dwelling older people. This PhD research project has begun to further explore the role of psychological and social characteristics, and the findings from this work have highlighted the role of these factors as important influences on diet quality in later life. This research project assessed the potential of a novel social network intervention to promote diet quality in an older community-based UK population. The results from this pilot study suggest that this type of intervention may hold promise for the promotion of diet quality of older adults.

Further well-designed intervention studies, with appropriate evaluation, are needed to further establish the effectiveness of social network interventions to promote healthy eating among older people living in the community. In addition, psychological factors such as resilience, self-efficacy and outcome expectancies, should also be considered as a part of strategies to promote diet in older people. It may be crucial for these interventions to be put in place early on to prevent decline in diet quality and associated poor health outcomes. Moreover, partnerships between academics, policy makers and community organisations will likely be necessary to foster healthy diets and lifestyles in the older population.

The work in this thesis has developed the evidence-base on what might influence older people's diets, and has contributed to a greater understanding of how to develop more targeted interventions to improve the diets of community-living older people in the future. The findings could inform design of effective future strategies to support older people to maintain diet quality and good nutrition in older age. It is my belief that these will be key, if we are to reduce the risk of age-related disease, and to promote health and quality of life in the increasingly ageing UK population.

Appendices

Appendix A

MRC Lifecourse Epidemiology Unit

MRC Lifecourse Epidemiology Unit (University of Southampton)
Southampton General Hospital, Southampton SO16 6YD UK

NHS National Institute for Health Research

UNIVERSITY OF Southampton

DIET, PHYSICAL ACTIVITY & WELL-BEING OLDER ADULTS' DISCUSSION GROUPS

Participant information sheet

Would you like to take part in a discussion group & join us for refreshments?

We are inviting you to take part in a discussion about your eating and exercise habits with 5 - 8 other people of a similar age who are taking part in the Hertfordshire Cohort Study. This will last about an hour and half, and will be held at a local venue at a time to suit you and the others. We will provide refreshments and transport.

What is this study for?

We would like to find out more about the lifestyles of older adults. We are interested in talking to participants of the Hertfordshire Cohort Study about their food choices, diets and physical activity habits because we want to help to promote health in older adults living in the community.
We hope you'll enjoy the group.

Why have I been chosen?

You are taking part in the Hertfordshire Cohort Study and have been asked about your diet and physical activity previously.

I don't want to take part in these discussion groups!

If you don't want to take part in the discussion group, or if you change your mind about it at any time, that is fine.

Who will see what I have to say?

The discussions will be recorded and then transcribed by the researchers. All conversations will be anonymised and, once recordings have been transcribed they will be destroyed. All this information will be stored safely.

What if I have a question or query about this study?

Please call Ilse Bloom on **023 8077 7624** if you have any questions or concerns.

Research Ethics Committee Approval No.: 10/h0311/59
Version no.: 01_12/2013

Appendix B

Hertfordshire Qualitative Study – Focus Group Discussion Guide

Main research aim: To gain a better understanding of the factors that influence food choice, diet quality and physical activity in older adults.

Welcome, thank you and housekeeping: (tape-recording, fire exits/alarms, toilets, mobile phones, timings for the day)

Introduction: 'This study is interested in the lifestyle choices of older adults, in order to consider how they might be supported to maintain or improve their overall health. The purpose of the discussion today is to learn more about your food choices and physical activity.'

Introduction & opening question: 'Can you tell us who you are and say what a healthy lifestyle means to you?'

Questions (diet):

- What foods do you enjoy, eat often, rarely or never?
- What do you think influences your food choices? *(Refer to prompt list if necessary)*
- What prevents you from choosing other (healthier?) foods? *(Refer to prompt list if necessary)*
- How do you think your diet has changed over the last 10-15 years?
- What caused those changes to happen?

Questions (physical activity):

- What sort of physical activity do you do (in leisure time, structured or not, frequency…)?
- What motivates you to exercise? *(Refer to prompt list if necessary)*
- What do you think prevents you from doing more (any) physical activity? *(Refer to prompt list if necessary)*
- How do you think your exercise habits have changed over the last 10-15 years?
- What caused those changes to happen?

Questions (general):

- What do you think could help people maintain a healthy lifestyle as they get older?
- In order to help people achieve this, what services/initiatives do you think should be added/improved in the community?
- How would you feel about taking part in a lifestyle-focused intervention study?

Ending questions: We are almost finished with our discussion:

- What, if anything, have we not covered?
- What, if anything, would you like to add?

Prompts – Possible influences on <u>food choice/diet quality</u> in older people:

Dietary knowledge	Past experiences	Habit	Cooking skills
Social setting	Social support	Eating alone	Loss of a partner / loneliness
Physical and mental health / wellbeing	Weight concerns	Appetite	Taste
Priority of food	Transport	Access	Money
Self-efficacy			

Prompts – Possible influences on <u>physical activity</u> in older people:

Knowledge	Disease Management	Advice from healthcare professional	Physical and mental health / wellbeing
Fear and Negative Experiences	Social Isolation	Social Activity	Environment
Time	Money	Lack of Interest	Self-Efficacy

Appendix C

Focus group analysis coding framework – Hertfordshire Qualitative Study

Research question: What influences **diet** in community-dwelling older adults?

Theme	Descriptor	Examples of Quotes
1. Historical influences on and current beliefs about food	Role of mother/parents in upbringing, including teaching cooking skills. Wartime rationing and not wasting food. Discussion about early likes/dislikes, transitions such as leaving home, marriage. Availability of local shops and foods in the past vs now. Beliefs about food and diet, including about the manufacturing process of food. Media & government messages and their effects. Taking part in research.	'I used to help me mother and my mother was a great cook and she taught me how to skin rabbits and pluck chickens and how to gut things…' FG01 'I think being brought up in the war makes you appreciate food you don't waste it you do really appreciate it' FG03 'But they keep altering moving the goalposts don't they, they're now saying all this fat is not bad for you' FG07 'There are more chemicals put into margarine' FG09
2. Retirement and bereavement	Changes to cooking/eating behaviour or habits due to loss/illness of partner. Impact of bereavement more generally (not diet-specific). Impact of retirement on structure of day, meal patterns and diet. Impact of retirement more generally (not diet-specific).	'I'm still on me own but I'm still eating meat pud and I'm making meat puds and all that' FG02 'I used to buy 'em at the supermarket ready-made food 'cos my wife died ten ten years ago so I've been on my own quite a time I used to buy um ready-meals at the supermarket' FG02 'Since my husband died I don't eat as much meat at all, rarely eat meat' FG09 'Struggling a bit at the moment losing my husband…'FG01 'I think when you're retired … you've got more time … you can think a bit more about what you want – if you gotta cook, what you want to cook, or organise your week…' FG02 'I stopped work in March of this year and I find that the biggest problem is coming to terms with the lack of discipline that a working life gives you … I only gave up work because of the knee otherwise I'd probably still be there now… FG11
3. Age-related conditions	Any mention of changes in appetite, as well as weight changes. Dietary requirements or changes made to diet due to medical conditions. Doctor's advice, negative feelings about medication (including side effects), ageing/general decline/energy levels.	'Well I don't … eat half as much as I used to' FG01 '…I don't eat any fat and um eat plenty of fish and chicken and like no fat because I'm on statins' FG06 'I'm diabetic so I don't eat too much sugar' FG08 'My sense of smell is nothing like as good as it used to be' FG08
4. Food environment	Ability to get around/access (transport, bus passes, etc.). Availability of local shops and foods (excluding past vs current). Cost of food, allotment & garden.	'I do find it difficult though if you are on your own which I am now there are always offers in supermarkets and shops but not for the single person' FG04 'We've got a small Co-op shop just at the end of the road from us' FG05 'But then fish is going is more expensive than meat today' FG09
5. Psychological/personal factors	Food as a priority or not, motivation to keep healthy, maintaining a routine. Eating to remain healthy and eating what they fancy. Taste as an influence on foods eaten. General (not diet-specific) discussion of maintaining independence, keeping mentally active, keeping going, sleep.	'It is hard trying to everyday have something different but have something which is good for you' FG06 'When you stop doing something then you never take it up again so you go to keep doing what you've been doing all your life' FG08 'I do a lot of mental work like magazines and things like that I like to keep me brain going' FG09 'I try not to go to sleep after lunch it's only too easy to do it but I don't want to get in the habit of it…' FG09
6. Social engagement	Importance of engagement with friends, family, social clubs and activities for diet and also more generally. Discussion of social environment e.g. other people's activities/choices, influence of family/friends/peers generally. Social aspects of eating out. Caring/supportive community attitude.	'I think if you've got a partner to do things for you or to cook for or to do your life is different' FG09 'You know every day of the week you can go on a pub lunch with the U3A' FG10 'Well I'm lucky I come from a village and they are very very friendly' FG01
7. Food-related habits	Types of foods eaten. Methods used to cook & prepare food/meals and issues around these, for example, heating up pre-prepared meals in the microwave, getting foods delivered. Partner's likes/dislikes, home environment and household aspects of food choice e.g. who does the shopping/makes most food related decisions, who cooks. Eating out or at home, excluding social aspects. Changes made to diet (no explicit reason).	'My main meals are prepared meals you know microwave meals' FG02 'I buy braising steak from Tesco's or stick it in the pot with vegetables and things and let it go all day and then I just pack it up in bits and put it in the freezer' FG07 'And when we go out I always get something that I don't cook at home like a lovely piece of fish' FG04 'My husband insists well my husband insists on a meat and two veg every day at one o'clock' FG01 'I tell you my wife controls what we eat more than anything yeah' FG02

Appendix D

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What influences diet quality in older people? A qualitative study among community-dwelling older adults from the Hertfordshire Cohort Study, UK

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Abstract

Objective: To explore influences on diet in a group of community-dwelling older adults in the UK.

Design: Data were collected through focus group discussions with older people; discussions were audio-recorded, transcribed verbatim and transcripts analysed thematically.

Setting: Hertfordshire, UK.

Subjects: Participants were sampled purposively from the Hertfordshire Cohort Study, focusing on those whose diets had been assessed at two time points: 1998–2001 and 2011.

Results: Ninety-two adults participated (47 % women; 74–83 years) and eleven focus groups were held. A number of age-related factors were identified that were linked to food choices, including lifelong food experiences, retirement, bereavement and medical conditions, as well as environmental factors (such as transport). There appeared to be variability in how individuals responded to these influences, indicating that other underlying factors may mediate the effects of age-related factors on diet. Discussions about 'keeping going', being motivated to 'not give up', not wanting to be perceived as 'old', as well as examples of resilience and coping strategies, suggest the importance of mediating psychological factors. In addition, discussion about social activities and isolation, community spirit and loneliness, indicated the importance of social engagement as an influence on diet.

Conclusions: Interventions to promote healthier diets in older age should take account of underlying psychological and social factors that influence diet, which may mediate the effects of age-related factors.

Keywords
Ageing
Focus groups
Food choice
Psychological factors
Social relationships

Although poor diet quality is common in older people[1–4], the determinants of dietary choices and quality in later life are poorly understood. Much of the evidence to date is cross-sectional and largely fragmented, particularly regarding how factors interact to impact on diet. The lack of longitudinal evidence is particularly problematic since the ageing process itself is often accompanied by physiological, psychological and social changes that can affect food consumption. Importantly, the variability in diet across the older population suggests that some older adults are able to adapt to these changes and maintain diet quality, while others are not[5].

There is increasing evidence that social factors such as marital status, living arrangements and frequency of social contact are important influences on older people's diets[6–8]. For example, both living alone and having less frequent contact with friends have been found to exacerbate the negative effect of widowhood on diet[6,9]; other studies have highlighted roles of social isolation, lack of social support and lack of participation in leisure activities[8,10–12].

Less is known about the influence of psychological factors on diet in older age. In younger women,

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a perceived lack of control over life is linked to diets of poorer quality[13] and appears to mediate effects of social disadvantage on diet. In comparison, there is a gap in our understanding of the role of these factors in older age and how they impact on the effects of illness, disability and disadvantage on diet. Findings from Canada[5] have highlighted the roles of resilience (a process comprising positive adaptation despite significant adversity[14]) and self-efficacy (an individual's belief in his/her own ability to achieve a desired outcome), which is consistent with a recent study from Japan[15] that found that psychosocial factors, including increased self-efficacy and increased social influence, attenuated the association between lower socio-economic status and poorer diets in older people.

Gaining insight into what supports older adults to eat well will be important in the development of interventions to promote diet quality and enhance healthy ageing. The present study uses qualitative methodology to explore subjective experiences and attitudes, to provide deeper insights. It uses quantitative longitudinal data on diet quality as a starting point to enable comparison of individuals whose diet quality has declined and those whose diets remained stable over time. The primary aim was to explore influences on diet among community-dwelling older people in the UK; the secondary aims were to gain insight into gender differences and factors linked to differences in diet stability in older age.

Methods

Participants

Hertfordshire Qualitative Study (HQS) participants were selected from an established cohort, the Hertfordshire Cohort Study (HCS)[16], and included participants whose diets had been assessed at two time points. Between 1998 and 2003 (first time point), the diets of 1677 men and 1540 women, taking part in the HCS, were assessed by an administered FFQ[17]. In 2004–2005, 642 participants, resident in East Hertfordshire, took part in a sub-study that collected musculoskeletal data. In 2011, 592 of these participants were further approached, of whom 443 (75 %) agreed to be followed up[18]; at this point (second time point), diet was reassessed. A prudent diet score, derived from a principal component analysis of the dietary data, was calculated for each participant based on his/her consumption of twenty-four indicator foods[19] and was used as an indicator of diet quality. Prudent diet scores calculated using these indicator foods have been shown to be highly correlated with scores calculated from a complete dietary assessment (0·912 in men, 0·904 in women) and they showed comparable associations with blood biomarkers[18]. A high score indicated frequent consumption of fruit, vegetables, wholegrain cereals and oily fish. Changes in diet scores over the 10-year period were calculated. While in men average diet quality remained stable with increasing age, in women there was an overall decline: mean change in diet score per year 0·008 (SD 0·099) in men and −0·025 (SD 0·108) in women[12].

Of the 443 HCS participants with follow-up dietary data, 408 (still alive and taking part in the study) were approached and invited to attend a focus group to discuss influences on diet and barriers to eating healthily. These participants were divided into two groups according to change in diet over the past decade, defined using change in prudent diet scores. 'Diet-declined' and 'diet-stable' participants took part in different focus groups. Of the 408 participants approached, ninety-two (23 %) participants (forty-three women and forty-nine men; mean age 78 years) were successfully recruited into the study; the remaining 316 people did not take part for various reasons (unavailability in the study time frame, non-response to invitation letter or unwillingness). In comparison with the 316 HCS participants who did not take part, there were no differences in terms of age, education or social class; however, the ninety-two participants had slightly healthier diets: mean diet score 0·476 (SD 1·429), compared with 0·117 (SD 1·205) in those who did not take part ($P = 0·017$).

We selected focus groups as the method for data collection as they draw on the communication and interaction between research participants in order to generate data and are a useful method to investigate complex behaviours, such as dietary behaviours as is the case for the present study. Sufficient focus groups were conducted both to reach the point of saturation, the point at which no new information or themes were observed in the data[20], as well as to ensure approximately similar numbers of participants from the groups that we aimed to compare (men *v.* women; diet-declined *v.* diet-stable).

All participants were provided with an information sheet explaining the study and the nature of the discussion. Written informed consent was obtained from everyone before discussions began.

Procedure

Participants were contacted by post with an invitation letter, a participant information sheet detailing all important aspects of the study and a reply slip to indicate whether they would be willing to take part. If there was no response from a potential participant after two weeks, a reminder letter was sent. Thereafter, no further contact was made about this study. Willing participants were contacted by I.B. by telephone to arrange a convenient time for them to attend a focus group. Focus groups were held in a centrally located community venue in the town of Hertford, UK in mid-March, end May/beginning June and end September 2014. Upon arrival, W.L. and I.B. introduced themselves to participants, attendees were reimbursed for any travel costs incurred and refreshments were provided. Participants did not receive any further incentives for their participation. W.L. and I.B. worked as a pair, taking turns to moderate and

observe the discussions. W.L. is an associate professor of health psychology with experience and expertise in qualitative methods, including running focus groups, and I.B. is a research nutritionist with training in qualitative research and some experience conducting focus groups. Both researchers were present at every focus group, except for the last one where only I.B. was present due to practical constraints. Focus group discussions lasted between 75 and 99 min, with an average of approximately 1·5 h. Focus groups were guided by a semi-structured discussion guide developed by the research team, based on a literature review and discussions with nutritionists, epidemiologists and social scientists in the field (see online supplementary material for the full discussion guide). Discussions were audio-recorded and transcribed verbatim.

Data analysis

Transcripts were analysed thematically[21]; the process began with identifying initial codes from transcripts to be refined into themes. A coding framework was developed to represent emergent themes, which were identified using inductive coding, a process of coding the data without trying to fit it into a pre-existing coding frame (i.e. data-driven)[21]. All transcripts were double-coded and analysed using a constant comparative approach[22], whereby each theme was compared with the others and assessed for similarities and differences, driven by the study's central purpose (i.e. to explore influences on diet in older age, as well as any gender differences and differences between 'diet-declined' and 'diet-stable' groups). Both moderator and observer were involved in the data analysis to ensure that it was representative of the groups' views and they met regularly to discuss any disagreements, make suggestions for amendments and agree the coding framework. The themes were developed and depicted in a thematic map to illustrate how they link to form the interpretation presented here. Analyses took place at the group level as individuals were not identifiable from the audio-recording.

Results

Focus group characteristics

Eleven focus group (FG) discussions were held (see Table 1): six with participants whose diet quality had declined (n 41), five with participants whose diets had remained stable over time (n 51). All but one group were held separately for men and women in order to examine differences by gender. Of the ninety-two participants, 47 % were female and their age range was 74–83 years (mean 78 years). There was a similar spread of manual social class and non-manual social class participants, both within each category of focus group, as well as within each individual group. Numbers of participants in each focus group ranged from five to twelve, and all were white British, born in Hertfordshire in 1931–1939.

Thematic analysis

Analysis of the data, whereby themes were identified in an inductive (data-driven) process and then thematically coded and analysed using a constant comparative approach, revealed that a number of distinct themes appeared to be important influences on diet. A thematic map was created to depict these themes and this was developed into a hypothetical model to depict the relationships between the themes (Fig. 1). This shows how we propose the themes might interrelate to impact on diet. Four initial themes are proposed as contextual factors:

1. Historical influences on and current beliefs about food.
2. Retirement and bereavement.
3. Age-related conditions/symptoms.
4. Food environment.

Discussions with participants revealed two additional themes that appeared both to have a direct influence on diet and also to mediate the influence of the four contextual factors on diet; these themes are thus hypothesised to be underlying factors in this interpretation of the data:

5. Psychological/personal factors.
6. Social engagement.

The relationship between the contextual factors and the two underlying factors is seen as dynamic and bidirectional. The result of the interaction between the contextual and underlying factors determines how individuals make food choices and construct their diets, captured in the final theme:

7. Food-related habits (e.g. types and quantities of foods eaten, methods used to prepare food/meals).

These themes are set out below and illustrated with example quotes.

In addition to our primary aim, to explore influences on diet among community-dwelling older people, the study was designed to address two secondary aims: to explore differences (i) between 'diet-declined' (DD) and 'diet-stable' (DS) groups, and (ii) between men (M) and women (W). However, our analysis did not reveal any obvious differences between the diet groups and revealed few gender differences. Therefore, the Results section focuses on the themes (listed above) that address the primary aim; where appropriate, comments on gender differences are also given.

Historical influences on and current beliefs about food

All groups in the present study described the importance of their upbringing and past experiences on the foods they currently eat:

> 'My mother was a great cook and she taught me how to skin rabbits [laughter] and pluck chickens … she taught me all sorts of things and I continue that today … we eat basic and that's what I've been brought up on.' (FG1W DD)

Table 1 Characteristics of study participants by type of group interviewed; community-dwelling older adults from the Hertfordshire Cohort Study, UK, 2014

	Women, diet-declined	Men, diet-declined	Women, diet-stable	Men, diet-stable	Men and women, diet-stable
No. of focus groups conducted	3	3	2	2	1
Total no. of participants	20	21	21	23	7
Mean age (years)	78	78	78	78	80
Age left education, ≤14 years					
n	6	3	1	3	1
%	30	14	5	13	14
Age left education, ≤15 years					
n	14	18	20	20	6
%	70	86	95	87	86
Social class, non-manual					
n	10	8 (2 missing)	9	11 (1 missing)	5
Social class, manual					
n	10	11	12	11	2

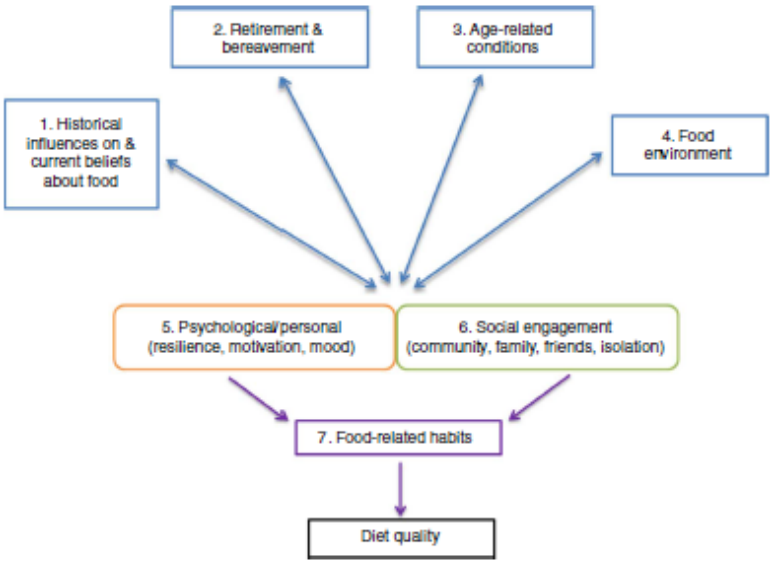

Fig 1 Hypothetical model of the relationships between the themes and potential routes to impact on diet quality in older age

But discussions conveyed that a general shift towards healthier eating habits was guided by current messages and beliefs about what constituted 'healthy', including less fat, sugar, salt:

> 'I know that we all eat a lot more fish than we used to, and probably more chicken, but a great deal less red meat … I think because in the media there's been quite a lot about it not being good for you.' (FG9W DS)

Retirement and bereavement

Most spoke of the impact retirement had had on their lifestyles and particularly on their food habits. One outcome was having more time to prepare food and another was how the new daily structure led to changes in eating patterns:

> 'I've cut out the two cooked meals a day 'cos when I was in the office I had a restaurant and … had a proper meal, but when I got home in the evening my wife hadn't had anything so I'd keep her company with a cooked meal. Now … we just have a cooked lunch and then have a lighter meal.' (FG10M DS)

Following bereavement there were often significant changes to cooking or eating behaviour. The impact on diet following the loss of a partner appeared to affect men

and women differently. For women, the loss of their partner elicited a range of differing responses in relation to eating, both positive and negative. Women who had lost their partner felt less motivated to cook for themselves, as is described further on. Some tried different foods or went to different places to eat:

> 'I have a sister-in-law … and our husbands died within six months of each other and I decided to take her out and we went to [restaurant] and ooh she'd never been anywhere like that, it was wonderful so we've been there several times.' (FG4W DD)

Some had difficulty in accessing the shops, since it was their husband who had done most of the driving:

> 'My husband died and so I haven't got the car now … I didn't drive a lot … I am lucky because if I go shopping, I've got my cousin's husband, always picks me up you know and takes me home.' (FG4W DD)

For men, the primary outcome from the loss or illness of their partner appeared to relate to their ability or motivation to learn or continue to cook. Men largely spoke about having to adapt after losing the person who did most of the cooking. Some learnt to cook and found enjoyment in this; others found alternative solutions such as opting for ready-meal deliveries.

> 'Well ten years ago I suddenly found myself on my own as my wife suddenly died … so I suddenly found I had to learn how to cook, and anyway I found that I liked to steam all my vegetables mainly because you could do it all in one pot and you only had one to wash up.' (FG3M DD)

> 'My main meals are prepared meals you know microwave meals … I have them delivered from a frozen food company … I feel rather lazy [laughter] … I've been doing that for must be three or four years now … I didn't take much notice of what she was doing unfortunately.' (FG2M DD)

Age-related conditions

Having a smaller appetite as a result of the natural ageing process was discussed in all groups and many considered portion sizes to be too large when eating out. All groups discussed making changes to their diets, such as choosing or avoiding certain foods, due to medical conditions or medication they were taking. Furthermore, most groups spoke about how physical incapacity or decline had affected food-related activities:

> 'My knees are so bad now I just don't walk far … I used to drive but I had to give it up, but I wish I could drive now, it would be easy as I could go down and get my own shopping. I miss doing the shopping.' (FG4W DD)

Food environment

Price or getting value-for-money was widely discussed, as well as availability and quality of foods. Many spoke about issues with accessing shops or food-related activities:

> 'We used to walk down for tea to Hertford and catch the bus back 'cos it's uphill, but you can't rely on the buses now so we've stopped doing that.' (FG7W DS)

Women who lived alone had difficulty finding smaller portions, with supermarkets not catering for the single person and a lack of availability of small shops, such as local butchers:

> 'If you're on your own, supermarkets don't really cater for single portions.' (FG7W DS)

It is hypothesised that there are two underlying factors (presented below), namely psychological/personal factors and social engagement, that impact on how older people respond to and cope with the influences identified above.

Psychological/personal characteristics

Our analyses identified a series of contextual and underlying themes that describe influences on diet in older age. One of the underlying themes identified in the present study was the role of psychological and personal factors. A frequently cited driver apparent in these discussions was the need to 'keep going', by being positive and maintaining an interest in life, for fear of being a burden on others or losing their health/independence, like others (peers) have. Participants spoke of wanting to be part of the wider community and to be able to do the things that they had always done, including cooking and eating well. This, along with other explicit references to being motivated to 'not give up' and to not be perceived and treated as 'old', as well as implicit examples of resilience and coping strategies, highlights the importance of resilience and self-efficacy in overcoming dietary setbacks, and suggests an important mediating role of psychological and personal factors on diet. A consistent message from the discussions was the importance of staying positive and being motivated to keep healthy and independent to avoid having to rely on others:

> W1: 'You just do it.'
>
> W4: 'You must be positive …'
>
> W2: 'Motivation …'
>
> W3: 'I think it's fear of having to rely on other people.'
>
> W4: 'Just like you're going home tonight [you want] a meal, so you're going to cook it, aren't you?' (FG7W DS)

There was an emphasis on not being regarded as old, or accepting that old age meant behaving in a certain way, and on wanting to remain part of the wider community:

> 'Making sure you can keep doing all the things you did all your life … and that's only by keeping on doing exactly what you've always done, not suggesting that you're too old anymore … that's my policy.' (FG8M DS)

> 'My daughter always says "Why do you like to go out shopping on a Saturday mum?" It's because I like to be with people of all ages … you go out in the week … it's like an old people's club.' (FG9W DS)

For most groups, cooking and food were viewed as a priority:

> Moderator: 'And what kind of priority is there for food in everybody's lives?'

> M: 'Oh, number one … I'm still on me own but I'm still … making meat puds and all that.' (FG2M DD)

For all groups, taste and enjoying food were significant influences on food choices and it was evident that for some this may be more important than potential health benefits:

> 'I eat what I wanna eat. I know I have a fat belly as you can see. I eat butter, milk, cream, everything, you name it I'll have it. 'Cos you know life's too short, you have what you want.' (FG8M DS)

Both genders spoke of being too lazy, not bothering to cook or not enjoying cooking, but this appeared to be more dominant for women. This seemed to be linked with the issue of eating alone and no longer having the role of providing meals for someone else (described below in the section about social engagement), and was another aspect of the interaction between gender and how bereavement/loneliness influenced food-related behaviours:

> 'I admit I'm lazy, I don't bother to cook dinners very often … I very rarely eat meat and I don't eat chicken so I find it really difficult to eat proper, so possibly I have too much things on toast … I never used to be like this I used to eat… possibly since I've been on my own I think … I used to cook dinners every day, we used to be quite big meat eaters but I can't eat much meat now ...'

> Moderator: 'Do you enjoy cooking?'

> 'No, not now.' (FG6W DD)

Social engagement

In addition, there was much discussion about social activities and isolation; of community spirit and loneliness – indicating the importance of maintaining and developing ways to ensure social engagement, the other underlying theme identified in the present study. For those who have a good level of social engagement, it may be easier to cope with the process of ageing and other contextual influences we identified. There was recurrent discussion about taking part in various social activities and clubs. The motivation to keep going and not be perceived as old led these participants to seek opportunities for social engagement. Eating out or with friends/family was widely spoken of as a key social activity:

> 'We have a monthly pub lunch … and you see people there that you probably haven't seen for donkey's years ... the food is dreadful [laughter] – it really is! I said to a bloke the other day "I could never stop coming" because I only see him … when I go there … I moan about it something rotten but you go again and that is very good for socialising.' (FG2M DD)

Friends also played an important role in facilitating engagement with a range of social activities, not necessarily food-related.

There was discussion of the influence of family members on eating habits; family members, such as children or grandchildren, had an important influence on participants' eating habits:

> 'I do me own cooking … 'cos I'm on me own now but my daughter occasionally brings things in for me to eat.' (FG5M DD)

Women were more likely to speak about the loneliness of eating alone or not having a supportive community around them, particularly following bereavement. They emphasised the importance of family, friends and community in supporting them through difficult times and ensuring they did not become isolated. For women, eating alone was seen as a difficult or lonely activity; they spoke of the importance of having a partner or others to cook for:

> 'I find um eating on your own, you take ages cooking a meal and you sit at the table … and within a few minutes you've eaten it and there's no one to talk to.' (FG1W DD)

The role of friends or family in motivating and supporting women to take part in social activities, especially following the loss or illness of a partner, was particularly important:

> 'Luckily I've got good family and friends, so they would rally around and say "Oh come on go and do this". But it is a completely different life because I find … friends … if they're all couples when you're on your own in the group … you feel more alone, you think "Well I'd rather be at home".' (FG7W DS)

Discussion about the importance of having supportive neighbours or community environment was also more prominent for women:

> 'The cul-de-sac I live in, not one person has come up to me and said "I'm ever so sorry your husband died". I could do with somebody caring, not *for* me but *about* me, 'cos at the moment it's eleven months today my husband died and I am lonely … it's horrible, nobody comes up to you and says "Want a cup of tea?" or anything.' (FG1W DD)

The above described analysis suggests that the interaction between contextual and underlying themes impacts differently on people's food-related habits, which could underlie differences in dietary quality observed across the population.

Food-related habits

All participants had a great deal to say about how they prepared food and what they liked to eat. For instance, preparing one-pot dinners, cooking extra and freezing were strategies to dealing with eating alone. All groups discussed the division of food-related tasks within the household; two main patterns emerged: the wife doing most or all of the shopping or cooking, and the husband and wife sharing the tasks. For women, it was clear that their husbands' likes and dislikes played a major role in influencing the types of foods they cooked and hence the current family food habits. At the same time, many men appeared to prefer home-cooked meals, cooked by their wives, to meals eaten out.

Discussion

The current study suggests that social and psychological factors may mediate the influence of background characteristics on the diets of older people, which to our knowledge has not been demonstrated before. The study also generated testable hypotheses as to how this complexity of factors might interrelate to impact on diet.

Our primary aim was to explore what influences older people's diets. Perhaps as expected, various contextual factors relating to the process of ageing had a significant impact on diet. This encompassed experiences over a long lifetime, represented as past and present food influences and beliefs; the impact of retirement, bereavement, medical conditions and symptoms; and the interaction of environmental and ageing factors (such as cost or access to shops, including having a means of transport to get around). All of these potentially constrain food choices, but there appeared to be variability in how individuals responded to these influences, indicating that other underlying factors may condition their effects on diet. We conducted separate focus group discussions with men and women whose diets had declined in recent years and those whose diets had remained relatively stable, making it possible to explore differences between them. All but one group was single-sex, allowing an exploration of gender effects. However, surprisingly, our analysis revealed no obvious differences in influences on diet between diet-stable and -unstable groups. Furthermore, despite evidence of poorer diet quality among older men compared with women[12], we found few differences by gender.

We developed a hypothetical model to illustrate the relationships between the themes identified through analysis of the data, where we suggest how these factors might interact to influence diet. To our knowledge only one other model[23] has sought to comprehensively synthesise the complex interaction between the broad range of influences on dietary choices in later life. Although the models differ in various ways, the influences on dietary choices identified in the present study are essentially similar to those observed by Winter Falk *et al.* in a US context. The present model explicitly depicts contextual factors related to ageing, such as retirement, bereavement and medical conditions. Our model also highlights the importance of resilience as a psychological/personal factor and suggests an important role of social engagement in mediating the effects of other influences on diet.

Participants talked about eating foods for enjoyment, as opposed to eating to maintain health. It appeared that some believed that changing unhealthy eating habits would not necessarily improve their health, whereas others were convinced that a healthy diet would keep them healthy and independent. These differing outcome expectancies – believing that one's behaviour will lead to a desired outcome – are likely to influence food behaviour in older age[24].

According to social cognitive theory[25], psychological factors such as self-efficacy and outcome expectancies can mediate the influence of environmental or situational factors on an individual's behaviour; if an individual believes he/she can undertake an action and that this will lead to a positive outcome, he/she is more likely to overcome barriers to healthy behaviours and to make changes to these[26].

In line with previous research[27,28] the current study highlighted the importance of life transition points, such as retirement, loss of a partner and onset of illness, in leading to changes in dietary habits. Previous research[29] suggests that older men may be ill-prepared to undertake food-related activities when losing their spouse, as women traditionally carried out food-provisioning tasks; while others suggest[30] that particularly for men, poor cooking skills may have a negative influence on diet. Women who had lost their partner felt less motivated to cook for themselves, which is consistent with previous qualitative research in older community-dwelling adults (mostly female) that found that food apathy (lack of interest or enthusiasm regarding eating) influenced diet[5]. A recent

qualitative study of widowed older women living alone[28] suggests that women adopt new eating patterns in widowhood in a process that is influenced by various factors including their social network.

Previous research has found that older men and women who live alone have worse diet quality than those living with a partner[11,31]. A study of adults aged over 50 years in the EPIC (European Prospective Investigation into Cancer and Nutrition) cohort (UK)[6] found that people who were single or widowed had decreased variety of fruit and vegetable intake in comparison to those who were married, in men more than in women. The study found that both living alone and having less frequent contact with friends exacerbated the effect of widowhood on decreasing vegetable variety, suggesting that friends may compensate for the lack of social ties to a partner[6,9].

Research has shown that increased frequency of social contact is associated with healthier dietary habits in older people[6]. We have recently shown in the Hertfordshire cohort[12] that greater participation in leisure activities, especially cognitive activities, was associated with smaller declines in diet quality over a 10-year follow-up period. Others[32] found that social relationships, rather than socio-economic status, enhance resilience in older people, when these precede, and continue throughout, the period of adversity. Involvement in leisure activities has been found to become increasingly important with age and could contribute to resilience in older people[33].

Increased social contact might influence diet through various mechanisms, such as increased social support, which can provide encouragement and companionship; social control; increased social influence/social comparison; an increased sense of purpose; meaning in life; and sense of belonging[34]. It has been suggested that these pathways could promote positive psychological states that could motivate healthy behaviours, including diet[34].

Strengths and limitations

Analysis of focus group data is generally conducted at the group level, increasing the likelihood of some views being weighted inaccurately. Although two researchers were present at most focus groups, one of the groups was only attended by one of them. We acknowledge that the current study presents only one possible interpretation of the data and that other interpretations could be possible. However, the study benefits from having input from an experienced multidisciplinary research team. Through a rigorous approach to the analyses, including double-coding, a high level of quality control was achieved, in order to minimise misinterpretation. A limitation of the study is that the age range of the study population (74–83 years) was determined by the prior quantitative study and does not represent the full age range of older adults (i.e. ≥65 years). Only white, British older adults took part, and participants had slightly healthier diets than members of the cohort who did not take part, such that the findings may not be generalisable to all senior populations. However, as the HCS has been shown to be broadly representative of the wider population of older adults in England[16], there is no reason to believe a vastly different interpretation would be presented if others from this population were sampled. It is a strength of the study that a good sample size was achieved, that included older adults from a range of different social backgrounds, which suggests that the findings could be of relevance to the wider population of older adults in the UK.

Conclusion

The present study has highlighted the potential importance of underlying social and psychological factors in understanding why, in the face of dietary challenges that commonly accompany ageing, some older people are able to adapt and maintain a healthy diet, while others are not. Hence, future interventions to promote quality of diet and better health in older age may need to consider social engagement and psychological factors (resilience, self-efficacy, outcome expectancies) in their design, as levers for change. The development of a hypothetical model of influences on diet in older age presents the opportunity to test quantitatively the hypothetical relationships between these factors and how they could interrelate to impact on diet in later life.

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the manuscript and approved the final version. *Ethics of human subject participation:* This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects were approved by the NRES Committee East of England, Hatfield (REC reference: 10/H0311/59). The HCS had ethical approval from the Bedfordshire & Hertfordshire Local Research Ethics Committee and the West Hertfordshire Local Research Ethics Committee. Written informed consent was obtained from all participants.

Supplementary material

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Appendix E

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Influences on diet quality in older age: the importance of social factors

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Abstract

Background: poor diet quality is common among older people, but little is known about influences on food choice, including the role of psychosocial factors at this age.
Objective: to identify psychosocial correlates of diet quality in a community-dwelling population of men and women aged 59–73 years; to describe relationships with change in diet quality over 10 years.
Design: Longitudinal cohort, Hertfordshire Cohort Study (HCS).
Subjects: HCS participants assessed at baseline (1998–2003: 1,048 men, 862 women); 183 men and 189 women re-assessed in 2011.
Methods: diet was assessed by administered food frequency questionnaire; diet scores were calculated to describe diet quality at baseline and follow-up. A range of psychosocial factors (social support, social network, participation in leisure activities, depression and anxiety, sense of control) were assessed by questionnaire.
Results: at baseline, better diet quality was related to a range of social factors, including increased confiding/emotional social support (men and women), practical support (men) and a larger social network (women) (all $P < 0.05$). For both men and women, greater participation in social and cognitive leisure activities was related to better diet quality ($P < 0.005$). There were few associations between measured psychosocial factors at baseline and change in diet score over 10 years, in the follow-up sub-group. However, greater participation in leisure activities, especially cognitive activities, at baseline was associated with smaller declines in diet quality over the 10-year follow-up period for both men ($P = 0.017$) and women ($P = 0.014$).
Conclusions: in community-dwelling older adults, a range of social factors, that includes greater participation in leisure activities, were associated with diets of better quality.

Keywords: *ageing, diet, older people, social relationships, UK*

Introduction

Poor diet quality in older people is associated with poorer future health [1–4] and greater mortality [5, 6]. However, little is known about influences on food choice at this age. Poor diets are known to be more common among younger and older adults of lower social class [7, 8] and those with lower levels of education [7, 9]. Among younger adults, psychosocial factors have been shown to be important determinants of diet quality [10]. Less is known about their importance in older age, although findings from Canada [11] have highlighted the roles of 'resilience' and self-efficacy as important influences on diet quality, and among older Japanese adults, psychosocial factors have been shown to mediate associations between socioeconomic status and diet [12].

There is cross-sectional evidence to suggest that some social factors contribute to poorer diets in older age, such as social isolation and lack of social support [13, 14]. Marital status, living arrangements and frequency of contact with friends have been associated with diet quality. For example, less frequent social contact has been associated with low fruit and vegetable consumption in older adults [15], and both living alone and having less frequent contact with friends have been found to enhance the negative association of widowhood with diet [16]. Such differences in diet may contribute to the higher risk of mortality observed in people who have poor social connections [17], although the mechanisms that underlie this association are not fully understood [17].

Understanding psychosocial influences on diet is important for the development of future interventions to improve diet quality in older people. The aim of this study was to identify psychosocial correlates of diet quality in a cohort of older community-dwelling men and women, and determine their associations with change in diet quality over 10 years.

Methods

The Hertfordshire Cohort Study

In 1998, 7,106 men and women who were born between 1931 and 1939 in Hertfordshire were traced [18]. A total of 1,684 (54%) men and 1,541 (52%) women agreed to be interviewed at home. In 2004–2005, 642 participants, resident in East Hertfordshire, took part in a sub-study that

collected musculoskeletal data. In 2011, 592 of these participants were further approached, of whom 443 (75%) agreed to be followed up [19].

Dietary assessment

At baseline (1998–2003), the diets of 1,677 men and 1,540 women, were assessed using an administered food frequency questionnaire (FFQ) [7]. A 'prudent' diet score was calculated for each participant based on their consumption of 24 indicator foods [20] and was used as a measure of diet quality. Prudent diet scores calculated using these indicator foods have been shown to be highly correlated with scores calculated from a complete dietary assessment (0.912 in men, 0.904 in women). High scores indicated diets characterised by frequent consumption of fruit, vegetables, wholegrain cereals and oily fish but low consumption of white bread, added sugar, full-fat dairy products, chips and processed meat [20]. At follow-up (2011), the diets of 221 men and 221 women were re-assessed using a short FFQ that was administered by trained research nurses [7, 20]. Changes in prudent diet scores from baseline were calculated by subtracting baseline diet scores from follow-up scores, such that a positive change value indicates an increase in diet quality and a negative change value indicates a decline.

Assessment of social and psychological variables

At baseline, a social health questionnaire was completed by 1,048 men and 862 women; this assessed a range of psychosocial factors, including social support, social network, participation in social and cognitive leisure activities, and control at home. The measures were based on those used in the Whitehall II Study [21–23]. See Appendix 1 in the supplementary data at http://www.ageing.oxfordjournals.org/ for details of the social and psychological variables assessed. Of the 442 participants who had follow-up dietary data, 183 men and 189 women (372, 84%) had completed the social health questionnaire at baseline.

Statistical analysis

Descriptive characteristics were given as mean with standard deviation (SD), median with interquartile range (IQR), or counts and percentages, as appropriate. Differences between men and women were assessed using *t*-tests, Mann–Whitney tests or χ^2-tests as appropriate. Univariate and multivariate linear regressions were used to explore the correlates of dietary pattern scores and their changes over time; based on earlier analysis of dietary patterns in this cohort [7], the potential confounding factors considered were social class and education. In addition, we considered the number of comorbidities (out of bronchitis, diabetes, ischaemic heart disease, hypertension, stroke and fracture after age 45). Data were analysed using Stata version 14.

Results

At baseline, participants (n = 1,910; 1,048 men and 862 women) were aged between 59 and 73 years (mean 66 years). About 57% of men and women were in manual social classes. Most men (81%) and women (84%) left full-time education at age 15 or above, and most (86% and 73%, respectively) were married or living with a partner. There were differences between men and women in the social factors assessed—men had higher scores for confiding/emotional support, practical support and for social activities, and lower scores for cognitive activities (all $P < 0.05$). There were also differences in the number of people that men and women felt close to ($P < 0.001$)—a higher proportion of men felt close to fewer than five people. With regard to psychological factors, a lower proportion of men than women had anxiety ($P < 0.001$). See Appendix 2 in the supplementary data at http://www.ageing.oxfordjournals.org/ for a summary of baseline population characteristics in terms of social and psychological factors. At baseline, mean (SD) prudent diet score was significantly lower in men −0.245 (1.216) than women 0.388 (1.109), indicating less healthy diets ($P < 0.001$). Over half (59%) of men and women had at least 1 comorbidity at baseline; 6% of men and 5% of women had 3 or more.

In comparison with other Hertfordshire Cohort Study (HCS) participants, the sub-group who were followed up (183 men, 189 women) were younger (64.8 vs. 66.0 years), had healthier diets (0.239 vs. −0.007), and had fewer comorbidities (45.9 with none vs. 40.1%) (P for all < 0.05). In addition, their leisure activity scores and scores for 'cognitive' activities were slightly higher and they were more likely not to have depression or anxiety (P for all < 0.05). Prudent diet scores at follow-up were highly correlated with baseline scores (men: $r = 0.696$; $P < 0.001$; women: $r = 0.656$; $P < 0.001$). In men, average diet quality remained stable with increasing age, but in women there was an overall decline in diet quality with age: mean (SD) change in diet score per year 0.008 (0.099) in men and −0.025 (0.108) in women ($P = 0.003$).

Correlates of baseline diet

Table 1 shows associations between baseline social and psychological factors and baseline prudent diet score. At baseline, diet quality was related to a range of psychosocial factors. In both men and women, diet quality was related to social support; specifically, greater confiding/emotional support was associated with a higher prudent diet score ($P < 0.02$). In men, but not in women, greater practical support was also associated with a higher diet score ($P = 0.014$). A large social network and feeling close to many people were associated with higher prudent diet scores in women only (all $P < 0.05$). For both men and women, greater overall participation in leisure activities was related to higher prudent diet scores; furthermore, increased participation in activities of a more cognitive nature, as well as in activities of a more social nature

Table 1. Associations between baseline social and psychological factors and baseline 24-item prudent diet score in all men and women[a]

	Men			Women		
	N	Regression coefficient (95% CI)	*P*-value	*N*	Regression coefficient (95% CI)	*P*-value
Social factors						
Confiding/emotional support score	922	0.006 (0.002, 0.010)	0.002	775	0.005 (0.001, 0.009)	0.019
Practical support score	932	0.004 (0.001, 0.006)	0.014	781	0.002 (−0.001, 0.004)	0.261
Negative aspects of support score	912	−0.001 (−0.006, 0.003)	0.601	763	−0.002 (−0.006, 0.003)	0.448
Social Network Score	878	0 (−0.004, 0.005)	0.864	749	0.006 (0.001, 0.011)	0.015
Number of people close to	907			757		
<5 (reference)		0 (0.000, 0.000)	–		0 (0.000, 0.000)	–
5–9		−0.042 (−0.252, 0.168)	0.693		0.140 (−0.095, 0.375)	0.243
10–19		0.066 (−0.141, 0.274)	0.531		0.241 (0.004, 0.478)	0.046
20+		−0.006 (−0.258, 0.245)	0.960		0.418 (0.101, 0.736)	0.010
Leisure activity score	861	0.019 (0.013, 0.025)	<0.001	696	0.016 (0.009, 0.022)	<0.001
score for 'social' activities	861	0.009 (0.004, 0.014)	<0.001	696	0.008 (0.003, 0.013)	0.003
score for 'cognitive' activities	861	0.017 (0.012, 0.022)	<0.001	696	0.014 (0.009, 0.020)	<0.001
Psychological factors						
Control at home	919			784		
High (reference)		0 (0.000, 0.000)	–		0 (0.000, 0.000)	–
Low		−0.194 (−0.466, 0.079)	0.163		0.032 (−0.268, 0.332)	0.835
HAD-D	957			810		
Non-case (score 0–7) (reference)		0 (0.000, 0.000)	–		0 (0.000, 0.000)	–
Possible case (score 8–10)		−0.524 (−0.924, −0.125)	0.010		−0.165 (−0.528, 0.198)	0.371
Probable case (score 11+)		0.331 (−0.547, 1.210)	0.460		−0.411 (−1.106, 0.284)	0.246
HAD-A	957			810		
Non-case (score 0–7) (reference)		0 (0.000, 0.000)	–		0 (0.000, 0.000)	–
Possible case (score 8–10)		−0.289 (−0.546, −0.031)	0.028		−0.187 (−0.404, 0.029)	0.090
Probable case (score 11+)		−0.198 (−0.578, 0.182)	0.306		0.031 (−0.232, 0.295)	0.816

[a]Analyses were adjusted for social class, age left education and number of comorbidities.

were both associated with higher prudent diet scores (all $P < 0.005$). Diet score was not related to control at home. Diet scores were lower in men who had a possible case of depression, compared to non-cases, and in men who had anxiety, compared to non-cases (both $P < 0.05$), whereas there were no associations with depression or anxiety in women. The pattern of all associations was similar after adjusting for social class, education and number of comorbidities, for both men and women separately.

Predictors of change in diet

Table 2 shows baseline social and psychological factors as predictors of change in prudent diet score in the follow-up sub-group of men and women. Overall, there were few associations between psychosocial factors at baseline and change in diet score over 10 years. However, in men and women, baseline participation in leisure activities, as well as participation in cognitive leisure activities, were associated with smaller declines in diet scores: for a one point increase in leisure activity score, change in diet score increased by 0.002 (95% CI 0.000, 0.003, $P = 0.017$) in men and 0.002 (95% CI 0.000, 0.003, $P = 0.014$) in women. With the exception of women who had a possible case of anxiety, there were no associations between psychological factors and change in diet score. The pattern of associations remained robust to adjustment for social class, education and number of comorbidities.

The relationship between the leisure activity score and prudent diet score at baseline and follow-up is illustrated in Figure 1. There were graded increases in scores across the range of leisure activity. As an example, in the highest quarter of leisure activity score, 81% of men and 84% of women were involved in clubs and organisations weekly or monthly, compared to around 12% of men and women in the lowest quarter. To illustrate the nature of differences in diet quality across the range of leisure activity scores at baseline, green salad was consumed more frequently in the highest quarter (men and women: median 3 times per week (IQR 1–3)) than the lowest (men: 1 (0.2–3), women: 1 (0.5–3)); the equivalent figures for wholemeal bread consumption were men: 3.5 (0.1–8.8), women: 3.5 (0.5–8.8) vs. men: 1.5 (0–8.8), women: 2.8 (0.1–8.8).

Discussion

We have identified psychosocial correlates of diet quality in a cohort of community-dwelling older men and women, and described relationships with change in diet quality over 10 years in a sub-group. Baseline diet quality was positively related to a range of psychosocial factors; a consistent finding for both men and women, was that greater participation in leisure activities, as well as in cognitive and social activities, was related to higher diet scores. There were few associations between psychosocial factors at baseline and

Table 2. Baseline social and psychological factors as predictors of change in 24-item prudent diet score in men and women sub-groups[a]

	Men			Women		
	N	Regression coefficient (95% CI)	*P*-value	*N*	Regression coefficient (95% CI)	*P*-value
Social factors						
Confiding/emotional support score	160	−0.001 (−0.001, −0.000)	0.040	179	−0.001 (−0.001, 0.000)	0.187
Practical support score	163	−0.001 (−0.001, 0.000)	0.076	179	0.000 (−0.001, 0.000)	0.493
Negative aspects of support score	158	0.000 (−0.001, 0.001)	0.718	174	0.001 (−0.000, 0.001)	0.288
Social network score	153	0.000 (−0.001, 0.001)	0.847	173	0.000 (−0.001, 0.001)	0.844
Number of people close to	157			178		
<5 (reference)		0 (0.000, 0.000)	–		0 (0.000, 0.000)	–
5–9		−0.018 (−0.060, 0.025)	0.414		0.007 (−0.042, 0.056)	0.781
10–19		−0.039 (−0.081, 0.004)	0.074		−0.003 (−0.050, 0.044)	0.899
20+		0.009 (−0.043, 0.060)	0.733		0.003 (−0.060, 0.067)	0.922
Leisure activity score	149	0.002 (0.000, 0.003)	0.017	169	0.002 (0.000, 0.003)	0.014
score for 'social' activities	149	0.001 (−0.000, 0.002)	0.070	169	0.001 (−0.000, 0.002)	0.238
score for 'cognitive' activities	149	0.001 (0.000, 0.002)	0.041	169	0.001 (0.000, 0.002)	0.023
Psychological factors						
Control at home	161			178		
High (reference)		0 (0.000, 0.000)	–		0 (0.000, 0.000)	–
Low		−0.036 (−0.095, 0.023)	0.226		−0.044 (−0.104, 0.016)	0.149
HAD-D	165			182		
Non-case (score 0–7) (reference)		0 (0.000, 0.000)	–		0 (0.000, 0.000)	–
Possible case (score 8–10)		0.001 (−0.116, 0.118)	0.987		−0.075 (−0.164, 0.014)	0.097
Probable case (score 11+)		0.073 (−0.126, 0.272)	0.471		–	–
HAD-A	165			182		
Non-case (score 0–7) (reference)		0 (0.000, 0.000)	–		0 (0.000, 0.000)	–
Possible case (score 8–10)		−0.030 (−0.102, 0.043)	0.415		−0.051 (−0.099, −0.003)	0.038
Probable case (score 11+)		−0.015 (−0.092, 0.062)	0.701		−0.035 (−0.098, 0.027)	0.261

[a]Analyses were adjusted for social class, age left education and number of comorbidities.

change in diet score over 10 years in the follow-up subgroup of men and women. However, baseline participation in leisure activities, as well as participation in cognitive leisure activities, was associated with smaller declines in diet quality over time. These associations were not explained by social class, education or number of comorbidities. To our knowledge these findings have not been described before in a UK population.

There were some differences in the pattern of associations between social and psychological factors and diet quality between men and women. One consistent finding at baseline was that for men and women diet quality was positively related to having greater confiding/emotional support. This may be explained by a greater level of confiding, sharing interests, and reciprocity with a person someone feels very close to, contributing to increased self-esteem, sense of mattering to others and mastery over activities [24]. Although this includes tasks such as cooking, which might increase motivation to cook and eat healthier meals, confiding/emotional support was not related to change in diet quality in men and women followed up at 10 years. At baseline, greater practical support was also associated with better diet quality among men. Poor cooking skills have been identified as a barrier to a healthy diet in older men [25], and these skills may be poorer in older men than in older women [26]. A greater level of practical support might reflect greater help received with shopping for food and cooking, but consistent with associations with emotional support, it was not related to changes in diet quality over the follow-up period. In a recent Canadian study [27], Rugel and Carpiano found that higher emotional support was positively associated with adequate fruit and vegetable consumption in older women, whereas for older men, there was no association with emotional support nor practical (or tangible) support. The differences in findings could in part reflect the different measures used to assess social support; for example in the Canadian study [27] participants were asked about social support availability, rather that the support received, as in the present study.

In women, a large social network and feeling close to many people were associated with better quality diets at baseline, although not with change over follow-up. Older women may lose motivation to cook for themselves when alone [14] and may regard social aspects of meals to be of great importance for maintaining an adequate diet [27], which could explain the benefits of a larger social network. Positive effects of maintaining social contact have also been reported by Conklin and colleagues [16], although in this case an association was evident in both genders. Although 'number of people close to' was higher in HCS women (see Appendix 2 in the supplementary data), there was no difference in social network scores between men and women and it is not clear why their associations with social network differed.

A key finding was that higher overall participation in leisure activities, including both social and cognitive activities, was related to better quality diets at baseline. Furthermore,

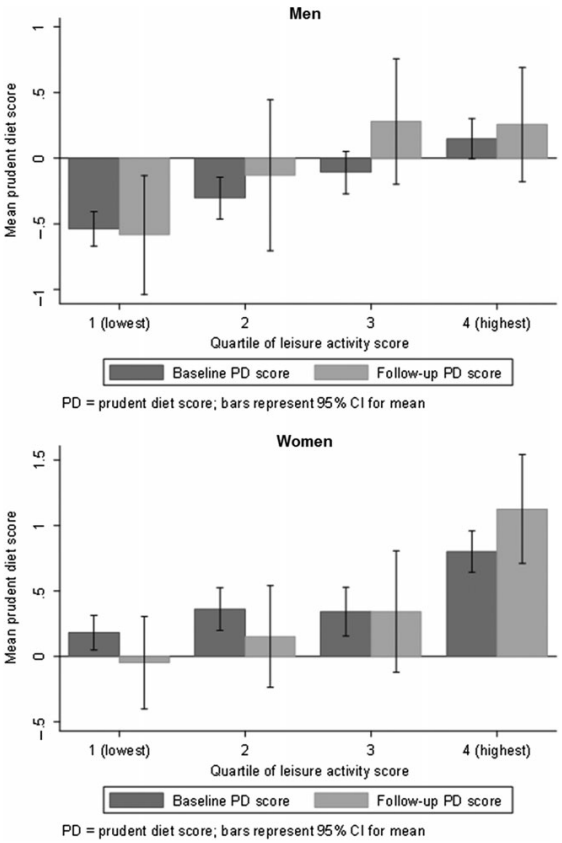

Figure 1. Mean prudent diet score by quartile of leisure activity score for men and women.

baseline participation in leisure activities was associated with smaller declines in diet quality over time, in the follow-up sub-group; this was a consistent finding for both men and women although the effect size was modest. A previous study [28] from the US found that high social contact, including meeting with family and friends and engaging in leisure activities, namely attending religious services and club meetings, was related to better diet quality in older adults. In addition, a longitudinal study of community-living older disabled women in the US [29] found that attending more activities predicted an increase in diet quality over a 1-year period. There are various possible pathways through which participation in leisure activities, and indeed other social relationships, might impact upon diet, such as increased social support, social influence, an increased sense of purpose, meaning in life and sense of belonging [24]. These pathways may promote positive psychological states that could motivate healthy behaviours, including diet [24].

Strengths and limitations

This study uses baseline data from a large well characterised cohort. As baseline participants' characteristics are comparable with those of the wider population [18], the cross-sectional findings should have relevance to older adults in other parts of the country. A strength of the present study is the longitudinal data, although these were only available for a subsection of the HCS, who were slightly younger and healthier than the remainder of the cohort, which may have implications for the generalisability of the findings, and the interpretation of the changes in diet quality we describe. Additionally, we cannot exclude the possibility of residual confounding by factors that were not considered in the multivariate analyses, such as the general health status of participants. We considered a limited number of comorbidities and did not consider other linked health behaviours that may be relevant, such as levels of physical activity. A further limitation is that social factors were not re-assessed at follow-up and it is unknown if there were changes that could have affected diet quality over time. Self-reported diet may be affected by measurement error. However, short questionnaires have been shown to describe diet quality well [20]. Diet quality scores assessed using the questionnaire in this study have been shown to be correlated with blood biomarker concentrations and compared to a full FFQ, show comparable associations with nutrient intake [20]. It is unlikely that measurement error explains the associations we describe.

Conclusion

In community-dwelling older adults, a range of social factors, that include greater participation in social and cognitive leisure activities, were associated with diets of better quality. Further exploration is warranted of the role and importance of psychosocial factors as determinants of diet quality in later life, and of the implications of the present study's findings for future practice.

Key points

- Although poor diet quality is common among older people, little is known about psychosocial influences on diet at this age.
- We found cross-sectional associations between a range of social factors and diet quality.
- Participation in leisure activities, especially cognitive activities, was associated with smaller declines in diet quality.
- Further work is needed to extend and replicate these findings, to understand how social factors influence diet in later life.
- This will be important for the development of interventions to promote diet quality in older people.

Supplementary data

Supplementary data mentioned in the text are available to subscribers in *Age and Ageing* online.

Conflicts of interest

None declared.

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Appendix F

Health Behaviour Tool (for use in the GENIE in COPD study)

1. Food Frequency Questionnaire

Please complete the table below. Place a tick in the box that shows approximately how often you have eaten each of the particular foods in the table. Think about how often you have eaten those foods in the past 3 months. **Please tick one box on every line.**

	FOOD AND AMOUNTS	AVERAGE USE IN PAST 3 MONTHS									
		Never	Less than once/ month	1-3 per month	Once a week	2-4 per week	5-6 per week	Once a day	2-3 per day	4-5 per day	6+ per day
	EXAMPLE: Rice				✓						
	White bread (one slice)										
	Brown and wholemeal bread (one slice)										
	Biscuits e.g. digestive (one)										
	Apples (one fruit)										
	Bananas (one fruit)										
	Melon, pineapple, kiwi and other tropical fruits (medium serving)										

	FOOD AND AMOUNTS	AVERAGE USE IN PAST 3 MONTHS									
		Never	Less than once/ month	1-3 per month	Once a week	2-4 per week	5-6 per week	Once a day	2-3 per day	4-5 per day	6+ per day
	Green salad eg lettuce, cucumber, celery										
	Garlic – raw and cooked dishes										
	Marrow and courgettes										
	Peppers – cooked & fresh										
	Yogurt (125g pot)										
	Eggs as boiled, fried, scrambled etc. (one egg))										
	White fish e.g. cod, haddock, plaice, sole (not in batter/crumbs)										
	Oily fish, e.g. mackerel, tuna, salmon										
	Bacon and Gammon										
	Meat pies, e.g. pork pie, pasties										

(*Continued on page 3 of the questionnaire*)

	FOOD AND AMOUNTS	AVERAGE USE IN PAST 3 MONTHS									
		Never	Less than once/ month	1-3 per month	Once a week	2-4 per week	5-6 per week	Once a day	2-3 per day	4-5 per day	6+ per day
	Boiled, mashed and jacket potatoes (one egg size potato)										
	Chips										
	Pasta e.g. spaghetti, macaroni										
Which is the main spreading fat you have used for example on bread or vegetables?											
	Spreading fat (teaspoons) Please name the spreading fat you use (e.g.Flora) _____										

Participant Identification

Additional dietary questions:

2. Which types of milk have you used regularly in drinks and added to breakfast cereals over the past three months? Please tell us, on average, how much of each milk type you have consumed per day, over the past 3 months.

	Type of milk	Please tick	On average, over the past 3 months, how much milk have you consumed per day?
EXAMPLE	**Whole milk**	✔	**0.5 pints or ½ pints per day**
1	Whole pasteurised or UHT milk		_____pints per day
2	Semi-skimmed pasteurised or UHT milk (include 1% milks)		_____pints per day
3	Skimmed pasteurised or UHT milk		_____pints per day
4	Other – please specify _____		_____pints per day
5	None, go to question 3		

3. Have you added sugar to tea and coffee or breakfast cereals in the past 3 months? Please tick one box.

Yes ☐ **No** ☐

4. If yes, approximately how many teaspoons of sugar have you added each day?

☐

Participant Identification

5. Do you ever drink alcohol?
Please tick one box.

Yes ☐ **No** ☐

6. How often do you currently alcohol (lager/cider/wine/sherry/port/ spirits/liqueurs etc.)

0 = never
1 = once every 2-3 months
2 = once a month
3 = once a fortnight
4 = 1-2 times per week
5 = 3-6 times per week
6 = once per day
7 = more than once per day

☐

If more than once, times per day ☐

7. When you drink these, how many pints or glasses would you normally have? (If range given code mid-point)

☐☐.☐

8. Do you currently smoke?
Please tick one box.

Yes ☐ **No** ☐

9. Have you ever been a smoker? (at least once a day for a year or more)
Please tick one box.

Yes ☐ **No** ☐

Participant Identification

10. Simplified Nutritional Appetite Questionnaire (SNAQ)

a. My appetite is

1 = very poor, 2 = poor, 3 = average, 4 = good, 5 = very good

b. When I eat I feel full after

1 = a few mouthfuls, 2 = 1/3 of a meal, 3 = 1/2 a meal

4 = most of the meal, 5 = I hardly ever feel full

c. Food tastes

1 = very bad, 2 = bad, 3 = average, 4 = good, 5 = very good

d. Normally I eat

1 = less than one meal a day, 2 = one meal a day, 3 = two meals a day

4 = three meals a day, 5 = more than three meals a day

11. Height and Weight

Height (cm)

Weight (kg)

BMI (kg/m^2)

Participant Identification

12. Self-reported assessment of physical function (SF-36 PF)

The following items are about activities you might do during a typical day. Does your health now limit you in these activities? If so, please indicate how much.

	Yes limited a lot	Yes limited a little	No, not limited at all
a) **Vigorous** activities, such as running, lifting heavy objects, participating in strenuous sports	☐	☐	☐
b) **Moderate** activities, such as moving a table, pushing a vacuum cleaner, bowling or playing golf	☐	☐	☐
c) Lifting or carrying groceries	☐	☐	☐
d) Climbing **several** flight of stairs	☐	☐	☐
e) Climbing **one** flight of stairs	☐	☐	☐
f) Bending, kneeling or stooping	☐	☐	☐
g) Walking **more than one mile**	☐	☐	☐
h) Walking **half a mile**	☐	☐	☐
i) Walking **one hundred yards**	☐	☐	☐
j) Bathing or dressing yourself	☐	☐	☐

Participant Identification

13. Physical Activity

Think about all the **vigorous** activities that you did in the **last 7 days**. **Vigorous** physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. Think *only* about those physical activities that you did for at least 10 minutes at a time.

13.1. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, digging, aerobics, or fast bicycling?

☐ days per week

Record as 0 days if no vigorous physical activities and skip to qn. 13.3.

13.2. How much time did you usually spend doing **vigorous** physical activities on one of those days?

_____ hours per day

_____ minutes per day

☐ Don't know/Not sure

Think about all the **moderate** activities that you did in the **last 7 days**. **Moderate** activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal. Think *only* about those physical activities that you did for at least 10 minutes at a time.

13.3. During the **last 7 days**, on how many days did you do **moderate** physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking.

☐ days per week

Record as 0 days if no moderate physical activities and skip to qn. 13.5.

13.4. How much time did you usually spend doing **moderate** physical activities on one of those days?

_____ hours per day

_____ minutes per day

Participant Identification

☐ Don't know/Not sure

13.5. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time?

☐ days per week

Record as 0 days if no walking and skip to qn. 13.7.

13.6. How much time did you usually spend **walking** on one of those days?

_____ hours per day

_____ minutes per day

☐ Don't know/Not sure

13.7. During the **last 7 days** how much time did you usually spend **sitting** on a weekday?

_____hours per day

_____minutes per day

☐ Don't know/Not sure

13.8. During the **last 7 days** how much time did you usually spend **sitting** on a weekend day?

_____hours per day

_____minutes per day

☐ Don't know/Not sure

Appendix G

UNIVERSITY OF Southampton

Participant Information Sheet

Study Title: Implementing and Evaluating the GENIE tool in Southampton Integrated COPD Service: A clinical trial and evaluation to ascertain cost effectiveness and patient benefit.

Researcher: Ms Lindsay Welch **Ethics number**: 17/SC/0044

Please read this information carefully before deciding to take part in this research. If you are happy to take part then you will be asked to sign a consent form.

What is the research about?
This research is part of a student project by Ms Lindsay Welch. Lindsay is also the lead of the Integrated COPD service at Solent NHS Trust.

People with long term health conditions can cope better with their health problems if they have support from family and friends.
When you become unwell it can be difficult for you to see people as much because you are unable to travel as far or have less energy to go out. This means that your circle of friends and family can get smaller and you could have less support.

This study aims to test a facilitated (assisted) online tool that will help you make new connections so that you are able to manage better on a day to day basis despite your symptoms.

The online, social networking tool is called the GENIE tool, and it can map your social groups and offer you more and varied social activities. You will be guided through the GENIE tool by a researcher, so you won't need to use the computer yourself if you find this difficult. The researcher will ask you questions about your friends and family and how often you see them. This will be recorded using circles to demonstrate how important certain people are to you.

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If you feel this is too personal then you can use a pretend name for both you and your family members, if you wish. The GENIE tool then asks you questions about your preferred social activities, these can be related to your health, but the focus is your preferences.
At this point you can just let the researcher know what interests you have and what sort of activities you prefer. The tool then provides you with a print out of activities and groups you can join on your own or with existing friends in your local area.

We are testing this tool in people with COPD. So if you have COPD you will then be invited to join the study. Everyone who joins the study will have their usual care after the exercise classes, but some of you will be able to use the GENIE tool as well.
The study has been reviewed by the Health Research Authority NHS Ethics committee. This is to make sure the study is both a safe and a useful study for local people with COPD. If you decide to join in the study the study team will also ask permission to tell your GP.

Why have I been invited?
You have been invited to join the study because you have a lung disease called COPD and you are a patient in the care of Solent NHS Trust. Also you are a patient that is currently attending pulmonary rehabilitation and / or maintenance exercise classes in the East of the city. Also you have told the team looking after you that you would like to take part.

What will happen to me if I take part?
You will be approached by your usual clinical team and asked if you are interested in research, information (this information) will be provided for you to read. You will be provided with information about the study that you can take home to read and share with family and friends. In order to ensure you have enough time to read the information the research team will allow you at least 3 days. If you need more time to read the sheet, or speak to friends and family you can keep the information for longer.

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Once you are happy to take part, your usual clinical team will ask if you are happy to book an appointment with the research team, and if you are happy for the research team to have your details, to enable them to write to you about appointments. You will then be offered an appointment to see the research team, at this appointment you will be asked to sign a consent form.
You will still be offered all of your usual clinical care by the team at all times and you are still able to withdraw at any time. If you consent to join the GENIE study, this will be in addition to your usual care.
At this point you will be allocated to either join the social network GENIE intervention group, or the usual care only group, in both groups you will always receive your usual care. You will not know which group you are assigned to. Once you are assigned to a group then the intervention or usual care (visit 1) will be delivered. This is to ensure you don't have to make another journey to the health centre.

Consent and Randomisation
The first thing you will be asked is to sign a consent form, to give your permission for us to ask you questions and for you to be part of the study. You will then be 'randomised' – automatically selected by a third party to be in either the social intervention group, or to just receive your usual COPD care. Both groups have usual care.

Visit 1 – Baseline
During this appointment both groups will be asked to complete between four and seven questionnaires, if you have recently completed them as part of your usual care, we won't ask you to do them again. Two questionnaires are about how you currently use health care, and two questionnaires will be about your health and wellbeing. The other questionnaires are about how troubled you are by your COPD and your mood. A further optional questionnaire asks you about your lifestyle and dietary habits.

Depending on which group you have been selected to take part in, you will be given a usual discharge plan alone or your usual discharge plan and support to use the social

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networking tool. You will be supported through this by the researcher.
The information used in the tool is kept secure, if you are worried about using your own name or your family's names, then you can use pretend names (pseudonyms), the tool will then offer you social activities based on your preferences.
The interview and facilitation of the intervention will be tape recorded, with your permission. This is to ensure the intervention is being delivered correctly, and the tapes will not be used for publication or disclosed to anyone outside the GENIE research group. They will be downloaded onto secure NHS computers, and then deleted from the audio recorder.

A date and appointment will be made for you to return in 3 months time. You will be sent a reminder letter nearer to this appointment and if you have a mobile phone, then a text message may also be sent. The appointment will take 45-50 mins and will be held at Bitterne Health Centre.

Visit 2 – 3 month follow up
We will ask you to complete the same questionnaires and the optional questionnaire you completed at visit 1. You will also be asked whether you have joined any social groups or have become more active in your local community.

You may be asked if you are happy for some of the discussions to be audio recorded. You do not have to be recorded if you don't want to. The recordings are to assess the researcher, and are not going to be directly used for the research.

Visit 3 – 12 month follow up
You may also be asked, via follow up letter and/ or telephone call to come back in 1 year (post visit 1). This will be to repeat the same questionnaires as you completed in your previous visits. Not all patients will be approached to attend this visit.

Are there any benefits in my taking part?
We are unsure whether taking part in the research will help you. However if you are in the intervention group there may

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be some benefit to your well-being and an improvement to your COPD. This work may also help other patients with COPD and other long term conditions by improving our understanding of how social network tools can improve well-being and health.

Are there any risks involved?
We see no potential risk to you. During the course of the study you will always be offered your usual care. However the tool does ask you about your social networks (friends and families), some people may find this intrusive, or distressing. If this is the case then please do let the research facilitator know so as they can support you, if need be.

Will my participation be confidential?
If you are part of the intervention group you will need to provide your name or pseudonym and post code to enable the online intervention to work, but no other personal details are required.
All clinical information we collect will be kept confidential by allocating you a unique study number. All research paperwork will only have your unique number and your initials on it so that you cannot be identified. All research data will be stored on a secure database within an NHS computer and will not include any personal details. In the GENIE tool itself we could use a pseudonym (a pretend name) instead of your name, so as you cannot be identified, you can use pseudonyms for your friends and family if you wish.

For data analysis, the research data will be shared with the University of Southampton. However this will not contain any personal details, only the unique number and initials. Personal details will only be accessible by your usual clinical team, and the direct contact researcher(s) on the study – in order for them to call you and make appointments for you.

What happens if I change my mind?
You can withdraw from the study for any reason at any time; your usual care will not be affected. If you withdraw from the study the research team will retain the data collected up until the point you withdraw. Again this will remain numbered and without personal detail.

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What happens if something goes wrong?
In the unlikely case of concern or complaint, you are welcome to contact the independent University of Southampton Research Governance office.
Isla Morris
University of Southampton Research Integrity and Governance Manager

Rgoinfo@soton.ac.uk
023 80 595058

Where can I get more information?
If you have any further questions please do not hesitate to contact the lead researcher, Ms Lindsay Welch on:

Mobile: 07789920092
Or COPD Admin: 0300 123 3794

Appendix H

nutrients

MDPI

Review

Diet Quality and Sarcopenia in Older Adults: A Systematic Review

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Abstract: The increasing recognition of sarcopenia, the age-related loss of skeletal muscle mass and function (muscle strength and physical performance), as a determinant of poor health in older age, has emphasized the importance of understanding more about its aetiology to inform strategies both for preventing and treating this condition. There is growing interest in the effects of modifiable factors such as diet; some nutrients have been studied but less is known about the influence of overall diet quality on sarcopenia. We conducted a systematic review of the literature examining the relationship between diet quality and the individual components of sarcopenia, i.e., muscle mass, muscle strength and physical performance, and the overall risk of sarcopenia, among older adults. We identified 23 studies that met review inclusion criteria. The studies were diverse in terms of the design, setting, measures of diet quality, and outcome measurements. A small body of evidence suggested a relationship between "healthier" diets and better muscle mass outcomes. There was limited and inconsistent evidence for a link between "healthier" diets and lower risk of declines in muscle strength. There was strong and consistent observational evidence for a link between "healthier" diets and lower risk of declines in physical performance. There was a small body of cross-sectional evidence showing an association between "healthier" diets and lower risk of sarcopenia. This review provides observational evidence to support the benefits of diets of higher quality for physical performance among older adults. Findings for the other outcomes considered suggest some benefits, although the evidence is either limited in its extent (sarcopenia) or inconsistent/weak in its nature (muscle mass, muscle strength). Further studies are needed to assess the potential of whole-diet interventions for the prevention and management of sarcopenia.

Keywords: ageing; diet quality; muscle; older people; physical function; sarcopenia

1. Introduction

Sarcopenia is now widely recognised, consisting of a loss of skeletal muscle mass and physical function (muscle strength or physical performance) that occurs with advancing age [1–3]. It is associated with physical disability, poor quality of life and increased mortality in older adults [2] and with significant financial costs, having been estimated to increase hospitalization costs by 34% for patients aged 65 years and over [4]. Although a loss of muscle mass and decline in physical function may be expected with ageing, there is variation in the rates of decline across the population [5]. This indicates that modifiable behavioural factors such as diet could influence the development of sarcopenia. As poor diets and nutritional status are commonly reported [6–9], improving diet and

nutrition may be effective for both prevention and treatment of this condition, and promoting health in later life [10].

There is significant interest in the role of dietary patterns and the effects of whole diets in predicting health, in order to take account of the collinearity between foods and nutrients and the effects of complex interactions between food constituents. The term "diet quality" is broadly used to describe how well an individual's diet conforms to dietary recommendations and to describe how "healthy" the diet is [11,12]; often identified using principal component or factor analysis, it also includes a-priori-defined patterns, such as the Mediterranean diet. Despite using different assessment methods, there are commonalities across diet quality measures, as the "healthiness" of diets is characterised by similar foods [13]. When compared with poorer diet quality, better diet quality is characterised by higher intake of beneficial foods (e.g., fruit and vegetables, whole grains, fish, lean meat, low-fat dairy, nuts, and olive oil), but lower in energy-dense, nutrient-poor foods (e.g., refined grains, sweets and animal products that are high in saturated fats) [11,13].

Higher diet quality in older adults has been linked with various health outcomes, including to a reduced risk of common age-related diseases and to greater longevity. In general, adherence to diets of better quality, assessed by different dietary indices or a "prudent"/healthy dietary pattern, is associated with beneficial health effects; better quality diets are associated with significantly reduced risk of all-cause mortality, cardiovascular disease, cancer, type 2 diabetes, and neurodegenerative disease, as well as reduced mortality in cancer survivors [14–17].

Less is known about the influence of diet quality on sarcopenia (muscle mass and physical function) in older age, although there is a growing evidence base linking "healthier" diets with greater muscle strength and better physical performance outcomes in older adults [10,18]. However, much of this evidence is cross-sectional. A recent systematic review on the relationship between diet quality and successful ageing [19] concluded that with regards to physical function, there were too few longitudinal studies to draw firm conclusions, although there is growing evidence of benefits of greater adherence to a Mediterranean diet [20,21]. To the best of our knowledge no reviews have collated studies, using different definitions of diet quality, to examine effects on sarcopenia. The aim of this systematic review was to bring this evidence together and to assess the relationship between diet quality and muscle mass, muscle strength and physical performance, and sarcopenia, among older adults.

2. Materials and Methods

We used the methods recommended by the Centre for Reviews and Dissemination (CRD), University of York [22] and followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement [23]. The study protocol was registered on 17 January 2017, with the PROSPERO International Prospective Register of Systematic Reviews, registration number CRD42017047597.

2.1. Literature Search and Eligibility Criteria

2.1.1. Inclusion and Exclusion Criteria

Eligible studies were those that reported a relationship between overall diet quality and a measure of muscle mass and/or physical function in older adults. Studies were included which met criteria in terms of the sample of people investigated, the exposure, the outcomes and the study design.

To be included in this review, studies were required to meet the following criteria: (1) be published in a peer-reviewed journal, with full-text availability in English; (2) the study participants were aged 50 years or older, or aged 50 years or older at study baseline for longitudinal studies (in order for a study to be included in this review, all participants needed to be over 50 years), and we included studies concerning specific patient groups such as overweight older adults or those with type 2 diabetes; (3) the study reported an analysis of the relationship between diet quality as measured using dietary patterns (including a priori dietary indices or *a posteriori* (or data-driven) methods [11]), or a measure of dietary

variety, and an appropriate outcome measure as specified below; or an intervention study that reported the effect of following recommendations for a "healthy" diet (leading to improvements in the overall quality of diet) on an appropriate outcome measure; (4) the study included at least one physical function outcome measure of the following: muscle mass, muscle strength, physical performance, or sarcopenia (see Table 1 for further details); (5) observational studies (cohort, case-control, cross-sectional), as well as randomised controlled trials with relevant data. The exclusion criteria included: (1) the study included age groups younger than 50 years; (2) the study combined diet quality with other lifestyle measures into a "lifestyle score" (except where associations with diet quality was reported separately); (3) the study evaluated intake of individual nutrients or single foods or food groups only; (4) the study only included a subjective measure of the physical function outcome, with no objective measure available; (5) the study outcome was protein synthesis, muscle fibre hypertrophy or biochemical properties of muscle.

Table 1. Types of measures considered for relevant outcomes, namely muscle mass, strength, physical performance, and sarcopenia.

Outcome	Muscle Mass	Muscle Strength	Physical Performance	Sarcopenia
Acceptable measures	Anthropometry [a] Dual energy X-ray absorptiometry (DXA) Bio impedance analysis (BIA) Computed tomography (CT) Magnetic resonance imaging (MRI)	Handgrip strength Quadriceps strength Muscle quality index	Short Physical Performance Battery (SPPB) Gait/walking speed Timed get-up-and-go test Balance Stair climb power test	Combined outcomes of muscle mass, muscle strength or physical performance

[a] Includes mid-arm circumference and triceps skinfold measures to determine mean arm muscle area (MAMA).

2.1.2. Search Strategy

An information specialist provided assistance in generating relevant search terms and performing the literature search. Eight databases, namely MEDLINE, Embase, Web of Science Core Collection, CINAHL, AMED, Cochrane Database of Systematic Reviews, Cochrane Central Register of Controlled Trials, and DARE via Cochrane Library, were searched for relevant articles using both MeSH (Medical Subject Headings) terms and free-text terms related to diet quality and muscle outcomes. A sample of the search strategy and search terms that were used for this research (applied in the MEDLINE database) are detailed in a supplementary table (see Table S1 in the Supplementary Materials published online). The search terms (including terms relating to ageing) were combined using Boolean operators ("AND", "OR"), and filters were used to limit the results to those in the English language and in humans. The search was performed in August 2016 and no date restrictions were applied. We considered studies conducted in any part of the world and the setting was noted during the data extraction process.

2.2. *Study Selection*

Figure 1 shows how studies were identified and selected for inclusion in the review. The database search yielded 25,254 results and discussions with experts, followed by hand searching, yielding another two studies. A total of 5382 duplicate articles were removed, leaving a total of 19,874 articles to screen titles and abstracts. Two authors (I.B. and C.S.) independently screened these records with 19,738 articles being excluded at this stage. Full-text articles were retrieved for 136 records and both authors assessed these for eligibility. This led to the identification of 23 papers which were eligible for inclusion in the review. In cases of disagreement about a study's suitability, a third author (J.B.) was consulted. I.B. and C.S. also screened the reference lists of the included papers for any further potentially relevant articles, although none were found.

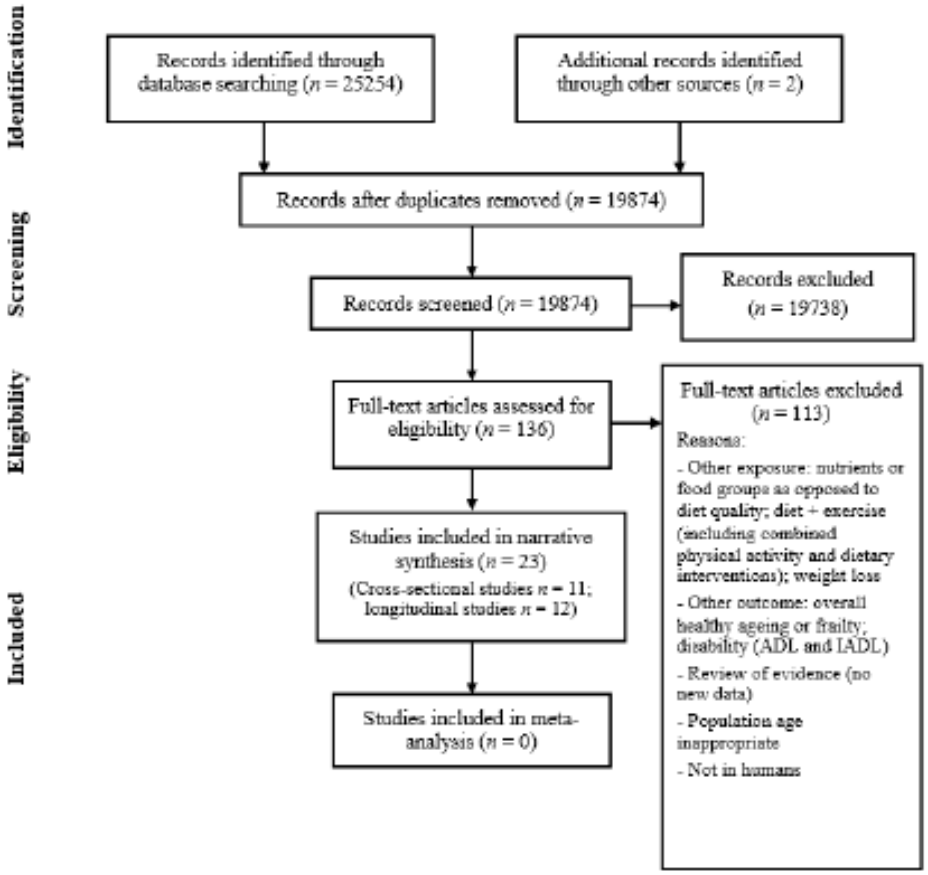

Figure 1. Flow diagram summary of articles identified in search and showing the selection of studies for inclusion in the review.

2.3. *Data Extraction and Assessment of Risk of Bias*

The two reviewers, I.B. and C.S., working independently, extracted relevant data from each included article and assessed risk of bias using established criteria for observational studies, following the methods recommended by the CRD and adapted from a standard assessment tool [24]. The form was piloted on the included studies. The reviewers assessed the risk of bias of each study in relation to the review question using a set of 10 criteria, and recorded the results electronically (see Table S2 in the Supplementary Materials published online for details on the criteria and scoring system used to assess risk of bias of studies included in this review). These addressed areas including study setting, design and population, whether the exposure and outcome measurements were reliably obtained, losses to follow-up and the appropriateness of analyses presented. Regarding the confounding factors adjusted for in the analyses, we decided a priori which were important and assessed studies on the basis of how many of these were adjusted for in the analyses (the following factors were considered as important confounding factors: age, gender, physical activity, ethnicity, socioeconomic status/education, co-morbidities, smoking status). I.B. and C.S. independently carried out the quality assessment of each paper, and any discrepancies in scoring were resolved by mutual discussion or through discussion with J.B. An overall risk of bias rating was assigned to each study based on the quality score; studies were classified as either "high risk" (total score −9 to −3); "medium risk" (−2 to +3); or "low risk" of bias (+4 to +10) (see Table S2 in the Supplementary Materials for further details).

2.4. Data Synthesis

We carried out a narrative synthesis of study findings and considered the scope for meta-analysis.

3. Results

Twenty-three studies met review inclusion criteria. Studies are grouped according to outcome in Table 2 and their characteristics are shown in Table 3, also presented by outcome, first describing longitudinal and then cross-sectional studies. There were 11 cross-sectional and 12 longitudinal studies. Sample sizes ranged from 98 to 5350 participants. Almost half of the studies ($n = 11$) had over 1000 participants. Most studies ($n = 21$) were set in the community, with one set in a nursing home and another including participants from either the community or care facilities. Most of the studies ($n = 16$) had participants whose mean age ranged between 65 and 75 years, with five studies featuring mean ages > 75 years and only two studies having participants whose mean age was below 65 years.

Diet quality as an exposure was measured using different methods. Eight studies used *a posteriori* or data-driven methods, namely principal component analysis or factor analysis [25–30], and cluster analysis [31,32], to assess diet quality. Seventeen of the included studies included a priori measures of diet quality (i.e., diet indices) [26,29,33–47]; 15 different diet indices were used (Table 3) (dietary variety score, $n = 1$; fruit and vegetable variety score, $n = 1$; Mediterranean-type diet score (mMedTypeDiet), $n = 1$; Canadian Healthy Eating Index (C-HEI), $n = 1$; Dietary Variety Score (DVS), $n = 2$; Mediterranean diet score (MDS), $n = 6$; Alternative Healthy Eating Index (AHEI), $n = 1$; Nordic diet score (NDS), $n = 1$; Mediterranean Diet Adherence Screener (MEDAS), $n = 1$; Healthy Eating Index-2005 (HEI-2005), $n = 1$; alternate MED score, $n = 1$; Mediterranean Style Dietary Pattern Score (MSDPS), $n = 1$; Healthy Eating Index (HEI), $n = 1$; Healthy Diet Indicator (HDI), $n = 1$; Diet Quality Index-International (DQI-I), $n = 1$), with four studies including multiple indices [29,33,42,47] and two studies including both indices and *a posteriori* methods in their analyses [26,29]. The most common a priori method used was assessment of adherence to a Mediterranean diet.

The outcomes considered, namely muscle mass, muscle strength, physical performance, and sarcopenia, were assessed using various objective tests or measurements (the outcomes considered were decided by the inclusion criteria—see Table 1). Muscle mass outcomes included appendicular lean mass (ALM) or appendicular skeletal muscle mass (ASM) [46]; ALM/Wt (Weight) [31]; ALM/BMI (body mass index) [34]; ALM/FM (fat mass) [34]; percentage lean mass [47]; mean arm muscle area [33]; and thigh muscle area [33]. Muscle strength outcomes included handgrip strength (most commonly assessed) [25,28,32,35,41,42,44–46]; knee extensor strength [35,36,43]; and elbow flexor strength [35]. Physical performance outcomes comprised walking speed (most commonly assessed) [26,28,38,40–44,46]; Short Physical Performance Battery (SPPB) [37,45,47]; Timed Up-and-Go (TUG) test [32]; chair–rise test (sit–stand chair rises) [27]; balance test [27]; and the Senior Fitness Test (SFT) battery [39]. Sarcopenia was defined in one study according to the Asian Working Group for Sarcopenia (AWGS) algorithm [29], and in the other according to the European Working Group on Sarcopenia in Older People (EWGSOP) criteria [30]. More than half of the studies ($n = 13$) used cut-off values for muscle mass, strength or function, and ten of the included studies used continuous scales to describe muscle outcomes.

Eight of the included studies were classified as having a low risk of bias in relation to our research question, while only two were deemed to have a high risk of bias (Table 2). Over half of the studies ($n = 13$) were classified as having a medium risk of bias (see Table S3 in the Supplementary Materials published online for a summary table of risk of bias for all studies included in the review).

The synthesis of study findings is presented by outcome in the following order: muscle mass, strength, physical performance, and sarcopenia.

Table 2. Summary of systematic review studies by outcome.

Muscle Mass	Muscle Strength	Physical Performance	Physical Performance + Muscle Strength	Physical Performance + Muscle Strength + Muscle Mass	Physical Performance + Muscle Mass	Sarcopenia
Bernstein, 2002 [33] Cross-sectional Risk of bias: High	Rahi, 2014 [35] Longitudinal; FU: 3 years Risk of bias: Medium	Milaneschi, 2011 [37] Longitudinal; FU: 3 years, 6 years and 9 years Risk of bias: Medium	Talegawkar, 2012 [41] Longitudinal; FU: 3 years and 6 years Risk of bias: Medium	Yokoyama, 2017 [46] Longitudinal; FU: 4 years Risk of bias: Medium	Smee, 2015 [47] Cross-sectional Risk of bias: High	Chan, 2016 [29] Longitudinal; FU: 4 years Risk of bias: Low
Oh, 2014 [31] Cross-sectional Risk of bias: Medium	Kojima, 2015 [36] Longitudinal; FU: 4 years Risk of bias: Medium	Shahar, 2012 [38] Longitudinal; FU: 8 years Risk of bias: Low	León-Muñoz, 2014 [42] Longitudinal; FU: 3.5 years Risk of bias: Low			Hashemi, 2015 [30] Cross-sectional Risk of bias: Medium
Nikolov, 2016 [34] Cross-sectional Risk of bias: Medium	Robinson, 2008 [25] Cross-sectional Risk of bias: Low	Akbaraly, 2013 [26] Longitudinal; FU: 16 years Risk of bias: Medium	León-Muñoz, 2015 [28] Longitudinal; FU: 3.5 years Risk of bias: Low			
		Perälä, 2016 [39] Longitudinal; FU: 10 years Risk of bias: Low	Granic, 2016 [32] Longitudinal; FU: 5 years Risk of bias: Medium			
		Martin, 2011 [27] Cross-sectional Risk of bias: Medium	Xu, 2012 [43] Cross-sectional Risk of bias: Low			
		Zbeida, 2014 [40] Cross-sectional Risk of bias: Medium	Bollwein, 2013 [44] Cross-sectional Risk of bias: Low			
			Fougère, 2016 [45] Cross-sectional Risk of bias: Medium			

FU: length of follow-up, for longitudinal studies.

Table 3. Characteristics of studies included in the systematic review.

First Author, Year	Setting	Study Participants	Study Design	Measure of Physical Function	Assessment of Dietary Intake + Measure of Diet Quality (DQ)	Association of Outcome with Exposure	Risk of Bias [a]
Muscle Mass							
Bernstein, 2002 [33]	The Boston FICSIT Study, Boston, MA, USA	98 men and women older than 70 years (aged 72 to 98 years) were recruited among residents of a nursing home Mean ± SD age: 87.1 ± 0.6 years	CS	Mean arm muscle area (MAMA) was calculated and thigh muscle area was measured using computerized tomography (CT) scanning.	3-day weighed food records on 3 consecutive days of the week Dietary indices: 2 dietary variety scores.		−4: High
					(1) Dietary variety score equal to the number of different foods eaten over 3 days.	MAMA approached a significant relationship with dietary variety score ($p = 0.06$) in both men and women. No association with thigh muscle area was reported.	
					(2) Fruit and vegetable variety score equal to the number of different fruits and vegetables consumed over the 3 days.	In women, high fruit and vegetable variety score only was associated with higher MAMA ($\beta = 2.94$) ($p \leq 0.03$). Thigh muscle area was tested and no significant association was found. Conclusions: Results suggest that a highly varied diet in elderly nursing home residents is associated with higher MAMA.	
Oh, 2014 [31]	The KNHANES 2011, Korea	1435 non-institutionalized Korean people who were aged 65 years or more Mean ± SD age: not given	CS	Appendicular skeletal muscle mass (ASM) was measured by DXA. ASM was defined as the sum of lean soft tissue masses for the arms and legs, after the method of Heymsfield et al. [48].	Single 24-h dietary recall Data-driven: cluster analysis.		+3: Med
					(1) "Traditional Korean" dietary pattern [b], in which consumption of white rice accounted for 76% of total energy intake.	Compared with the "Traditional Korean" pattern, the "Westernized Korean" pattern was associated with a 74% increased abnormality of ASM/Wt (kg) by logistics analysis.	
					(2) "Meat and Alcohol" dietary pattern, with a higher consumption of meat and alcohol.	No association was observed.	
					(3) "Westernized Korean" dietary pattern, based on a rice and vegetable diet but characterized by a variety of food groups such as other grains, fruit, bread, eggs, fish, milk, and alcohol.	See above. Conclusions: A "Westernized Korean" pattern was associated with a markedly increased abnormality of muscle mass, compared to the "Traditional Korean" pattern.	

Table 3. *Cont.*

First Author, Year	Setting	Study Participants	Study Design	Measure of Physical Function	Assessment of Dietary Intake + Measure of Diet Quality (DQ)	Association of Outcome with Exposure	Risk of Bias [a]
Muscle Mass							
Nikolov, 2016 [34]	BASE-II, Berlin, Germany	1509 community-dwelling, well-functioning older men and women between 60 and 80 years. Mean ± SD age: 68.2 ± 3.7 years	CS	Body composition was assessed by using DXA. ALM was calculated as the sum of bone-free lean mass of arms and legs and related to height and weight (ALM/BMI). The proportion of ALM to whole body fat mass (FM) was defined as the ALM/FM ratio.	Self-administered EPIC-FFQ. Dietary indices: Adherence to a Mediterranean dietary pattern was assessed using the Mediterranean-type diet score (mMedTypeDiet) suggested by Grosso and colleagues.	A higher adherence to the mMedTypeDiet was associated with higher ALM/BMI in women and better ALM/FM ratio when compared to a medium and a low diet quality. No significant association was found in men. Conclusions: Higher adherence to a Mediterranean-style diet was associated with a positive effect on ALM/BMI in women.	+3: Med
Muscle Strength							
Rahi, 2014 [35]	Secondary analysis of the NuAge cohort, QC, Canada.	156 community-dwelling men and women with type 2 diabetes Mean ± SD age: at baseline 74.6 ± 4.2 years	LS	Handgrip, knee extensor and elbow flexor strengths, were measured at recruitment and at the 3-year follow-up. Crude change was calculated by subtracting values at recruitment from values at the 3-year follow-up. In order to show the yearly MS decline, the percentage relative change per year was adjusted for baseline value.	Three non-consecutive 24-h dietary recalls (on two randomly-chosen weekdays and one weekend day). Dietary indices: DQ was evaluated at recruitment using the Canadian Healthy Eating Index (C-HEI).	There was no effect of DQ at baseline on maintenance of the three measures of muscle strength, in either males or females. Likewise, DQ, which was dichotomized based on the median or categorized into quartiles, showed no significant effects on MS maintenance. Conclusions: DQ alone had no effect on MS maintenance in this sample of diabetic older men and women. However, when good DQ was combined with stable or increased PA, MS losses were minimal in diabetic older males over the 3-year follow-up, despite some discordance between changes in MS in the upper and lower extremities.	+2: Med
Kojima, 2015 [36]	Itabashi Ward of Tokyo, Japan	575 community-dwelling women from the Itabashi Ward of Tokyo Mean ± SD age: ages ranged between 75 and 85 years (78.07 ± 2.56) in 2008 and between 78 and 89 years (82.07 ± 2.55) in 2012	LS	Isometric knee extension strength (KES, in N) was measured in the dominant leg using a hand-held dynamometer incorporated into a custom-made frame.	Participants were asked closed-ended questions about intake frequencies of 10 food groups Dietary indices: A DVS, an index of dietary variety introduced by Kumagai et al. [49], was calculated.	There was no significant cross-sectional relationship between KES and DVS. Longitudinal analysis showed that except for 3 food groups, no lifestyle-related variables at baseline were related to changes in KES over 4 years. Conclusions: The age-related decline in muscle strength was lower in people who frequently ate soy products or green and yellow vegetables, but no association was found with DVS.	+1: Med

Table 3. *Cont.*

First Author, Year	Setting	Study Participants	Study Design	Measure of Physical Function	Assessment of Dietary Intake + Measure of Diet Quality (DQ)	Association of Outcome with Exposure	Risk of Bias [a]
Muscle Strength							
Robinson, 2008 [25] *	HCS, UK	2983 community-dwelling men and women aged 59 to 73 years Mean ± SD age: Men: 65.7 ± 2.9 years; Women: 66.6 ± 2.7 years	CS	Maximum grip strength was measured using a handgrip Jamar dynamometer.	Administered FFQ based on EPIC questionnaire, pertaining to 3-month period preceding the interview. Data-driven: PCA. Using PCA, a "prudent" dietary pattern [c] was identified.	Men and women with high prudent diet scores had higher grip strength. In men, the association was no longer evident when fatty fish consumption was accounted for. In women, independent associations between grip strength and prudent diet score and fatty fish consumption remained, although the size of the effect was markedly reduced (regression coefficient of 0.17, 95% CI = 0.00 to 0.34 kg per unit change in score, $p = 0.044$). Conclusions: Whilst a healthier pattern of eating was associated with higher grip strength, this effect was at least partly explained by more prudent diets also being characterised by greater consumption of fatty fish.	+5: Low
Physical Performance							
Milaneschi, 2011 [37] *	InCHIANTI (Invecchiare in Chianti), study, Tuscany, Italy	Older men and women: 705 participants had available data on lower body mobility at 3-year follow-up, 614 at 6-year follow-up and 486 at 9-year follow-up. Mean ± SD age: at baseline 74.1 ± 6.8 years	LS	Lower extremity function was measured at baseline, and at the 3-, 6- and 9-year follow-up visits using the SPPB, which was derived from three objective tests: 4-m walking speed, repeated chair rises and standing balance in progressively more challenging positions.	FFQ created for EPIC, validated in this population. Dietary indices: Adherence to a Mediterranean dietary pattern was assessed using the MDS by Trichopoulou et al. [30].	At baseline, higher adherence to Mediterranean diet was associated with better lower body performance. Participants with higher adherence experienced less decline in SPPB score, which was of 0.9 points higher ($p < 0.0001$) at the 3-years follow, 1.1 points higher ($p = 0.0004$) at the 6-year follow-up and 0.9 points higher ($p = 0.04$) at the 9-year follow-up compared to those with lower adherence. Among participants free of mobility disability at baseline, those with higher adherence had a lower risk (HR (hazard ratio) = 0.71, 95% CI = 0.51–0.98, $p = 0.04$) of developing mobility disability (defined as SPPB ≤ 9 points). Conclusions: High adherence to a Mediterranean-style diet is associated with a slower decline of mobility over time in community-dwelling older persons.	+2: Med

Table 3. *Cont.*

First Author, Year	Setting	Study Participants	Study Design	Measure of Physical Function	Assessment of Dietary Intake + Measure of Diet Quality (DQ)	Association of Outcome with Exposure	Risk of Bias [a]
Physical Performance							
Shahar, 2012 [38]	Health, Aging, and Body Composition cohort study, USA	1201 participants Mean ± SD age: at baseline 74.6 ± 2.9 years (middle category of MD score)	LS	Performance-based evaluations included usual and rapid walking speed assessed over a 20-metre course.	Administered FFQ Dietary indices: Adherence to a Mediterranean dietary pattern was assessed using the MDS by Trichopoulou et al. [50].	Higher MD adherence was an independent predictor of less decline in usual 20 m walking speed ($p = 0.049$). The effect decreased after adding total body-fat-percent to the model ($p = 0.134$). Similar results were observed for MD adherence and rapid 20 m walking speed; the association remained significant after adjustment for total body-fat-percent ($p = 0.012$). Conclusions: Walking speed over 8 years was faster among those with higher MD adherence at baseline. The differences remained significant over 8 year, suggesting a long-term effect of diet on mobility performance with aging.	+4: Low
Akbaraly, 2013 [26]	Whitehall II study (London-based office staff), UK	5350 men and women aged 60 years or older at the final follow-up Mean ± SD age: at baseline 51.3 ± 5.3 years	LS	Walking speed over a 8-feet walking course.	Semi-quantitative FFQ Data-driven: PCA. Two dietary patterns were identified.		+2: Med
					(1) "Healthy-foods" dietary pattern.	No association was reported	
					(2) "Western-type" dietary pattern.	Participants in the highest tertile of "Western-type" dietary pattern, compared with those in the bottom tertile, were more likely to have poorer musculoskeletal functioning (OR (odds ratio) = 1.45; 95% CI = 1.14–1.84).	
					Dietary indices: Adherence to the Alternative Healthy Eating Index (AHEI) was calculated.	No association was reported Conclusions: Avoidance of "Western type foods" might increase the possibility of achieving older ages with better musculoskeletal functioning (faster walking speed).	

Table 3. *Cont.*

First Author, Year	Setting	Study Participants	Study Design	Measure of Physical Function	Assessment of Dietary Intake + Measure of Diet Quality (DQ)	Association of Outcome with Exposure	Risk of Bias [a]
Physical Performance							
Perälä, 2016 [39]	Helsinki Birth Cohort Study, Finland	1072 men and women Mean ± SD age: 61.3 ± 0.2 (SE) years	LS	Physical performance was assessed using the validated Senior Fitness Test (SFT) battery [d].	Self-administered FFQ pertaining to the previous 12 months Dietary indices: An a priori-defined Nordic diet score (NDS) was calculated, as a measure of a healthy Nordic diet.	In a fully adjusted model, the overall Senior Fitness Test (SFT) score was 0.55 (95% CI = 0.22, 0.88) points higher per 1 unit increase in the NDS. Women in the highest fourth of the NDS had on average 5 points higher SFT score compared with those in the lowest fourth (p for trend 0.005). No such association was observed in men. Women with the highest score had 17% better result in the walk test, 16% better arm curl and 20% better chair stand results compared with those with the lowest score (all p values < 0.01). Conclusions: The study indicates that among women a healthy Nordic diet predicts better physical performance, and especially better aerobic endurance and upper- and lower-body strength 10 years later.	+5: Low
Martin, 2011 [27] *	HCS, UK	628 community-dwelling men and women Mean ± SD age: 68.0 ± 2.5 years	CS	Participants completed a short physical performance battery. This included measures of time taken to complete a 3-m customary pace walk and 5 sit–stand chair rises; balance performance was assessed by measurement of one-legged timed standing balance.	Administered FFQ pertaining to 3-month period preceding the interview Data-driven: PCA. A "prudent" dietary pattern was identified [c].	In men, no independent associations were found between 3-m walk time and diet. For women, a higher prudent diet score was associated with shorter 3-m walk time (p = 0.016), although this association was not robust to adjustment for confounding factors. In men, there were no associations between diet and chair-rise time. Among the women, univariate comparisons showed that shorter chair-rise times were associated with higher prudent diet scores (p = 0.011). However, this association was not robust to adjustment. Higher prudent diet scores in the women were associated with better balance (p = 0.033) but this was not robust to adjustment for confounders. This association was not observed in men. Conclusions: There were no independent associations between the dietary pattern and physical performance.	+3: Med

Table 3. *Cont.*

First Author, Year	Setting	Study Participants	Study Design	Measure of Physical Function	Assessment of Dietary Intake + Measure of Diet Quality (DQ)	Association of Outcome with Exposure	Risk of Bias [a]
Physical Performance							
Zbeida, 2014 [40] *	US NHANES and the Israeli MABAT ZAHAV survey °	NHANES: 2791 people aged 60 years and older. Mean age: 71.2 years.	CS	Observed timed 20-feet walk.	24-h multiple-pass dietary recall interview on a random day of the week. Dietary indices: Adherence to a Mediterranean dietary pattern was assessed using the MDS, similar to that constructed by Trichopoulou et al. [50].	MDS (high vs. low) was associated with faster walking speed after adjusting for confounders in a logistic regression model (OR = 0.71, $p = 0.034$, 95% CI = 0.511–0.974). Conclusions: In a secondary analysis of the national health and nutrition survey data from the US, adherence to the Mediterranean diet was significantly associated with better physical functional abilities among older people.	+2: Med
Physical Performance + Muscle Strength							
Talegawkar, 2012 [41] *	InCHIANTI (Invecchiare in Chianti), study, Tuscany, Italy	690 older men and women (people ≥ 65 years) Mean ± SD age: at baseline 73.0 ± 6.24 years	LS	MS: grip strength. PP: walking speed (time to walk 15 feet).	FFQ created for EPIC, validated in this population. Dietary indices: Adherence to a Mediterranean dietary pattern was assessed using the MDS by Trichopoulou et al. [50].	MS: No association was observed for grip strength. PP: After a 6-year follow-up, higher adherence to a MD at baseline was associated with a lower risk of low walking speed (OR = 0.48 (95% CI = 0.27, 0.86)). Conclusions: In community-dwelling older adults, higher adherence to a Mediterranean-style diet was associated with a lower risk of low walking speed.	+2: Med
León-Muñoz, 2014 [42] *	ENRICA cohort, Spain	1815 community-dwelling people aged ≥ 60 years Mean ± SD age: at baseline 68.5 ± 0.3 years	LS	MS: measured with a Jamar dynamometer on the dominant hand. PP: walking speed was assessed using the 3-meter walking speed test.	Validated computerized diet history. Dietary indices: Adherence to a Mediterranean dietary pattern.		+4: Low
					(1) Mediterranean Diet Adherence Screener (MEDAS).	MS: No significant association was observed. PP: Being in the highest tertile of the MEDAS score (highest MD adherence) was associated with reduced risk of slow walking (OR = 0.53; 95% CI = 0.35–0.79).	
					(2) MDS.	MS: Participants in the highest tertile of the MDS had lower risk of low grip strength, but the association was not statistically significant. PP: No association was observed. Conclusions: Among community-dwelling older adults a higher adherence to the MD was associated with reduced risk of slow walking.	

Table 3. *Cont.*

First Author, Year	Setting	Study Participants	Study Design	Measure of Physical Function	Assessment of Dietary Intake + Measure of Diet Quality (DQ)	Association of Outcome with Exposure	Risk of Bias [a]
Physical Performance + Muscle Strength							
León-Muñoz, 2015 [28]	ENRICA cohort, Spain	1872 community-dwelling people aged ≥ 60 years Mean ± SD age: at baseline: 68.7 ± 0.3 years	LS	MS: strength on the dominant hand was measured with a Jamar dynamometer. PP: walking speed was assessed with the 3-m walking speed test.	Validated computerized diet history. Data-driven: Factor analysis. Two patterns were identified.		+5: Low
					(1) The first was called the "prudent" pattern due to the high consumption of olive oil, vegetables, potatoes, legumes, blue fish, pasta, and meat.	MS: No association was observed	
						PP: A greater adherence to the prudent pattern showed a non-statistically significant tendency to a lower risk of slow walking speed.	
					(2) The second was called the "Westernized" pattern because of the high consumption of refined bread, whole dairy products, and red and processed meat, as well as the low intake of whole grains, fruit, low-fat dairy, and vegetables.	MS: No association was observed.	
						PP: The westernized pattern showed an association with an increasing risk of slow walking speed. Specifically, the OR (95% CI) of slow walking speed across tertiles of the WP were 1, 1.15 (0.74–1.76), and 1.85 (1.19–2.87); *p*-trend = 0.007. Conclusions: Greater adherence to the "Westernized" pattern was associated with increased risk of slow walking speed.	

Table 3. *Cont.*

First Author, Year	Setting	Study Participants	Study Design	Measure of Physical Function	Assessment of Dietary Intake + Measure of Diet Quality (DQ)	Association of Outcome with Exposure	Risk of Bias [a]
Physical Performance + Muscle Strength							
Granic, 2016 [32]	The Newcastle 85+ Study, UK	791 men and women (living either at home or in a care facility) were followed-up for change in hand grip strength (HGS) and Timed Up-and Go (TUG) test over 5 years. Participants with DP and HGS data 5 years later ($n = 291$). Participants with DP and TUG data 5 years later ($n = 271$) Mean age: the Newcastle 85+ Study targeted 85 years old at baseline	LS	MS: hand grip strength (HGS) was assessed using a hand-held dynamometer. PP: assessed by the Timed Up-and-Go (TUG) test.	24-h multiple-pass dietary recall on two different days of the week, at least one week apart. Data-driven: Cluster analysis. Three dietary patterns (DP) were identified.		+3: Med
					(1) DP1 ("High Red Meat").	MS: Men in DP1 ("High Red Meat") had worse overall HGS ($\beta = -1.70$, $p = 0.05$) compared with DP2 ("Low Meat"). No association between DP and HGS was observed in women.	
						PP: Men in DP1 and women in DP3 had overall slower TUG than those in DP2 ($\beta = 0.08$, $p = 0.001$ and $\beta = 0.06$, $p = 0.01$, respectively), but similar rate of decline.	
					(2) DP2 ("Low Meat").	MS: See above and below.	
						PP: See above.	
					(3) DP3 ("High Butter").	MS: Men in DP3 ("High Butter") had a steeper decline in HGS ($\beta = -0.63$, $p = 0.05$) than men in DP2 ("Low Meat"). No association between DP and HGS was observed in women.	
						PP: See above. Conclusions: DP high in red meats, potato and gravy (DP1), or butter (DP3) may adversely affect muscle strength and physical performance in later life.	

Table 3. *Cont.*

First Author, Year	Setting	Study Participants	Study Design	Measure of Physical Function	Assessment of Dietary Intake + Measure of Diet Quality (DQ)	Association of Outcome with Exposure	Risk of Bias [a]
Physical Performance + Muscle Strength							
Xu, 2012 [43] *	1999–2002 NHANES, USA	The final sample size was 2132 for gait speed and 1392 for knee extensor power. Men and women aged 60 years or older Mean ± SD age: 70.4 ± 0.3 (SE) years	CS	MS: knee extensor power. Right knee extensor force production was measured using an isokinetic dynamometer. PP: gait speed; the timed 20-feet walk test was performed at the participant's usual pace.	24-h multiple-pass dietary recall interview. Dietary indices: The Healthy Eating Index-2005 (HEI-2005), a composite score assessing an individual's adherence to the 2005 Dietary Guidelines for Americans, was used to measure an individual's overall diet quality.	MS: Total HEI-2005 scores were positively associated with knee extensor power (p for trend = 0.05). Those with HEI-2005 scores in Quartile 4 had a greater knee extensor power compared with those with HEI-2005 scores in the lowest quartile (p = 0.04). The associations were no longer statistically significant after further adjustment for PA. PP: Total HEI-2005 scores were positively associated with gait speed (p for trend = 0.02). Older adults with higher HEI-2005 scores had a faster gait speed (p = 0.03 for both Quartile 3 and Quartile 4 versus Quartile 1) compared with those with HEI-2005 scores in the lowest quartile. The associations were no longer statistically significant after further adjustment for PA. Conclusions: Adherence to overall dietary recommendations was associated with better physical performance among older adults.	+4: Low
Bollwein, 2013 [44]	Region of Nürnberg, Germany	192 community-dwelling older men and women, aged 75 years and older Mean ± SD age: 83 ± 4 years	CS	MS: grip strength was measured with a dynamometer. PP: walking speed.	Administered FFQ of the German part of the EPIC study. Dietary indices: Adherence to a Mediterranean dietary pattern was assessed using the MD score used was the alternate MED score of Fung et al. [51] who adapted the original score of Trichopoulou et al. [50] for a non-Mediterranean population.	MS: No association was observed. PP: There was a significant inverse association between "low walking speed" and the MED score; there was an association between a high diet quality and a lower risk of low walking speed. Compared with the lowest quartile (least healthy diet), the participants in the highest quartile (most healthy diet) had a significantly decreased risk of low walking speed (OR (95% CI) = 0.29 (0.09–1.00), p for trend = 0.043). Conclusions: There was an association between adherence to a healthy dietary pattern and low walking speed.	+4: Low

Table 3. *Cont.*

First Author, Year	Setting	Study Participants	Study Design	Measure of Physical Function	Assessment of Dietary Intake + Measure of Diet Quality (DQ)	Association of Outcome with Exposure	Risk of Bias [a]
Physical Performance + Muscle Strength							
Fougère, 2016 [45]	TRELONG study, Northeast Italy	304 men and women, over 70 years of age at baseline (aged 77 years and over). Mean ± SD age: 86.3 ± 6.8 years	CS	MS: hand grip strength was measured using a dynamometer with the stronger hand. PP: The SPPB was used: standing balance, walking, and chair stand tests. Standing balance tests included tandem, semi tandem and side-by-side stands.	Unclear how dietary data were collected. Dietary indices: Adherence to a Mediterranean dietary pattern was assessed using the Mediterranean Style Dietary Pattern Score (MSDPS).	MS: No correlation was found for hand grip strength. PP: A statistically significant association (Regression coefficient = 1.0006; Std. Error = 0.4780; p-value = 0.0363) between participants with the highest adherence to the Mediterranean diet (fourth quartile) and high physical performance (SPPB > 7) was found. Conclusions: A statistically significant association between a high adherence to the Mediterranean diet and higher physical performance (SPPB) was found. These findings suggest that MD does not improve the muscle (hand grip) but rather improve global function (indicated by SPPB).	+1: Med
Physical Performance + Muscle Strength + Muscle Mass							
Yokoyama, 2017 [46]	Kusatsu Longitudinal Study, and the Hatoyama Cohort Study, Japan	Community-dwelling Japanese aged 65 years or older. Grip strength: n = 781; Gait speed: n = 772; Body composition: n = 542 Mean ± SD age: according to DVS categories: Lowest: 71.1 ± 4.9; Middle: 71.8 ± 5.1; Highest: 72.8 ± 5.6	LS	MM: Body composition was measured using the InBody 720 device. In this study, lean body mass refers to bone-free lean mass. The sum of non-fat, non-bone tissue in both arms and legs was used to represent ALM. MS: grip strength was measured using hand dynamometers, with the dominant hand. PP: usual gait speed was measured over a straight 11-m walkway.	Participants were asked about consumption frequencies during 1 week for 10 food items. Dietary indices: Dietary variety was assessed at the baseline survey using the DVS (a method of assessing dietary quality based on a count of the number of foods consumed). DVS was categorized into 3 groups.	MM: Dietary variety was not significantly associated with changes in lean body mass or ALM. However, the OR for decline in ALM tended to decrease with increasing DVS at baseline; the multivariable-adjusted OR for decline in ALM was 0.28 (0.07–1.07) for the highest DVS category as compared with the lowest DVS category (p for trend = 0.068). MS: ORs for decline in grip strength was 0.43 (95% CI = 0.19–0.99), for the highest category of dietary variety score as compared with the lowest category. PP: ORs for decline in usual gait speed was 0.43 (confidence interval, 0.19–0.99), respectively, for the highest category of dietary variety score as compared with the lowest category. Conclusions: Greater dietary variety was associated with lower risk for future declines in physical function (muscle strength and gait speed), but the associations with lean body mass and ALM were less clear. The findings indicate that among older adults, greater dietary variety may help maintain physical performance and muscle strength but not lean mass.	+3: Med

Table 3. *Cont.*

First Author, Year	Setting	Study Participants	Study Design	Measure of Physical Function	Assessment of Dietary Intake + Measure of Diet Quality (DQ)	Association of Outcome with Exposure	Risk of Bias [a]
Physical Performance + Muscle Mass							
Smee, 2015 [47]	Canberra, Australia	171 cognitively unimpaired, community-dwelling men and women aged 60 years and over Mean ± SD age: 68.12 ± 6.21 years	CS	MM: Lean mass was assessed by DXA. PP: measured using the SPPB.	Valid semi-quantitative self-administered questionnaire. Dietary indices: Diet quality was determined using two measures.		–4: High
					(1) Healthy Eating Index (HEI)	MM: Lean mass was not significantly associated with the HEI-total score.	
						PP: SPPB was not significantly associated with the HEI-total score.	
					(2) Healthy Diet Indicator (HDI)	MM: In women, there was a weak positive association between HDI score and % lean mass ($r = 0.20$, $p = 0.03$). When controlling for age, there was a weak negative correlation ($r = 1.19$, $p = 0.03$).	
						PP: Men showed weak positive associations between HDI score and SPPB ($r = 0.26$, $p = 0.04$). Conclusions: In women, there was a weak association between better diet quality and higher lean mass, which disappeared when controlling for age. In men there was a weak association between better diet quality and better physical function (SPPB).	

Table 3. *Cont.*

First Author, Year	Setting	Study Participants	Study Design	Measure of Physical Function	Assessment of Dietary Intake + Measure of Diet Quality (DQ)	Association of Outcome with Exposure	Risk of Bias [a]
Sarcopenia							
Chan, 2016 [29]	Hong Kong, China	Chinese community-dwelling men and women, aged 65 years or older. The final sample size for the cross-sectional analyses was 3957 and for the prospective analyses was 2948 Mean ± SD age: At baseline: Non-sarcopenic participants (n = 3667): 72.2 ± 5.0 years; Sarcopenic participants (n = 290): 76.2 ± 6.1 years	LS	Sarcopenia was defined according to the AWGS algorithm. An individual with low muscle mass, low muscle strength, and/or low physical performance was categorized as having sarcopenia.	Validated semi-quantitative FFQ Data-driven factor analysis.		+5: Low
					(1) "Vegetables-fruits" dietary pattern.	At baseline, men with higher "vegetables-fruits" dietary pattern score, and higher "snacks-drinks-milk products" dietary pattern score had lower likelihood of being sarcopenic. Men in the highest quartile of "vegetables-fruits" pattern score (adjusted OR = 0.60, 95% CI = 0.36–0.99, p for trend = 0.034) showed reduced likelihood of sarcopenia compared with men in the lowest quartile. No such associations were observed in women. No significant associations were found between any of the dietary patterns and 4-year incident sarcopenia.	
					(2) "Snacks-drinks-milk products" dietary pattern.	See above. Higher quartile of "snacks-drinks-milk products" pattern score was associated with lower likelihood of sarcopenia in men (adjusted OR = 0.41, 95% CI = 0.24–0.70, p for trend < 0.001). No such associations were observed in women.	
					(3) "meat-fish" dietary pattern.	Sarcopenia: No association was observed.	
					Dietary indices.		
					(1) Adherence to a Mediterranean dietary pattern was assessed using the MDS by Trichopoulou et al. [50]	Sarcopenia: No associations were found between MDS and sarcopenia.	
					(2) The Diet Quality Index-International (DQI-I) was calculated.	Sarcopenia: At baseline, men with higher DQI-I score had lower likelihood of being sarcopenic. Men in the highest quartile of DQI-I had reduced likelihood of sarcopenia (adjusted OR = 0.50, 95% CI = 0.31–0.81, p for trend = 0.004) compared with men in the lowest quartile. No such associations were observed in women. No significant associations were found between dietary patterns and 4-year incident sarcopenia. Conclusions: Higher DQI-I score, higher "vegetables-fruits" dietary pattern score, and higher "snacks-drinks-milk products" dietary pattern score were associated with lower likelihood of prevalent sarcopenia in Chinese older men.	

Table 3. *Cont.*

First Author, Year	Setting	Study Participants	Study Design	Measure of Physical Function	Assessment of Dietary Intake + Measure of Diet Quality (DQ)	Association of Outcome with Exposure	Risk of Bias [a]
Sarcopenia							
Hashemi, 2015 [30]	Tehran, Iran	300 elderly men and women (55 years old and older) who lived in the sixth district of Tehran Mean ± SD age: 66.8 ± 7.72 years	CS	Sarcopenia was defined according to EWGSOP criteria, based on a combination of relatively low appendicular muscle mass with either low muscle strength or low muscle performance.	Administered FFQ. Data-driven: PCA. Three major dietary patterns were identified.		+2: Med
					(1) Mediterranean, defined as a dietary pattern with high factor loadings (>0.4) in food groups such as olives and olive oil, low and high carotenoid vegetables, tomatoes, whole grains, nuts, fish, fresh and dried fruits, and pickles.	Participants in the highest tertile of the MD pattern had a lower odds ratio for sarcopenia than those in the lowest tertile (OR = 0.42; 95% CI = 0.18–0.97; *p* for trend = 0.04).	
					(2) Western, defined as a dietary pattern with high factor loadings in tea, soy, sweets, desserts, sugars, and fast foods.	Adherence to the Western dietary pattern was not associated with sarcopenia (OR = 0.51; 95% CI = 0.21–1.24; *p* for trend = 0.13).	
					(3) Mixed, identified as a pattern with high factor loadings in the following food groups: animal proteins, legumes, potatoes, and refined grains.	Adherence to the Mixed dietary pattern did not affect the odds of sarcopenia (OR = 1.45; 95% CI = 0.66–3.19; *p* for trend = 0.95). Conclusions: The study suggests that adherence to the MD is associated with lower odds of sarcopenia among Iranian older adults.	

DQ: diet quality; FICSIT, Frailty and Injuries: Cooperative Studies of Intervention Techniques; SD: standard deviation; KNHANES: Korean National Health Examination and Nutrition Survey; CS: Cross-sectional study; LS: Longitudinal study; DXA: dual-energy X-ray absorptiometry; ALM: Appendicular lean mass; EPIC: European Prospective Investigation into Cancer and Nutrition; FFQ: food frequency questionnaire; PA: physical activity; DVS: Dietary Variety Score; PCA: Principal component analysis; SPPB: short physical performance battery; HCS: Hertfordshire Cohort Study; MDS: Mediterranean diet score; MD: Mediterranean diet; NHANES: National Health and Nutrition Examination Survey; AWGS: Asian Working Group for Sarcopenia; EWGSOP: European Working Group on Sarcopenia in Older People. [a] Risk of bias quality rating: total score −9 to −3 = high risk of bias; −2 to +3 = medium risk of bias; +4 to +10 = low risk of bias. [b] The Korean diet typically consists of white rice, soup and side dishes with many plant foods, and is characterized as a low-fat and high-vegetable diet. [c] A "prudent" dietary pattern reflects recommendations for a healthy diet. A "prudent" diet score was calculated for each participant that indicates compliance with the pattern. A high prudent diet score (in the upper part of distribution of scores) indicates a diet characterised by high consumption of fruit, vegetables, whole-grain cereals and oily fish, but low consumption of white bread, chips, sugar and full fat dairy products. [d] The Senior Fitness Test (SFT) battery consisted of five measurements of physical fitness: (1) number of chair stands during 30 s to assess lower-body strength, (2) arm curl to assess upper-body strength, (3) chair sit and reach to assess lower-body (hamstring) flexibility, (4) back scratch to assess upper-body (shoulder) flexibility and (5) 6-min walk test to measure aerobic endurance (distance walked in 6 min). [e] MABAT ZAHAV: Physical function data were collected using subjective criteria and therefore not relevant to this review. * There is another included study related to this cohort or survey in this table (these studies are separate studies within the same cohort).

3.1. Muscle Mass

Of the five studies that included muscle mass as an outcome (Table 2), four showed a positive association with diet quality. Four were cross-sectional [31,33,34,47]; none had a low risk of bias, and two had a high risk of bias [33,47]. Of the five studies, one used *a posteriori* methods to assess diet quality [31], and four used dietary indices or a priori measures of diet quality [33,34,46,47]. One of the studies was European [34], one was from the US [33], one was Australian [47], and two were from Asia [31,46].

A cross-sectional study [33] found that in women, a higher fruit and vegetable variety score was associated with higher mid-arm muscle area. Another cross-sectional study from Korea [31] found that a westernized dietary pattern was associated with a markedly increased abnormality of muscle mass (ASM/Wt (kg)) (authors defined abnormality of ASM/Wt as being less than the value of a young reference group, aged 20–39 years), compared to a more traditional pattern. However, no association was observed for a dietary pattern characterised by a higher consumption of meat and alcohol, and muscle mass. Another cross-sectional study [34] found that better adherence to a Mediterranean diet was associated with better muscle mass outcomes in women, but not in men. An Australian cross-sectional study [47] did not find an association between lean mass and the HEI (Healthy Eating Index) score; however, in women, there was a weak association between a higher HDI (Healthy Diet Indicator) score and higher percentage of lean mass, which disappeared when adjusted for age. The single longitudinal study [46] found that better diet quality (greater dietary variety) was not significantly associated with changes in either lean body mass or appendicular lean mass.

To summarise, there is a small body of mainly cross-sectional evidence regarding the relationship between diet quality and muscle mass, suggesting a possible relationship between healthier diets and better muscle mass outcomes in older people, especially in women. Overall, however, the evidence for an association between diet quality and muscle mass is weak, especially given the relatively lower quality of studies in this group.

3.2. Muscle Strength

Eleven of the included studies examined muscle strength as an outcome (Table 2), of which five showed a positive association with diet quality. Four were cross-sectional studies [25,43–45] and five had a low risk of bias [25,28,42–44]. Of the 11 studies, three used *a posteriori* methods to assess diet quality [25,28,32], and eight used a priori measures of diet quality [35,36,41–46]. Seven of the studies were European [25,28,32,41,42,44,45], two were North American [35,43], and two were from Japan [36,46].

One of the cross-sectional studies [25] found a healthier pattern of eating to be independently associated with higher handgrip strength in women but not in men. Another cross-sectional study [43] found that higher total HEI-2005 scores were associated with greater knee extension strength, however this association was no longer statistically significant after adjustment for physical activity. Two cross-sectional studies [44,45] found no statistically significant associations between higher adherence to a Mediterranean dietary pattern and handgrip strength. In a longitudinal study [32], dietary patterns high in red meats, potato and gravy, or butter were associated with lower grip strength and greater decline in grip strength in men, however, no association was observed in women. A longitudinal Japanese study [46] found greater dietary variety to be associated with lower risk for future declines in grip strength. Conversely, three other longitudinal studies [28,41,42] found no statistically significant associations between diet quality and handgrip strength. Another longitudinal study [35] showed no significant association between diet quality measured using the C-HEI (Canadian Healthy Eating Index) at baseline and maintenance of three measures of muscle strength. Similarly, a longitudinal study of Japanese women [36], found no significant relationship between diet quality (dietary variety) and knee extension strength.

To summarise, few studies have found positive associations between diet quality and muscle strength, and there is limited evidence for a link between "healthier" diets and lower risk of declines in

muscle strength. There was a suggestion that the effects of diet on muscle strength might be different for men and women, however the evidence was inconsistent. The quality of studies was fairly good, given that almost half the studies had a low risk of bias and the others had a medium risk of bias. Overall, however, the current evidence regarding the relationship between diet quality and muscle strength is inconsistent.

3.3. Physical Performance

Of the 15 studies that looked at physical performance (Table 2), 14 showed a positive association with diet quality. Six studies were cross-sectional [27,40,43–45,47]; and six had a low risk of bias [28,38,39,42–44]. Of the 15 studies, four used *a posteriori* methods to assess diet quality [26–28,32], and 12 used a priori measures [26,37–47]. Ten of the studies were European [26–28,32,37,39,41,42,44,45], three of the studies were from the US [38,40,43], one was Australian [47], and one from Japan [46].

Two cross-sectional studies [40,44] found an association between higher adherence to a Mediterranean dietary pattern and faster walking speed (better physical performance). Another cross-sectional study [45] found that high adherence to a Mediterranean dietary pattern was associated with a higher SPPB score (better physical performance). A cross-sectional study [43] found that older adults with higher HEI-2005 scores had a faster walking speed, although this association was no longer statistically significant after adjustment for physical activity. On the other hand, another cross-sectional study [47] found no significant association between HEI score and SPPB score in either men or women (separately), but in men there was a weak association between a higher HDI score and better SPPB. Another study [27] did not find any independent associations between a "prudent" dietary pattern and physical performance measures. A longitudinal study [28] found that greater adherence to a "Westernized" diet pattern was associated with increased risk of slow walking speed, after a follow-up period of three and a half years. A greater adherence to a "prudent" diet pattern showed a statistically non-significant association with a lower risk of slow walking speed. Similarly, another longitudinal study [26] found that participants with greater adherence to the "Western-type" dietary pattern were more likely to have lower walking speed; the study did not find an association for the "healthy-foods" dietary pattern, or for adherence to the AHEI (Alternative Healthy Eating Index). A longitudinal study [42] found that a higher Mediterranean diet score was associated with reduced risk of slow walking after the follow-up period. Another longitudinal study [46] found that greater dietary variety was associated with lower risk for future declines in walking speed. Three other longitudinal studies [37,38,41] reported consistent associations between higher adherence to a Mediterranean diet at baseline and better physical performance (smaller decline) after follow-up periods ranging from three to nine years (in two studies, measured as walking speed, and in one using the SPPB), even when adjusting for physical activity in two of them [37,38]. In a longitudinal study [32], men with dietary patterns high in red meats and women with dietary patterns high in butter had worse physical performance (slower Timed Up-and-Go Test) than those with a "low meat" pattern, but similar rates of decline. Another longitudinal study [39] found that for women a healthy Nordic diet predicted better physical performance (SFT) at 10-year follow-up; however, no such association was observed in men.

To summarise, there is a sizeable body of longitudinal evidence regarding the relationship between diet quality and physical performance, which shows consistent evidence for a link between "healthier" diets and smaller declines in physical performance. The evidence suggests that there may be differences in the effects of diet on performance for men and women, although these gender differences were inconsistent across the studies reviewed. The quality of studies was fairly good, given that the majority of studies had a medium risk of bias and six had a low risk of bias. Overall, the current observational evidence of a positive relationship between diet quality and physical performance is strong.

3.4. Sarcopenia

Both of the studies that looked at sarcopenia (Table 2) showed an association with diet quality; one had a low risk of bias [29] and the other a medium risk of bias [30]. Both of the studies used data-driven methods to measure diet quality and one also used dietary indices [29]. A cross-sectional Iranian study [30] found that individuals with greater adherence to a Mediterranean diet pattern had a lower odds ratio for sarcopenia. A longitudinal study from China [29] found that a higher "vegetables–fruits" dietary pattern score was associated with lower likelihood of prevalent sarcopenia in older men; however, no such associations were observed in women. Although the study [29] found no association between adherence to a Mediterranean diet and odds of sarcopenia, it found that a higher DQI-I (Diet Quality Index—International) score was associated with lower likelihood of prevalent sarcopenia in older men, although no such association was observed in women. Furthermore, no significant associations were found between any of the diet quality measures and four-year incident sarcopenia in either gender.

To summarise, the small body of evidence for the relationship between diet quality and sarcopenia points to a possible association between healthier diets and lower likelihood of sarcopenia in older people. There is, however, a lack of longitudinal evidence for a relationship. The quality of studies was fairly good, given that one had a low risk of bias and the other a medium risk. Overall, there is some cross-sectional evidence for a link between "healthier" diets and lower odds of sarcopenia.

We could not carry out a meta-analysis for any of the groups of studies because the definitions of both the exposure (measures of diet quality) and outcomes (measures of muscle mass, muscle strength, physical performance and sarcopenia) varied widely between studies.

4. Discussion

We systematically assessed the evidence regarding the relationship between diet quality and muscle mass, muscle strength and physical performance, and sarcopenia in later life. To the best of the authors' knowledge this is the first study to systematically review this body of evidence. We found 23 studies of older adults (≥50 years) in which the association of overall diet quality and relevant outcomes was examined. The studies were diverse in terms of the design (cross-sectional vs. longitudinal, and the duration of follow-up), setting, participants included (ages varied from early old age to the very old), measures of diet quality, outcome measurements, as well as confounding factors adjusted for in the statistical models. These discrepancies could potentially contribute to some of the heterogeneity in the results.

Overall, there is a small body of mainly cross-sectional evidence suggesting a possible relationship between healthier diets and better muscle mass outcomes in older people, although, on the whole, the current evidence is fairly weak. There is limited evidence for a link between "healthier" diets and lower risk of declines in muscle strength, and overall the evidence is inconsistent. In contrast, there is a sizeable body of longitudinal evidence providing consistent evidence of a link between "healthier" diets and smaller declines in physical performance; overall, the current observational evidence for a positive relationship between diet quality and physical performance is strong. Overall, there is a small body of cross-sectional evidence pointing to a possible association between healthier diets and lower likelihood of sarcopenia in older people. There is, however, a lack of longitudinal evidence for a relationship. Some of the evidence suggests that there may be differences between men and women in terms of the effects of diet quality on both muscle strength and physical performance, although these findings were inconsistent and the overall message on differences by gender was not clear.

A recently published longitudinal study by Perälä and colleagues [52], not included in this review, provides further evidence of the benefits of diet quality for muscle strength (both grip strength and knee extensor strength). The authors found that in women, adherence to a healthy Nordic diet was associated with greater muscle strength measured 10 years later.

In general, "healthier" diets are characterised by greater fruit and vegetable consumption, greater consumption of wholemeal cereals and oily fish, which indicate higher intakes of a range of nutrients

and dietary constituents that could be important for health, including for muscle function, such as higher intakes of vitamin D and n-3 long-chain polyunsaturated fatty acids (LCPUFAs), higher antioxidant and protein intakes [18]. There is evidence for a link between differences in nutrient intake and status and the components of sarcopenia, with the most consistent associations found for protein, vitamin D, antioxidant nutrients and long-chain polyunsaturated fatty acids [18]. Protein intake has been recognised as one of the main anabolic stimuli for muscle protein synthesis [18]. There is growing evidence for benefits of supplementation with vitamin D to preserve muscle mass, strength and physical function in older age and to prevent and treat sarcopenia, and it could be that supplementation with vitamin D in combination with other nutrients might be important [18]. Sarcopenia is considered to be an inflammatory state driven by cytokines and oxidative stress; an accumulation of reactive oxygen species may lead to oxidative damage and likely contribute to losses of muscle mass and strength [10]. Omega-3 LCPUFAs have potent anti-inflammatory properties, and variations in intake could be of importance [10]. Aside from effects on inflammation, these fatty acids could also have direct effects on muscle protein synthesis [18]. "Healthier diets" are also higher in plant phytochemicals, such as polyphenols, which could have antioxidant and anti-inflammatory effects on muscle mass and function [18].

Although we did not find evidence for a longitudinal relationship between diet quality and sarcopenia in this review, there is evidence from a recent systematic review that better diet quality is associated with lower risk of prevalent, as well as future, frailty [53]. Nevertheless, of the 19 studies that were included in that review, only three studies examined the relationship between overall diet quality and frailty. The identification of frailty was based on the frailty phenotype described by Fried et al. [54], in two of the three studies, and on the FRAIL scale [55] in the other study. Some of the Fried frailty assessment components, namely muscle strength (grip strength) and physical performance (walking time), are common to sarcopenia. However, the FRAIL frailty scale is based on self-reported criteria (including difficulty walking), so the relationship with sarcopenia is less clear. A recent systematic review on diet quality and successful ageing [19] did not include any studies that investigated the link between diet quality measured using data-driven methods and physical function. The review did include studies that assessed the relationship between dietary indices and physical function in older adults (using both report-based and objective measures). Although there was a lack of longitudinal studies, the findings suggested a relationship between healthier diets and better physical function. Two recent systematic reviews investigated the relationship between adherence to a Mediterranean diet and musculoskeletal–functional outcomes; one focused on musculoskeletal health (including bone and muscle outcomes, specifically sarcopenia incidence or combined outcomes) in all ages [20], while the other investigated the association between a Mediterranean diet and frailty, functional disability and sarcopenia in older people [21]. The review findings indicate growing evidence of benefits of greater adherence to a Mediterranean diet, although they conclude that further research is needed to understand the relationship between a Mediterranean diet and sarcopenia and musculoskeletal health.

The studies included in the present review were all observational and most of them were from high-income countries (the majority of the studies were from countries in Europe or North America, four were from Asia, and one was from Australia). These are limitations of the current evidence-base and there is a need for more intervention studies, especially from lower-income populations, to improve our understanding of effects of diet quality on physical function. In most of the studies, diet was only assessed at one time point (baseline) therefore, any changes in diet during the follow-up period were not captured. Although different methods were used across the studies to assess dietary intake, different dietary assessment methods have been shown to define dietary patterns in a comparable manner [56–58]. The diversity in methods of diet quality assessment, e.g., different statistical techniques and numerous dietary indices with differing scoring approaches, should be noted; however, the core tenets of these measures are similar since the "healthiness" of diets is generally characterized by similar foods [11,13]. Around half of the included studies (n = 12) adjusted for energy intake in their analyses, and a limitation of this review is that energy intake was not considered as one of the important confounders when quality assessing the studies. A further limitation is that diverse measures of

effect sizes were used across the studies, making it difficult to draw any firm conclusions about effect size (the smallest effect size for the relationship between diet quality and physical performance was a regression coefficient of 0.06 and the largest was an odds ratio of 1.85). This systematic review employed a comprehensive search strategy, in which eight databases were systematically searched, and supplemented by hand searching and contact with experts. The approach to study selection, data extraction and quality assessment followed guidance for best practice in systematic reviews, and findings are reported according to the PRISMA guidance. Another strength is that this review provides evidence for the benefits of a range of diets on musculoskeletal–functional outcomes in older people, adding to the existing evidence base that links overall diet quality with health outcomes in later life, including all-cause mortality [16,59] and chronic disease [60]. A common limitation of systematic reviews is publication bias. Although we have attempted to mitigate against this by contacting experts and hand searching, we did not identify any unpublished analyses and it remains a potential limitation of this work.

5. Conclusions

This systematic review provides observational evidence to support the importance of diets of adequate quality to protect physical performance in older age. Findings for muscle mass, muscle strength and sarcopenia are also suggestive of a link with "healthier" diets, although there are gaps in the evidence base and further studies are needed. The balance of the existing observational evidence suggests that the potential of intervention studies that take a whole-diet approach, leading to changes in intakes of a range of foods and nutrients, should be explored as strategies for the prevention and/or management of age-related losses in muscle mass and physical function. Further intervention studies are needed, especially from lower-income countries and populations, to improve our understanding of effects of diet quality on sarcopenia and its components.

Supplementary Materials: The following are available online at http://www.mdpi.com/2072-6643/10/3/308/s1, Table S1: Search strategy and terms (application to the Ovid MEDLINE database); Table S2: Quality assessment form used to assess risk of bias of studies included in the review, alongside guidance notes relating to the scoring system; Table S3: Summary of scoring results in terms of risk of bias (low, medium or high) of all studies included in the review.

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Appendix I

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DEVELOPMENT OF A SHORT QUESTIONNAIRE TO ASSESS DIET QUALITY AMONG OLDER COMMUNITY-DWELLING ADULTS

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Abstract: *Objective:* To evaluate the use of a short questionnaire to assess diet quality in older adults. *Design:* Cross-sectional study. *Setting:* Hertfordshire, UK. *Participants:* 3217 community-dwelling older adults (59-73 years). *Measurements:* Diet was assessed using an administered food frequency questionnaire (FFQ); two measures of diet quality were defined by calculating participants' 'prudent diet' scores, firstly from a principal component analysis of the data from the full FFQ (129 items) and, secondly, from a short version of the FFQ (including 24 indicator foods). Scores calculated from the full and short FFQ were compared with nutrient intake and blood concentrations of vitamin C and lipids. *Results:* Prudent diet scores calculated from the full FFQ and short FFQ were highly correlated (0.912 in men, 0.904 in women). The pattern of associations between nutrient intake (full FFQ) and diet scores calculated using the short and full FFQs were very similar, both for men and women. Prudent diet scores calculated from the full and short FFQs also showed comparable patterns of association with blood measurements: in men and women, both scores were positively associated with plasma vitamin C concentration and serum HDL; in women, an inverse association with serum triglycerides was also observed. *Conclusions:* A short food-based questionnaire provides useful information about the diet quality of older adults. This simple tool does not require nutrient analysis, and has the potential to be of value to non-specialist researchers.

Key words: Diet quality, dietary assessment, short questionnaire, older adults.

Introduction

Declining food consumption and monotonous habitual diets make it difficult for some older people to meet nutrient needs (1, 2). However, relatively little is known about dietary choices in older age, and in particular, how age-related changes in physical and mental function impact on patterns of food consumption. As the 'healthiness' or quality of diet of older community-dwelling adults has been shown to be a strong predictor both of future health (3, 4) and mortality (5, 6), understanding more about the determinants of food choices is likely to be key to developing strategies to promote optimal health in later life.

Progress in this area is contingent on an ability to assess the diets of older community-dwelling adults, including individuals who may be hard to engage in research. The challenges of dietary assessment are significant, as current methods may be burdensome for older participants, and are also resource-intensive. With a growing focus on the importance of quality of diet in older age, Friesling and colleagues have recently conducted a systematic review of a priori-defined indexes of diet quality used in studies of older adults (7). In the majority of studies included in the review, the index scoring was based on estimates of food and nutrient intake, which require detailed dietary assessment and analysis. However, there is evidence to show that simpler, short food-based questionnaires describe diet quality well (8, 9). These have the advantages that they are less burdensome, do not require nutrient analysis, and offer the possibility that they can be used by non-specialists. This approach has been used successfully in one study of older people in the US; the dietary screening tool developed for the Geisinger Rural Aging Study has been shown to identify dietary patterns and detect nutritional risk in older adults (10, 11). To date, few studies have evaluated diet quality in older adults in the UK (5), and to our knowledge, there are no simple screening tools available to do this.

In this paper we describe the development of a short food-based questionnaire to assess diet quality in an older population of community-dwelling adults in the UK. We compare it with a full dietary assessment, and consider its characterisation of diet quality, in relation to nutrient intakes and blood lipid and vitamin C concentrations.

Methods

The Hertfordshire Cohort Study (HCS)

From 1911-48, detailed records were kept on all infants born in Hertfordshire, UK (12). In 1998, men and women born 1931-39 were traced using the NHS central registry; 1684 (54%) men and 1541 (52%) women agreed to be interviewed at home, when information was obtained on the participant's social and medical history, and diet was assessed. 1579 of these men (94%) and 1418 of the women (92%) subsequently attended a clinic for further investigations. Fasting blood

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samples were taken from participants who were not known to be diabetic (1459 men and 1329 women) for measurement of cholesterol and triglyceride concentrations; vitamin C concentration was assayed in a subgroup of participants (497 men and 545 women). Total cholesterol, high-density lipoprotein (HDL) cholesterol and triglyceride concentrations were measured using standard enzymatic methods; low-density lipoprotein cholesterol (LDL) concentrations were calculated using the Friedwald-Fredrickson formula (13). The measurement of Vitamin C concentration in plasma was based on the method of Margolis and Davis, using 6% metaphosphoric acid to stabilise the sample (14). Height was measured at clinic to the nearest 0.1cm using a Harpenden pocket stadiometer (Chasmors Ltd, London, UK) and weight to the nearest 0.1kg on a SECA floor scale (Chasmors Ltd, London, UK).

Dietary assessment

Diet was assessed using a food frequency questionnaire (FFQ) that was modified from the EPIC questionnaire (15). The FFQ includes 129 foods and food groups, and was used to assess an average frequency of consumption of the listed foods (never, <1/month, 1-3/month, 1/week, 2-4/week, 5-6/week, 1/day, 2-3/day, 4-5/day, ≥6/day) over the 3-month period preceding the interview. Each FFQ was administered by a trained research nurse. Prompt cards were used to show the foods included in each food group, to ensure standardised responses to the FFQ. Frequencies of other foods that were not listed on the FFQ were also recorded if consumed once per week or more. Standard portion sizes were allocated to each food apart from milk and sugar for which daily quantities consumed were recorded. Nutrient intakes were calculated by multiplying the frequency of consumption of a portion of each food by its nutrient content according to the UK national food composition database or manufacturers' composition data (13).

Development of the short dietary questionnaire

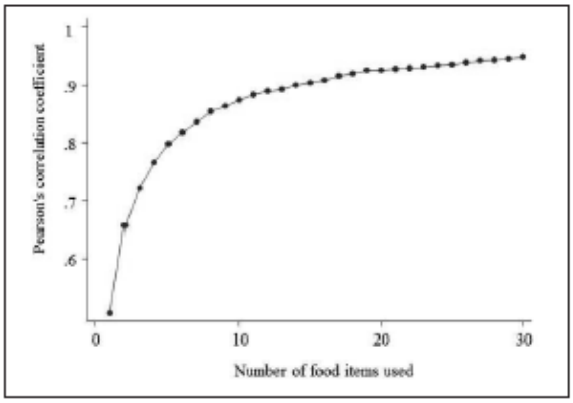
We have previously described the dietary patterns of the HCS participants, defined using principal component analysis (PCA) of the FFQ data (16). The first component in the PCA (that explains the greatest variance in the dietary data) described a dietary pattern that was characterised by high consumption of fruit and vegetables, oily fish and wholemeal cereals but low consumption of white bread, added sugar, full-fat dairy products, chips and processed meat. This pattern was labelled 'prudent' as it conforms to healthy eating recommendations. A prudent pattern score was calculated for every participant as follows: (i) fat spreads and milks were categorised as full-fat or reduced fat versions (reduced fat spreads <69g fat/100g, milks <3.5g fat/100g), (ii) weekly frequencies of consumption were calculated as: never=0, <1/month=0.2, 1-3/month=0.5, 1/week=1, 2-4/week=3, 5-6/week=5.5, 1/day=7, 2-3/day=17.5, 4-5/day=31.5, ≥6/day=42, (iii) food variables were standardised by subtracting the means and dividing by the SDs for the HCS population, (iv) the coefficient for each food (Table 2) was multiplied by the standardised food variable, (v) these values were summed - resulting in one score for each subject. The score indicates the participant's compliance with the prudent pattern, and was interpreted as a marker of their diet quality.

By definition, the foods that characterise the prudent pattern have the largest coefficients; variation in consumption of these indicator foods is therefore the primary determinant of variation in prudent pattern scores across the population. In a study of young women, we have previously shown that a short FFQ, that included 20 indicator foods, yielded useful information about quality of diet; when comparing prudent pattern scores calculated from the short or full FFQ, they were highly correlated and both showed comparable associations with a blood biomarker (red cell folate) (8). For the present study, we used the same approach, using HCS data (16), to develop a 'short FFQ' to estimate prudent diet scores, to characterise the diet quality of older adults.

To calculate the prudent diet score using a smaller number of foods, the individual coefficients from the PCA of the full FFQ (16), were used. To determine the number of foods to include in the short FFQ, we repeated the calculation of prudent diet scores, increasing the number of foods from 1 to 30; to evaluate the optimal number of foods to include, we examined the effect of increasing number of food items on the correlation between the prudent diet scores calculated from the smaller number of foods with the scores from the full FFQ.

Figure 1

Correlations between prudent diet scores calculated for 3217 older men and women in the Hertfordshire Cohort Study using the full FFQ and prudent diet scores calculated using between 1 and 30 food items



Data analysis

The normality of variables was assessed. Body mass index (BMI) and nutrient variables were not normally distributed and were transformed by taking their natural logarithms. Prudent diet scores were used as continuous variables to examine

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Table 1
Characteristics of participants in the Hertfordshire Cohort Study

	Men			Women		
	N	Mean	SD	N	Mean	SD
Age (yrs)	1677	65.6	2.9	1540	66.6	2.7
BMI (kg/m^2)[1]	1570	26.9	1.1	1416	27.2	1.2
		%			%	
Social class						
(N=1627 men, 1539 women)						
I-IIINM	664	40.8		639	41.5	
IIIM-V	963	59.2		900	58.5	
Current smokers						
(N=1677 men, 1538 women)	262	15.6		166	10.8	
Marital status						
(N=1676 men, 1540 women)						
Single/ divorced/						
separated/ widowed	246	14.7		429	27.9	
Married/cohabiting	1430	85.3		1111	72.1	
Age left education						
(N=1676 men, 1540 women)						
≤ 14 years	325	19.4		276	17.9	
≥ 15 years	1351	80.6		1264	82.1	

1. Geometric mean (SD)

how nutrient intakes and blood concentrations of vitamin C and lipids related to compliance with this dietary pattern; correlations and univariate linear regressions were used to explore the correlates of dietary pattern scores. In order to compare relationships between pattern scores and nutrient intake that were independent of total energy intake, nutrient intakes were adjusted for energy intake according to Willett's residual method (17). Data were analysed using Stata version 14 (18).

Results

Complete dietary data were available for 3217 men and women in the HCS. Their characteristics are shown in Table 1. To determine how many foods to include in the short FFQ, prudent diet scores were calculated using the principal component coefficients and reported consumption of an increasing number of foods (between 1 and 30 foods with the greatest coefficients (16), and compared with the prudent diet scores calculated from the full FFQ. We have previously reported that in separate principal component analyses of the HCS men's and women's dietary data, the dietary patterns were almost identical (16); the dietary data were therefore combined for the evaluation of the number of foods needed in a short FFQ. Figure 1 shows the correlation coefficients for each of these comparisons. Using a greater number of indicator foods in the calculation of the prudent diet score increased the correlations. For example, the correlation between the score calculated using the three foods with the largest coefficients (white bread, raw peppers, green salad (16)) and the score calculated from the full FFQ was 0.722, compared with a correlation of 0.948 when using 30 foods. The increases in correlation up to 10 foods were marked, but the increments thereafter with increasing number of foods became smaller. A pragmatic decision was made to include 22 foods in the short FFQ, to be able to provide good information about diet quality, but also including some other foods to mask the obvious contrast between 'healthy' and 'unhealthy' foods (eg eggs, boiled potatoes). Because the type of milks and spreading fats consumed were categorised as full-fat or reduced-fat, addition of the reduced-fat options increased the number of foods to 24 in the short FFQ (Appendix). The indicator foods for the prudent pattern identified in this cohort, together with the coefficients from the PCA, are shown in Table 2. The correlation between the short FFQ prudent diet score, based on 24 foods, and the prudent diet score calculated from the full

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FFQ was 0.912 in men and 0.904 in women.

Table 2
Indicator foods for the 'prudent' dietary pattern, identified in the Principal Component Analysis of the full FFQ: data from 3217 older men and women in the Hertfordshire Cohort Study

Food		Principal component coefficient
Positive coefficients		
1.	Peppers (raw and cooked)	0.193
2.	Green salad (eg lettuce, cucumber)	0.182
3.	Garlic (raw and cooked)	0.175
4.	Tropical fruits (eg melon, pineapple, kiwi)	0.154
5.	White fish (cooked, not in batter)	0.153
6.	Marrow and courgettes	0.151
7.	Oily fish (eg mackerel, salmon)	0.149
8.	Pasta (eg spaghetti, macaroni)	0.145
9.	Yogurt (low-fat)	0.134
10.	Brown or wholemeal bread	0.124
11.	Apples	0.114
12.	Bananas	0.103
13.	Reduced fat milk	0.054
14.	Reduced fat spread	0.018
Negative coefficients		
15.	Eggs (boiled, scrambled)	-0.047
16.	Boiled and jacket potatoes	-0.086
17.	Bacon and gammon	-0.089
18.	Biscuits	-0.101
19.	Full fat milk	-0.119
20.	Meat pies	-0.126
21.	Full-fat spreading fat	-0.149
22.	Chips	-0.152
23.	Added sugar	-0.159
24.	White bread	-0.201

We have previously shown in this cohort that, with the exception of retinol, prudent diet scores (full FFQ) are positively associated with micronutrient and protein intakes, but negatively associated with fat and saturated fat intakes (16). Figure 2 shows the pattern of correlations for prudent diet scores calculated from the full and short FFQs with intakes of individual nutrients. The pattern of associations between nutrient intake and prudent diet scores calculated using the short and full FFQs were very similar, and comparable for men and women.

Figure 2
Correlations between nutrient intakes calculated from the full FFQ and prudent diet scores assessed using the full or short FFQ: 3217 men and women in the HCS

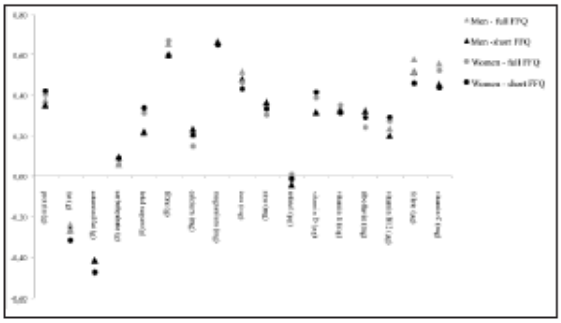

Table 3 shows associations between prudent diet scores (independent variable) and blood vitamin C and lipid concentrations (dependent variables). Prudent diet scores calculated from the full FFQ were positively associated with plasma vitamin C concentration and serum HDL; among women there was also an inverse association with serum triglycerides. There were no associations with serum total cholesterol or LDL concentrations in either sex. These patterns of association were also evident when using prudent diet scores calculated from the short FFQ (Table 3).

Discussion

We have shown that diet quality of older adults, defined by their 'prudent diet' scores, can be assessed using a short FFQ. Although the short questionnaire only included 24 indicator foods, the associations between prudent diet scores calculated from it, and nutrient intake, blood vitamin C and lipid concentrations, were similar to those seen with scores calculated from the full FFQ. These findings suggest that a short FFQ is a useful tool to assess diet quality among older community-dwelling men and women. The advantages of a short questionnaire are clear in terms of participant burden, and it may be of value for the collection of dietary information from older adults who are harder to reach in the population, and who may be more vulnerable. A particular advantage is that because it does not require nutrient analysis, it also offers potential as a useful tool for non-specialist researchers.

The quality of diet of older adults has received increasing attention in recent years, because of the clear links between diets of poor quality and poorer health (3-6). Although relatively few studies have evaluated diet quality in the UK, there is evidence that poor diets are common. For example, in a cross-country comparison of data from older adults, aged 50 and above, living in four European countries that included

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Table 3
Association between prudent diet scores (independent variable) calculated from full and short FFQs with blood vitamin C and lipid concentrations (dependent variables) in older men and women in the Hertfordshire Cohort Study

				Full prudent diet score			Short FFQ prudent diet score		
Men	**N**	**Mean**	**SD**	**β**	**95% CI**	**p-value**	**β**	**95% CI**	**p-value**
Vitamin C (μmol/l)	497	48.7	19.7	2.89	(2.19, 3.58)	<0.001	5.38	(3.97, 6.78)	<0.001
Triglycerides (z-score)[1]	1458	1.45	1.62	-0.017	(-0.038, 0.004)	0.104	-0.032	(-0.074, 0.010)	0.132
Cholesterol (z-score)	1458	5.93	1.03	-0.013	(-0.034, 0.008)	0.214	-0.031	(-0.073, 0.010)	0.142
HDL (z-score)[1]	1458	1.32	1.27	0.031	(0.010, 0.052)	0.004	0.054	(0.013, 0.096)	0.011
LDL (z-score)	1434	3.82	0.91	-0.017	(-0.038, 0.004)	0.110	-0.039	(-0.081, 0.003)	0.071
Women	**N**	**Mean**	**SD**	**β**	**95% CI**	**p-value**	**β**	**95% CI**	**p-value**
Vitamin C (μmol/l)	545	59.3	19.0	1.16	(0.50, 1.82)	0.001	3.33	(1.89, 4.77)	<0.001
Triglycerides (z-score)[1]	1329	1.47	1.57	-0.061	(-0.083, -0.039)	<0.001	-0.133	(-0.181, -0.086)	<0.001
Cholesterol (z-score)	1329	6.55	1.19	-0.014	(-0.036, 0.008)	0.214	-0.020	(-0.068, 0.028)	0.409
HDL (z-score)[1]	1329	1.66	1.27	0.055	(0.033, 0.077)	<0.001	0.113	(0.066, 0.161)	<0.001
LDL (z-score)	1313	4.08	1.06	-0.014	(-0.036, 0.009)	0.229	-0.016	(-0.065, 0.032)	0.510

1. Geometric mean (SD)

the UK, Irz and colleagues showed that overall diet quality in each of the older EU populations was low (19). These analyses used UK household food consumption data, but the message is consistent with findings from two other UK studies of older adults, in which detailed individual dietary assessments were carried out (5, 20). The cross-country comparison highlighted the heterogeneity within each population, indicating wide variation in diet quality (19). The influences on dietary choices and the causes of poorer diets in older age are not fully understood. As future development of effective nutrition policy to support older adults will require a clearer understanding of the drivers of diet quality, the development of simple assessment tools that enable routine collection of relevant dietary data could make an important contribution to this.

There may be particular challenges in assessing the diets of older adults. Experience from the Boyd Orr cohort, of collecting dietary data from adults aged 60 years and over, suggests that questionnaires need to be sufficiently detailed to capture dietary information across the population, whilst not being so onerous that they deter completion (21). There is growing interest in the use of short screening tools to assess diet, especially those that can be used in clinical practice (22). In a recent systematic review of 35 short dietary assessment tools for the management of obesity, cardiovascular disease and type 2 diabetes, England et al concluded that, in general, the tools demonstrated adequate validity (22), indicating the value of short assessment methods to enable collection of useful dietary information. Most studies were of younger adults, and many studies focused on specific foods or fat intake, rather than diet quality (22). Diet quality has been described in different ways, and a number of a priori scoring methods have been used, including the Healthy Eating Index, Recommended Diet Score and Mediterranean Food Score (23). As many overlap in terms of their common core tenets, they often show comparable associations with later health (6). However, a limitation is that the derivation of many of the existing dietary scores requires an assessment of nutrient as well as food intake. This has resource implications, and may limit data collection to specialist researchers. But to provide an overall 'picture' of diet quality may not require assessment of nutrient intake, and the potential for food based indices that retain the complexity of dietary information but are simple enough to enable use in monitoring and surveillance needs to be explored (21, 24, 25).

To our knowledge, the use of a food-based short assessment tool to evaluate dietary patterns of older adults was first reported in the Geisinger Rural Aging Study in the US (10, 11) The Dietary Screening Tool (DST) included 25 questions, and used a scoring algorithm to define diet quality (26). The DST captures information on the 'healthiness' of the diet in the US, and is therefore comparable with the prudent diet evaluated in the present study, although there are some differences in the foods included between the questionnaires developed in the two settings. We did not develop thresholds of nutritional risk from our data, but the overall findings of the studies are similar. Both the DST and the short FFQ-assessed prudent diet scores (based on 24 foods) showed associations with nutrient intake that were alike (positive associations with protein, fibre, most micronutrients, negative associations with fat and saturated fat intakes) as well as with blood lipid concentrations (positive association with HDL cholesterol concentrations, negative associations with serum triglyceride in women) (10). The two studies point to the value of short food-based questionnaires to provide useful information about the diet quality of older adults – a message that is consistent with findings of studies of

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younger age groups (8, 9, 27). Importantly, poor diet quality, identified by the DST has subsequently been shown to predict greater mortality in follow-up of the cohort (26).

A strength of the present study is that we collected dietary data from a large population of older men and women living in the community. Although membership of this cohort was defined by area of birth, and there has been loss to follow-up, the participants' characteristics are comparable with those of the wider community (12) and the findings should be of relevance to older adults in other parts of the UK. The prudent dietary pattern, that is the most important dietary pattern in the HCS cohort (16) describes compliance with healthy eating recommendations, and comparable patterns have been described in other studies of adults in the UK (28-30). A limitation of our study is that the short FFQ only defines compliance with the prudent dietary pattern; it does not provide useful information on other aspects of diet or measures of nutrient intake. However, the correlations between prudent diet scores assessed using the short FFQ and nutrient intake estimated from a complete dietary assessment (full FFQ) show that, a short food-based questionnaire can provide useful information about variation in nutrient intake (Figure 2). Although there are concerns about self-reported dietary data (31), and in particular, FFQs may be prone to measurement error (32), they have been shown to define dietary patterns in a comparable way to other dietary assessment methods (33, 34), and prudent diet scores in this study showed expected associations with a range of blood biomarkers. A weakness of the study is that the presented data are cross-sectional. A further limitation of our short FFQ is that it is designed to assess variation in diet in a UK context; because of cultural variations in diet between countries, its applicability in other settings would need to be evaluated.

Conclusion

This study provides strong evidence of the utility of a short food-based questionnaire to describe the diet quality of older adults. The tool is simple to administer, does not require nutrient analysis, and therefore has the potential to be of value to non-specialist researchers. The development of simple assessment tools that enable routine collection of relevant dietary data could make an important contribution to understanding the role of diet quality as an influence on the health of older adults.

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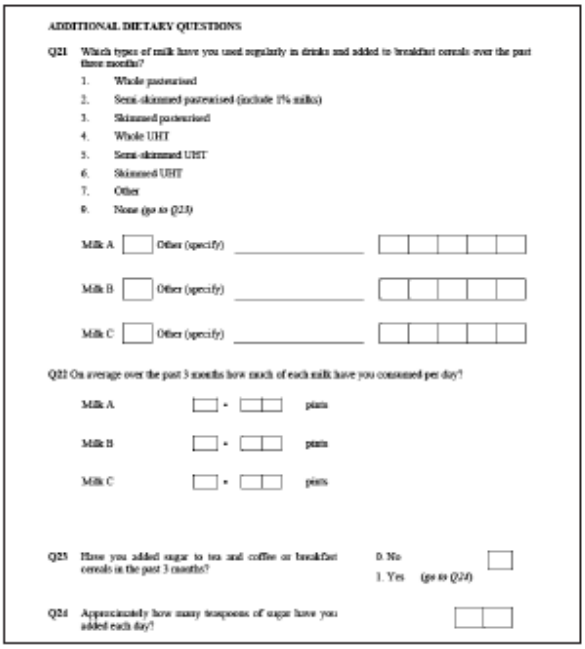
Conflict of interest: No author has a conflict of interest.

Ethical Standards: The study had ethical approval from the Bedfordshire & Hertfordshire Local Research Ethics Committee and the West Hertfordshire Local Research Ethics Committee. All participants gave written informed consent.

Appendix

Now I am going to ask you how often over the past 3 months you have eaten particular foods.

	FOOD AND AMOUNTS	AVERAGE USE IN PAST 3 MONTHS								
		Never	less than once a month	1-3 per month	Once a week	2-4 per week	5-6 per week	Once a day	2-3 per day	4-5 per day	6+ per day
1.	White bread (one slice)										
2.	Brown and wholemeal bread (one slice)										
3.	Biscuits eg digestive (one)										
4.	Apples (one fruit)										
5.	Bananas (one fruit)										
6.	Melon, pineapple, kiwi and other tropical fruits (medium serving)										
7.	Green salad eg lettuce, cucumber, celery										
8.	Garlic – raw and cooked dishes										
9.	Marrow and courgettes										
10.	Peppers – cooked & fresh										
11.	Yogurt (125g pot)										
12.	Eggs as boiled, fried, scrambled etc. (one egg)										
13.	White fish eg cod, haddock, plaice, sole (not in batter/crumbs)										
14.	Oily fish, eg. mackerel, tuna, salmon										
15.	Bacon and Gammon										
16.	Meat pies, eg. pork pie, pasties, steak & kidney, sausage rolls										
17.	Boiled, mashed and jacket potatoes (one egg size potato)										
18.	Chips										
19.	Pasta eg spaghetti, macaroni										
Which is the main spreading fat you have used for example on bread or vegetables?											
20.	Spreading fat (teaspoon) _____										



ADDITIONAL DIETARY QUESTIONS

Q21 Which types of milk have you used regularly in drinks and added to breakfast cereals over the past three months?

1. Whole pasteurised
2. Semi-skimmed pasteurised (include 1% milks)
3. Skimmed pasteurised
4. Whole UHT
5. Semi-skimmed UHT
6. Skimmed UHT
7. Other
9. None *(go to Q23)*

Milk A ☐ Other (specify) _____ ☐☐☐☐☐

Milk B ☐ Other (specify) _____ ☐☐☐☐☐

Milk C ☐ Other (specify) _____ ☐☐☐☐☐

Q22 On average over the past 3 months how much of each milk have you consumed per day?

Milk A ☐ . ☐☐ pints

Milk B ☐ . ☐☐ pints

Milk C ☐ . ☐☐ pints

Q23 Have you added sugar to tea and coffee or breakfast cereals in the past 3 months? 0. No ☐ 1. Yes *(go to Q24)*

Q24 Approximately how many teaspoons of sugar have you added each day? ☐☐

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