# Gender, diet quality and obesity

## Economic and social determinants, and their interactions, in older adults

Annalijn Ida Conklin

Trinity Hall

University of Cambridge

This dissertation is submitted for the degree of Doctor of Philosophy at the University of Cambridge

6 June 2014

Dedicated to Mom

With eternal love, infinite gratitude and deepest respect

# Contents

# List of tables

# List of figures

# Abbreviations

| | |
|---|---|
| BMI | Body mass index |
| CI95 | 95 percent confidence intervals |
| CVD | Cardiovascular disease |
| EPIC-Norfolk | European Prospective Investigation into Cancer United Kingdom Norfolk cohort |
| FFQ | Food Frequency Questionnaire |
| FH | Financial hardship |
| FV | Fruit and vegetable |
| HLEQ | Health and Life Experiences Questionnaire |
| HSQ | Health Survey Questionnaire |
| HRT | Hormone replacement therapy |
| SES | Socioeconomic status |
| T2D | Type 2 Diabetes |
| WC | Waist circumference |
| WHO | World Health Organization |

# Declaration of Originality

I declare that this dissertation is the result of my own work under the co-supervision of Drs Pablo Monsivais and Nita Forouhi, with additional advice of Professor Nicholas Wareham. I have not submitted this work, in whole or part, for any other degree at the University or elsewhere. This dissertation does not include work done in collaboration except where specifically indicated in the text and below.

My empirical studies used data collected by staff at either the University of Cambridge (for the EPIC-Norfolk cohort study) or the University College London (for the Whitehall II cohort study). I contributed 70% to the systematic review I present in Chapter 2 which I conducted in collaboration with Eva Maguire (EM) who was the second reviewer of the evidence examined. Most chapters are based on papers written in collaboration with multiple authors, together contributing approximately 10% to the work in my dissertation. For each study in Chapter 3 to Chapter 8, I solely performed all statistical analyses with advice from my co-supervisors and, for Chapter 3 and Chapter 7, from Professor Marc Suhrcke. I also conceived each study's objectives, interpreted the findings and led the writing of all manuscripts; thus, contributing approximately 90% to the work of co-authored papers. Chapter 2, 3, 4, 5, 7 and 8 were based on published papers or submitted manuscripts (see Appendix A); published work has been reproduced with permission from co-authors and, where required, from the publishers.

The dissertation complies with the 60,000 word limit for main text set by the Degree Committee of the Faculty of Clinical Medicine and Veterinary Medicine.

Annalijn Conklin, HBSc, MSc, MPH

MRC Epidemiology Unit, Centre for Diet and Activity Research

University of Cambridge, Trinity Hall

30 April 2014

# Acknowledgements

I am indebted to many colleagues and friends who have supported me in a diversity of ways. First and foremost, I am grateful to Dr Pablo Monsivais for his continuous enthusiasm of my ideas, regular discussions and feedback on the development of my research, and above all for his thoughtful mentorship. I am also thankful to Dr Nita G. Forouhi for her insightful and careful comments on my work, and for her willingness to provide guidance and advice on the Cambridge approach to collaborations. My work would not be possible without Professor Nicholas Wareham who gave me the opportunity to pursue this PhD and helped me to secure my funding from the Gates Cambridge Trust which I also acknowledge. Thank you Nick for your provocative "Wareham-onceover" questioning that challenged me on my decisions, thereby helping me to crystallise my thinking.

To my collaborators, thank you for providing me with timely and constructive feedback and support in the review process. I wish to thank Alvaro Ullrich for his contribution to the data structure used in the construction of the diversity scores from raw frequency data, and to Dr Andrew Cooper for his help in STATA coding and interpreting the variety scores used in Chapter 3 through Chapter 5. I further acknowledge statistical advice from Drs. Andy Atkin, Esther van Sluijs and Stephen Sharp, as well as assistance from Amit Bhaniani with my EPIC data request and updates. I am equally thankful to the Principal Investigators, managers, staff and participants of the EPIC-Norfolk cohort study.

Finally and most notably, I am deeply grateful to my father (Professor William E. Conklin), Daniela McDermott, Richard Leitch and my chosen family of Cambridge friends who have given me constant encouragement, love and praise. Thank you for your immeasurable gift of support!

# Abstract

Public health still needs to better understand how older people's life circumstances influence key risk factors for chronic disease, and also how women and men differ in their exposures and outcomes. This dissertation aimed to examine, separately for women and men, the role and inter-relationships of factors describing the economic and social contexts in relation to healthful eating and adiposity. A systematic review of economic determinants of diet in the elderly indicated that longitudinal evidence remains limited and focused on employment-related changes affecting diet. Thus, novel economic variables concerning financial hardship (FH) were examined in over-50s from the population-based EPIC-Norfolk cohort for associations with quantity and variety of fruit and vegetable intake, as proxies for healthful eating. FH was inversely associated with variety, more than quantity, independent of socioeconomic status (SES). Given the importance of social contexts for diet, it was notable that three aspects of structural social relationships were each associated with variety differently for women and men and, when combined, differed across categories of a second social tie. The next study of EPIC data investigated inter-relations between multiple economic variables, including FH, and social ties, demonstrating a magnification of unit differences in variety when economic and social disadvantage occurred simultaneously. Obesity is another chronic disease risk factor with known social gradients; thus a fourth study in EPIC examined associations of FH and SES with objectively measured obesity. All three FH measures were independently associated with general and central obesity, with the strongest relationships between greatest level of difficulty paying bills and central obesity in women, and general obesity in men. Finally, a longitudinal study of civil servants (Whitehall II) showed a strong association of persistent FH with 11-year adjusted mean weight change, and excess gain, in women only, which was not explained by any of the six potential mechanisms examined in mediation analyses. In sum, everyday financial troubles constituted a unique economic influence on diet quality and obesity in older adults, and the influence of a given economic or social factor on diet quality was modified when another

social factor was also considered. Unique aspects of economic or social circumstances, and their different combinations, must be considered separately in future public health research and practice as each reflects a distinct process of social differentiation and hence adds to our understanding of contextual influences on chronic disease risk factors.

# CHAPTER 1 Background and Introduction

## 1.1 Background context—why focus on older adults?

Healthy ageing across the lifespan is an important public health and policy issue in the EU and elsewhere.[1] Governments, including the UK, are facing not only a growing number of older-age individuals from changing demographics, but also a higher number of older adults who are in poor health. Many older people have one or more chronic conditions, often co-occurring, such as type 2 diabetes (T2D), hypertension, cardiovascular diseases (CVD), depression and dementia; and, the burden these place on individuals, their families and society at large is expected to increase.[2] The total number of people over 65 in England is estimated to rise by 50% over the coming two decades,[3] with several million estimated to have degrees of disability requiring daily personal help.[4]

In response, many countries are redesigning models of individual healthcare for chronic conditions so as to take a more comprehensive approach that often involves multiple, integrated channels of action. These health service models tend to require (1) individuals to make lifestyle changes and self-manage, and (2) care providers to promote healthy behaviours and reduce disease risk factors.[2 5-7] Behaviour change and self-management are therefore a key aspect of models of future chronic care management.

At a population level, strategic approaches to healthy ageing aim to include government actions that tackle not only individual 'lifestyle choices' but also tackle inequities in health linked to wider social, economic, and built environment factors. The UK government acknowledges that personal choices involving health-related decisions (often outside the health service system) are not isolated from the social forces that continually shape individuals' lives. This perspective is reflected in its review[4] of ageing and age-associated disability which drew on evidence for factors in a person's environment/context that drive unhealthful lifestyle choices and other risk factors. In promoting healthy ageing, the UK's National Service Framework for Older People therefore aims to strengthen activities at the

individual and contextual levels.[8 9] Health promotion in both areas, however, is not new; Ottawa's LaLonde Report previously identified the environment and lifestyle as interdependent 'health fields' responsible for individual wellbeing and population health.[10]

Future policy developments and preventive action for healthy ageing care standards, and for self-management support, must be informed by sound scientific evidence. A first step is to address an identified research need to better describe and examine the complex interplay of multi-level and interconnected heterogeneous drivers of disease risk factors.[11-13] This will require a theoretical perspective that understands a given set of drivers (at individual and/or contextual levels) to interact in a composite way that cannot be treated either as equivalent to another, or as an aggregation of the components in a set.[13-20]

## 1.2 Healthy diets and healthy weight contribute to healthy ageing

Eating a healthy diet and maintaining a healthy weight are important for population health, and each plays a critical role for supporting older individuals in maintaining independence which is reported to be their most highly valued goal.[21 22] The composition of foods in a diet (e.g. vegetable variety) has also been linked to: self-reported BMI and weight gain in middle-aged women;[23] objectively measured body fatness;[24] and, changes in central obesity, independent of body mass index (BMI).[25] The following subsection reviews the separate evidence for the role of healthful eating, and body weight, in ensuring good health in older adults.

### 1.2.1 Evidence on the health impact of diet quality in older adults

Diet is related to many of the major risk factors accounting for substantial morbidity and mortality from major chronic conditions in the UK and worldwide.[26] Specifically, poor quality diets are a leading cause of T2D, CVD, hypertension, and certain cancers.[27] In the UK, diets that do not match nutritional guidelines contribute to an estimated 70,000 premature deaths that are avoidable.[28] Inadequate consumption of fruits and vegetables (FV) in particular is estimated to contribute to 5% of excess deaths globally,[27] and may be associated with the risk of obesity, and long-term weight gain, in middle-aged women.[23] Some evidence suggests the rate of all-cause mortality is lower among older adults who spend more on fruits and vegetables.[29]

Diet-related behaviours, as a key modifiable 'lifestyle choice', are a prominent focus of diverse efforts in disease prevention and health promotion so as to support healthy ageing

of all populations. For example, WHO aims to promote and protect health through healthful eating, thereby supporting healthy ageing; it therefore offers several recommendations for a person's diet: namely, the consumption of more fruits, vegetables, legumes, nuts and grains combined with the reduction of salt, sugar and fats, with the additional advice that unsaturated fats should be chosen and trans-fatty acids be eliminated.[27] The 10 Recommendations for Cancer Prevention also focus on eating a healthy diet and include several dietary behaviours involving the combination of avoiding and limiting consumption of certain foods (e.g. red meats, energy-dense foods, etc.) with eating more of a variety of vegetables, fruits, whole grains and legumes.[30] Notably, many countries such as the UK,[31] Germany,[32] and France,[33] have developed local programs commonly known as the "5-a-day" campaign to encourage healthier eating by translating WHO's specific recommendation of daily consumption of at least 400g of fruits and vegetables.[34]

*Food variety and health*

Eating a varied diet in particular is also widely recommended as critical to healthful eating for both the general population[31 35-37] and older persons.[38 39] Food variety is a long-standing concept used by many national and international governments.[39-42] Eating a large number of different foods from different food groups is considered desirable for a healthful diet because greater variety increases a person's exposure to a wide range of nutrients and phytochemicals, thereby improving the quality of the diet.[43-45] In turn, a good balance of food components through a mixed diet reduces the risk of several chronic conditions and therefore provides the opportunity for better overall health through the life-course. Specifically, greater food variety in a diet is considered crucial for a person's adequate intake of the many vitamins, minerals and trace elements necessary for normal functioning of the human body.[42 43] The importance of food variety for nutritional adequacy and diet quality has been emphasised by many in different studies over the past thirty years.[43-48] And, despite heterogeneity of nomenclature and multiple scoring methods in the current literature, there is consistent prospective evidence in different settings showing older adults have less morbidity[49] and lower risk of mortality[48 50-55] with improved food variety. Some recent evidence in older adults also suggests that reduced hospitalisations and use of acute medical care are associated with a greater diversity of foods consumed.[56]

Yet, food variety is generally not a component of diet quality indices which tend to emphasise micronutrient adequacy and macronutrient distribution, with few exceptions

(e.g. Healthy Eating Index and Dietary Guidelines Index).[57 58] Investigating variety in food choices specifically is important because variety and diet quality are not synonymous, despite a positive association between the two.[46 47 59] For example, individuals in a French population who had high-quality diets according to US nutrition guidelines appeared to have, in contrast, the lowest variety based on a count of total number of foods regularly consumed.[60] Furthermore, it is likely that, beyond quantity, variety of FV has independent roles in disease prevention. Several prospective studies in the EPIC-Norfolk cohort study indicated that, independent of quantity, a higher variety of fruits and/or vegetables consumed reduced the risk of T2D and some cancers.[61-63] Thus, measures of variety of food intake in a diet are likely to represent an additional facet of diet quality not fully accounted for by existing measures and hence the relationship of food variety measures to selected health outcomes is a useful area of examination.[64]

### 1.2.2 Evidence on the obesity–health relationship in older adults

One of the greatest risk factors for the large and growing burden of chronic conditions across the globe is excess body weight, or obesity—defined based on BMI (kg/m$^2$) greater than or equal to 30.[26] Both general (weight status) and central (excess abdominal fat) obesity significantly increase older adults' absolute and relative risk of mortality and morbidity related to CVD, T2D, fatty liver disease, many cancers, osteoarthritis, mobility impairments, and poor quality of life (e.g. sleep apnoea).[26 65] As a chronic condition requiring ongoing management, obesity imposes a substantial cost burden on both the healthcare system and society at large, [2 66 67] and is therefore acknowledged as one of the biggest public health challenges that both rich and poor countries need to solve.[68 69] In England, a quarter of adults are obese (24% of men and 26% of women aged 16 and over), and current prevalence has doubled in the past two decades.[70] Obesity is predicted to increase globally in the coming decades, raising serious concern for the prevention of, for example, cancer.[71] In addition, gaining 5 kg or more in body weight during adulthood is a risk for many major chronic conditions.[27] It is also significant for healthy ageing and chronic disease prevention then that many prospective studies report average weight gain in adults over several decades exceeded recommended limits (range: 7.1—9.9 kg).[72-75] Rates of weight gain, however, generally decline with advancing age and weight loss is more common in older adults.[65 75-80]

Notably, the health risks of excess body weight and weight gain in older people are controversial and must be considered in light of age-dependent alterations in physiology and body composition. These include: reduced appetite, taste, basal metabolic rate, energy expenditure as well as enlargement and redistribution of fat stores.[65 76 81] The Health, Aging and Body Composition cohort study reported that older adults who gained or lost weight showed more changes in fat mass than in lean mass, but there was more reduction in the quantity of skeletal muscle during weight loss than muscle mass increases seen during weight gain.[82] Thus, weight loss in older adults has implications for both morbidity and mortality since losing lean mass, even with regain, can accelerate sarcopenia and incumbent impairments of physical functioning; whereas, increasing body weight is known to improve survival at higher ages.[65 78 81 82] However, it is perhaps not muscle quantity but quality that is important for mortality risk in older adults. Other findings from that cohort study showed muscle strength remained associated with mortality after considering low muscle mass.[83] Beyond survival, older adults can also benefit from higher body weight in other ways, including: lower mortality from CVD in overweight, despite an increased CVD risk, compared to normal weight; and reduced fracture rates and osteoporotic frailty due to increased bone density associated with higher body weight.[65 76] Obesity in older adults is therefore complex and paradoxical, involving both insalubrious and protective health impacts.

## 1.3 Understanding the drivers of diet and obesity

Diet-related behaviours and obesity are each influenced by a range of factors related to individual persons and to the contexts in which they live. Personal factors concern aspects of an individual's physiology and psychology; while the characteristics of a person's context concern a broad set of factors that can be broadly categorised into those describing the economic environment, those describing the built (physical) environment, those capturing the socio-cultural environment and those relevant to the political environment. This section briefly summarises the literature on the multiple drivers known to influence diet and obesity.

### 1.3.1 Multiple determinants of diet and eating behaviours

Eating and diet are a complex human behaviour and several reviews over the past two decades confirm that multiple and wide-ranging factors—social, economic, psychological, bio-cultural—influence people's food choices.[84-88] A large part of the variation in diets seen

across different social groups can be explained by personal factors of individual physiology (e.g. taste sensitivity; allergy; state of hunger, appetite and statiety; stress response) and psychology (e.g. motivation; affect, self-efficacy; food skills and knowledge; adventurous or picky food-styles; attitudes; beliefs; intention, resilience/coping skills).[89-95] Nevertheless, decisions people make about food are also influenced by factors related to a person's economic context, socio-cultural milieu, and political and physical environments, with most of this evidence considering the causal influences of economic and social factors operating within the family or local community.[89 96-101] Contextual factors are also likely to act at the national or regional level to influence a person's diet, but few have studied factors at these levels or those related to other types of environment, namely political and physical.[89] For example, media and advertising are factors in the socio-cultural environment that also concern the political environment. And, although more is spent on food than any other class of good and advertising spending is directly related to how much is purchased,[102] there is little attention in epidemiology and medical research on how the food industry and associated politics influence a person's nutrition and health.[103]

Furthermore, the interplay between personal and contextual factors is also likely to determine diet-related behaviours as shown, for example, in a study of the mediating role of depression in the established relationship between socioeconomic status (SES) and diet quality for many but not all adults.[104] Another example is the interplay between a person's moral attitude and cultural norms that establishes prioritised food values (e.g. quality and health) and influences food purchasing decision through the mediating factor of 'appropriateness'.[105 106] Although the added complexity of interactions (i.e. inter-relations) between multiple determinants of diet is well acknowledged in the literature,[89 90 98 99 107 108] studies on such interconnections are sparse and small in sample size.[105 106 109]

Studies of older adults suggest the drivers of food habits and diet involve some age-specific factors and many factors common to younger populations, although shared determinants vary in relative importance according to life stage. For example, economic conditions may have greater significance for older adults as they are more vulnerable to adverse economic consequences of employment-based transitions,[110-112] and spend the largest share of their total budget for basic needs on food than average adults (up to 53% versus up to 45%).[112 113] Overall, the diverse factors known to influence diet-related behaviours in older adults include: money; convenience and ease of preparation; transportation and rural location;

relationships and living arrangement; cultural function and social values (e.g. food hierarchy and gender roles); knowledge, beliefs and attitudes; changes in taste and appetite; and physical limitations such as loss of teeth and chewing ability.[84 114-125]

In terms of economic drivers, both the objective lack of financial means and subjective perceptions of low economic resources are shown to determine low FV intakes in older adults.[126 127] Some evidence suggests that perceived level of food-related resources was relatively more important than objective levels for determining an older person's diet variety.[128] Importantly, older people from different backgrounds vary in the trade-offs they make about food choices and hence in the most important drivers of diet, since different individuals will place greater salience on some competing priorities over others, often depending on their time preferences.[129 130] Thus, while the cost of food had greatest salience for low-income rural elderly[131] and single white-British elderly men,[132] price was not the most important dietary determinant for other groups of older adults.[130]

Table 1–1 below summarises the diverse personal and contextual factors considered to influence eating behaviours and diet, based on a scoping review of the broad literature in this area.

Table 1-1 Summary of the multiple determinants of diet-related behaviours

| Factor level | Domain | Examples |
|---|---|---|
| Personal | Physiology | Stress response, allergy, taste sensitivity (hedonic response), state of hunger (satiety response), sleep, chewing ability, age, sex |
| | Psychology | Self-efficacy, motivation, food skills & knowledge, food-styles & learning (adventurous/picky), attitudes, beliefs, resiliency/coping ability, depression & anxiety |
| Contextual | Economic environment (i.e. food costs and access) | Food costs, incentives (taxes, pricing policies, subsidies), financial support or sponsorship, access to resources (income, material conditions), employment, trade |
| | Socio-cultural environment (i.e. group relationships, attitudes, beliefs and values) | Social value & cultural function of foods (e.g. norms of masculinity/femininity, commensality, eating-away-from-home, age-related timing, etc.), religion and social custom, ethnicity and group identity, tradition and place of birth, media and advertising. |
| | Physical (built) environment (i.e. what is available) | Food location and store types (e.g. supermarket, take-away); modes of transport (manufacturing, distribution, purchasing), urban/ rural development, point-of-purchase information, access to nutrition knowledge, cooking training, home gardens, food storage facilities |
| | Political environment (i.e. food-related formal rules) | Family rules, food service regulation, health regulatory system (food & nutrition labelling), social welfare policies, town planning policies and public transport for food supply |

It is worthy to note a variety of theories and conceptual models are used to predict individuals' diet-related behaviours and food choices, or to explain population-level eating

patterns. Models used involve concepts taken from behavioural economics,[94 133-135] psychology,[95 96 105 109 119 136-149] consumer research,[106 150 151] health programming,[152 153] and socio-ecological perspectives.[97 98 120 154-158] Researchers most commonly apply the Theory of Planned Behaviour and Transtheoretical Model, or combined frameworks, such as the Social Cognitive Theory and Ecological Model of human behaviour, to predict eating behaviours, most notably FV consumption.[92 99 159] Ecological models are useful for emphasising linkages between environmental, interpersonal and intrapersonal factors to explain health behaviours or guide behaviour change interventions,[160] but their application is predominantly focussed on a limited number of either social or economic influences and on health behaviours ('lifestyle' factors) broadly.[90 98 99 101 161 162] In brief, the weakness of theoretically-based studies of the determinants of diet is that either they generally fail to use existing models of individual decision-making specific to food choices, such as the Food Choice Process model[107 108 151 163 164] or the Food Choice Kaleidoscope model;[151] or, they do not include diverse contextual drivers from multiple domains and levels of influence.

### 1.3.2 The 'obesity system': multiple opposing and synergistic causes

Similar to dietary behaviours, obesity is a cardio-metabolic risk factor with multiple synergistic and opposing determinants that operate dynamically at personal and contextual levels, while also interacting within and across levels.[11 13 68 69 89 161 165] Whereas diet-related behaviours in older people are influenced by factors specific to their life-stage contexts, the multiple drivers of obesity are largely similar across adult age groups since increasing prevalence of obese older adults is mainly due to the high and growing numbers of adults already obese when they reach older ages.[65 81 166] Nevertheless some contextual factors may be less strongly related to obesity at higher ages.[77 167]

The complex multifactorial 'obesity system'[12 27 68 89 161 165 168 169] is also commonly understood and studied using socio-ecological systems theory,[170] and is illustrated by a comprehensive map in the landmark Foresight Report.[165] The map can be simplified into three broad groups of determinants, centred on the energy balance between diet and physical activity.[165] The first group comprises individual-level factors related to personal physiology and psychology (e.g. heredity, prenatal development, stress, self-esteem, affect, and early life experiences related to acceptability of food intake or activity levels), with medical care included in physiological pathways of influence. The second group involves contextual factors concerning a person's socio-cultural milieu, including social values and religio-cultural norms

attributed to specific activities around food and exercise through education and traditional practices; values and norms that are repeated, reinforced and recreated through media and advertising. And the third group also comprises contextual factors pertaining to access and availability such as geography and seasons, food technology and fuel, worksite or school environments, and economics at the household and national/global levels. Macro-economic drivers of obesity reported in the literature range from wages, occupational trends, consumer prices, and residential property values, to global trade, farming practices and mass production that drive excess energy intake through added sugar and salt, and saturated fats.[66 165 171]

Economic and social conditions are argued to have the most salient role in influencing a person's health status,[172 173] and thus constitute major determinants, or 'fundamental causes', of obesity.[174] It is possible that economic conditions may be a relatively more important determinant.[175] Many studies have shown strong gradients in obesity prevalence and weight gain by income, education, and occupational grade, measured alone or combined.[176-178] Such gradients are suggested to reflect the direct health benefits of having more *economic* resources such as healthier nutrition, housing, neighbourhood conditions, or less stress from greater resources for coping.[174] Thus, income, employment grade and education can be conceived of as factors describing a person's economic context. As such, they are typically used as standard measures of SES, even though SES is a complex, multidimensional construct comprising other social factors such as power and prestige.[179] Since education is more distal to a person's other economic resources such as occupational grade and incumbent income, many describe it as one of the fundamental determinants, or causes, of health.[173 174] From a life-course perspective, parental wealth is likely to precede a person's education which in turn determines their future employment and income.

But, how economic and social conditions shape individual resources and opportunities for healthful body weight is, ultimately, a gendered experience.[75 180-186] Hence, gender discrimination across the life-course is an important fundamental determinant of obesity that deserves more commensurate attention in the literature.[174 187]

## 1.4 Conceptual framework for this dissertation

As illustrated above, the current literature does not lack models of behaviour and conceptual frameworks to understand the broader determinants of health and disease risk factors.

Nevertheless, some have argued for theoretical frameworks that are behaviour-specific,[99 188 189] such as the one for physical activity.[190] A diet-specific model may be better than generic behavioural models because broad determinants of physical activity can differ from those of FV consumption.[99] Moreover, research on the social cognitive predictors of poor nutrition in older adults indicates that diet-related behaviours influence health outcomes through nutritional self-efficacy rather than general self-efficacy.[191] Potential examples of diet-specific models aiming to integrate a systems perspective of the wider environment include the 'socio-ecological culture-cuisine food model' proposed for Maltese children,[192] and the Model of Community Nutrition Environments.[3] However, the shortcomings of existing models is that none encapsulates the complexity of both contextual factors and internal cognitive processes of the individual.[188]

Ultimately, the complexity, dynamism and inter-relationships of multiple determinants of diet and related food decisions requires an integrated explanation,[193] as reflected in the concept of 'constrained choices'.[180] Others have also called for an integrative perspective to better understand the personal and contextual determinants of disease risk factors—one that uses of a 'systems' model at multiple levels of influence,[69 193] and incorporates a life-course perspective of human behaviour and health.[194-199] Thus, while much research in economics, sociology, psychology, biology and consumer behaviour provides good evidence on the multiple drivers of disease risk factors, such as diet and obesity, a number of important knowledge gaps and challenges remain to be addressed to inform future health policy with evidence, particularly regarding the interactions of contextual factors within and between domains of influence.[200]

I therefore developed a conceptual framework for this dissertation that builds on the behaviour-specific Food Choice Process Model which is the result of about two decades of qualitative, social psychology work of the Cornell Food Choice Research Group.[107 108 164] This model had particular appeal for my conceptual framework as it places central focus on the complex deliberations and trade-offs that individuals must make when faced with a new choice about which foods and/or beverages to consume.[154] More specifically, the model illustrates how individuals vary not only in the considerations they bring to food choices in a given meal situation but also in the fact that they develop simplified food classification strategies (i.e. rules-of-thumb) based on previous deliberations in which competing interests were resolved and personal values negotiated.[107 108] In other words, the model captures the

simple heuristics people use to make satisfactory food-related decisions with minimal effort,[107 108 201 202] and therefore integrates notions of both conscious and automatic processes of decision-making for diet-related behaviours.[203] Economic evidence also supports the primacy of each person's system of diverse social and personal values and multiple competing priorities for understanding the variation in food-related behaviours across social groups.[94 129 204] A further strength of the Food Choice Process Model is that it also incorporates the necessary life-course perspective of temporality, and age-related transitions and turning points.

However, the Food Choice Process Model lacks sufficient detail on the diverse factors describing a person's 'environment' which much epidemiological evidence reviewed above indicated also influence the diet-related behaviours resulting from food choice decisions. I therefore extended this model by including the different 'types' (i.e. economic, socio-cultural, physical, political) and 'sizes' (i.e. micro, meso, macro) of environment that are detailed in the ANGELO framework for conceptualising the broad determinants of obesity.[89] Since the framework emphasises the complexity of interconnected contextual factors and their linkages with interpersonal and intrapersonal determinants of human behaviour and health, it complemented the Food Choice Process Model. Together, they offer a potentially more integrated perspective of the drivers of disease risk factors investigated in this dissertation. Hence, my conceptual framework brings a sophisticated intrapersonal (i.e. ego-centric) perspective of psychology and economics into the socio-ecological models of social science and social epidemiology literatures.

An additional novelty is that I incorporate a view to future development of interventions, and so underpin the framework with a logic model—a tool commonly used in evaluation research[205]—that considers activities involved in the process of translating inputs into desired outputs and outcomes (medium- and long-term). In brief, the logic model framing my conceptual framework envisions multiple contextual and personal factors to function as the 'inputs' to each person's cognitive 'process' of negotiating the multiple values and competing priorities for food choices and then constructing the strategies of resolved decisions. Such 'inputs' range in their proximity to the deliberative process and include diverse upstream 'fundamental' inputs as well as intermediate and proximate factors of influence.

The framework therefore shows four pathways of influence on the food choice process (Figure 1–1). Fundamental factors related to socio-demographic characteristics (e.g. gender, age, ethnicity, place of origin) influence the process directly through, for example, a person's food roots[108 164] established during their upbringing. Alternatively, fundamental factors can have indirect influence on the process through other pathways involving contextual and/or personal factors that are closer to the decision-making process. Thus, a second pathway between 'inputs' and 'process' concerns the diverse factors describing the economic, social, political and physical environment with several levels of influence.[89] Similarly, many personal factors of individual physiology and psychology can have direct influence on food choice decision-making and therefore constitute a third pathway of inputs to the process. Finally, the interplay (i.e. interactions) between contextual and personal factors can produce mediators such as appropriateness, practicality, attractiveness, affordability, etc., that in turn function as 'inputs' to the process through a fourth pathway of influence.

As detailed elsewhere,[107 108 164] the process of constructing food choice decisions involves a personal system of negotiating diverse values (e.g. convenience, quality, monetary considerations, sensory perceptions, health and nutrition, and managing relationships) and resulting rules-of-thumb to simplify subsequent decisions. The 'output' of the food choice process can be seen in terms of relatively consistent patterns of eating behaviour, such as high FV consumption or intake of high-fat and high-sugar foods. These eating patterns are either favourable to a person's health 'outcome' or not with respect to chronic condition(s), such as T2D, hypertension, CVD, or excess body weight. While not illustrated in Figure 1–1, the outputs of the food choice process should also be understood to interact with outputs from other health-related lifestyle choices, and then combined, increase or decrease the risk of poor health outcomes. Over the life-course, these medium-term outcomes then lead to longer-time outcomes (or impacts) concerning not only a person's health (e.g. survival or tertiary complications from chronic conditions), but also the wider society and political economy in terms of, for example, civic participation and labour productivity.

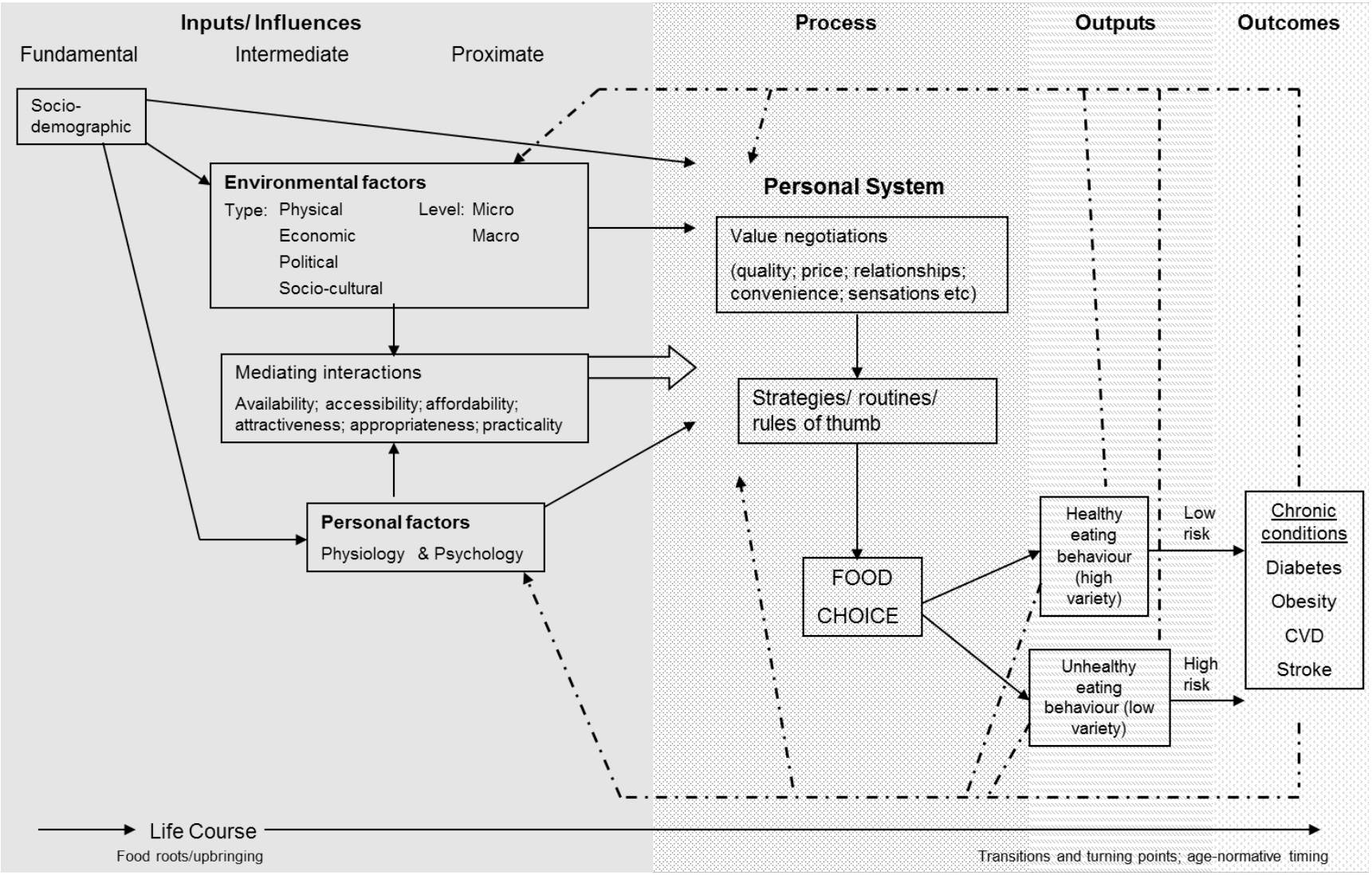



Figure 1-1 Conceptual framework for understanding determinants of eating behaviours, adapted from Furst et al[107] and Swinburn et al[89]

## 1.5 Overall aims and structure of this dissertation

This dissertation aimed to address a knowledge gap on the relative importance of contextual drivers of diet or obesity that will vary between older people occupying uniquely differentiated social categories.[180 187 206 207] Its objective was therefore to unpack the role and interplay of factors describing the economic and social contexts of older adults that are involved in healthful eating and body weight so as to better understand how an older person's life circumstances influence key risk factors for chronic conditions. It also had the objective of giving explicit research attention to gender. Research questions included:

(1) which aspects of diverse economic conditions show the strongest differences in diet quality in women and men?
(2) which aspects of different social relationships act more strongly, and how do they interact, to influence diet quality in women and men?
(3) how do multiple economic influences in combination with different social relationships influence diet quality in women and men?
(4) is an older people's financial situation more important for obesity than conventional economic resources of SES and does the relative importance differ by gender?
(5) do women and men differ in the vulnerability to excess weight gain from cumulative financial problems and is there a role for health behaviours or other factors?

The analyses centred on the economic conditions of older individuals' lives due to their greater exposure to both low income[111] and financial hardship (FH) from disruptive life events (e.g. divorce, widowhood, or involuntary job loss);[208 209] and, to poorer recovery from financial losses or economic shocks due to reduced employment prospects at older ages.[210] Specific attention to older people's everyday financial situation is warranted since paying bills and affording adequate food and clothing comprise the largest drains on disposable income for older adults.[211] Moreover, potentially important factors in this economic domain could reveal differences among individuals who are similar on conventional measures of SES such as education or occupational grade.[179] Acknowledging SES as a complex multidimensional construct involving factors that overlap the economic and socio-cultural environments, this dissertation will refer to conventional indicators of SES and novel measures of FH as economic factors. Ultimately, the link to the lived experiences of older people was a central focus key to this dissertation.

### 1.5.1 Structure

This dissertation is arranged over nine interlinked chapters. Following this Introduction chapter, current knowledge on known dietary correlates is extended by systematically reviewing evidence on the economic determinants of diet in older adults in Chapter 2. Associations between multiple economic factors, including novel measures of an older person's financial situation, are then explored in relation to quantity and variety of fruit and vegetable (FV) consumption (Chapter 3). Chapter 4 focused on older people's social circumstances and explored combined influences of different social ties on fruit variety and vegetable variety. Chapter 5 built on the two previous chapters by exploring the inter-relations of six economic factors and three social ties with respect to fruit variety and vegetable variety. Chapter 6 then transitions to a brief summary of literature on economic determinants of obesity and weight gain as equally important risk factors for chronic conditions. Multiple indicators of FH, and SES, were then examined in relation to measured general and central obesity in older adults (Chapter 7). Chapter 8 moved beyond novel correlates of obesity to assess the link between cumulative FH and weight gain over time, and also explored the contribution of health behaviours, psychological and social factors as potential mechanisms. Finally, Chapter 9 summarised the main findings, considered key methodological issues, and proposed future directions for public health research and practice.

### 1.5.2 Overview of shared methods

This dissertation comprised five empirical studies which shared a number of exposures and/or outcomes of interest. This section aims only to describe the common exposures and outcomes as study-specific detail is given in relevant chapter methods (and appendices).

Four empirical studies used data collected as part of the population-based EPIC-Norfolk prospective cohort—a component of the European Prospective Investigation of Cancer (EPIC) study in 10 countries.[212] The EPIC-Norfolk study was approved by the Norwich district ethics committee and all volunteers gave written informed consent. EPIC-Norfolk invited 77,630 individuals from age-sex registers of general practices in a geographically circumscribed area, and recruited 25,639 participants (55% women) aged 39 to 79 (99.7% white) who attended a first health check at entry (1993-97). Cohort participants were measured for anthropometric data on BMI (n=15,000) and waist circumference (n=15,024), and self-reported information on their diet (n=12,292) during a second clinical assessment

(1998-2002), with follow-up averaging 3.5 years. To place findings in a healthy ageing context, studies of older adults followed the precedence of using a threshold of aged 50 years and above.[38 213-215] Analyses therefore included only the 20,274 over-50s (54% women) from the full cohort (Appendix B-1 gives characteristics of over-50s and full cohort). In general, studies using EPIC-Norfolk data included variables collected at entry (1993-97), 18-months (1996-2000) and second health check (1998-2002).

The fifth empirical study (Chapter 8) used repeated measures data from the Whitehall II cohort study of London-based civil servants because it collected similar information on economic factors examined in studies of EPIC-Norfolk data, including two self-reported FH measures. The Whitehall II study recruited 10,308 employees (73% of those invited) who were clinically measured and completed a questionnaire at entry (Phase 1, 1985-88), with 33% women and wide salary ranges across each employment grade (from clerical/support to Senior Administrative).[216] Between 76% and 86% of Phase 1 responders received a questionnaire only at Phase 2 (n=8,132), and both screening and a questionnaire at Phase 3 (n=8,815) and Phase 5 (n=7,870). The study of Whitehall II information used variables from Phase 1 (1985-88), Phase 2 (1989-90), Phase 3 (1991-93) and Phase 5 (1997-1999).

*Common exposures of interest*

Three studies of EPIC-Norfolk over-50s (Chapter 3, Chapter 5, and Chapter 7) examined six economic factors as main exposures; these were operationalised through three classical indicators of SES and three novel measures of FH. Education level (no qualification, O-level (≤16 y), A-level (≤18 y), degree (>18 y)) and occupation were self-reported at cohort entry, with occupation used to classify participants into six hierarchical categories of the Registrar General's classification scheme of social class (professional, managerial and technical, skilled non-manual, skilled manual, partly skilled, and unskilled).[217] Social class was based on the partner's occupation for the majority of women (68%); her own occupation was used when she was single or her partner's was unclassified or missing.[218] A measure of home-ownership based on self-reported accommodation type (home-owner, public renting and private renting) was employed as another conventional SES indicator since a review of research documented the utility of home-ownership as a measure of wealth in older populations,[219] and wealth is associated with older adults' diet[220] and obesity.[221]

FH was assessed in EPIC-Norfolk using a postal "Health and Life Experiences Questionnaire" (HLEQ) (1996-2000) designed to assess social and psychological circumstances,[222 223]

following standard survey design principles.[224] Consistent with Leonard Pearlin's list of chronic strains of household economics,[208 209 225] three self-reported FH questions covered: having enough money for needs (3 responses); frequency of not having enough money to afford adequate food or clothing (5 responses, between 'never' and 'always'; hereafter referred to as "insufficient money for food/clothing"); and, difficulty paying bills (6 responses, between 'none' and 'very great') (see Table 1–2). These latter two questions were also asked of participants in Whitehall II using the repeated "Health Survey Questionnaire" (HSQ).

Table 1–2 Summary of questions, response categories and source for financial hardship measures examined

| FH questions | Response categories | Source |
|---|---|---|
| In general, would you say you (and your family living with you) have more money than you need, just enough for your needs, or not enough to meet your needs? | 1. More money than you need<br>2. Just enough money<br>3. Not enough money | • EPIC-Norfolk, HLEQ |
| How often does it happen that you do not have enough money to afford the kind of food or clothing you/your family should have? | 1. Never<br>2. Seldom<br>3. Sometimes<br>4. Often<br>5. Always | • EPIC-Norfolk, HLEQ<br>• Whitehall II, HSQ |
| How much difficulty do you have in meeting the payment of bills? | 1. None<br>2. Very little<br>3. Slight<br>4. Some<br>5. Great<br>6. Very great | • EPIC-Norfolk, HLEQ<br>• Whitehall II, HSQ |

FH, financial hardship; HLEQ, Health and Life Experiences Questionnaire; HSQ, Health Survey Questionnaire

*Common outcomes of interest*

Three empirical studies of EPIC-Norfolk data (Chapter 3 through 5) examined variety of intake of fruits and/or vegetables as a proxy for diet quality. Information on FV consumption came from two sections of a Food Frequency Questionnaire (FFQ)—previously validated by comparison with a 16-d weighed food record,[226] and nutrient biomarkers[227-229]—which pre-specified 11 fruit items and 26 vegetable items (see Table 1–3). The over-50 respondents (n=9,933) were asked to "estimate average food use during the last year" using nine standard frequency response categories,[230] from never or less than once a month to six or more a day (Table 1–3). Self-reported frequencies were combined with imputed portion sizes to calculate average daily consumption of each unique fruit or vegetable item (g/d) following an established method.[226] FFQ respondents in the sample with extreme estimated energy intakes (top 0.5% and bottom 0.5% of energy intake relative to basal metabolic rate

values)[231] were excluded (n=353), leaving 9,580 over-50s with plausible energy intakes for analysis (Figure 3–1 illustrates the sample selection process).

Variety of fruit and/or vegetable was a sum of the total number of unique items consumed, irrespective of quantity (>0g/d), and corresponded to response category of at least 1-3 times per month. This cut-point followed a similar approach previously demonstrated for reduced risk of T2D[61] and some cancers;[62 63] and it also reflected the minimum two weeks needed for a person to exhaust the variety of their food repertoire.[64] Other studies have demonstrated the reproducibility and validity of variety scores for nutritional adequacy in older populations.[44 64] Continuous scores were derived for variety (items/month) of fruit (range 0-11), vegetable (0-26), and combined FV (0-37).

Table 1–3 Summary of pre-specified fruit and vegetable items and frequency response categories in the EPIC-Norfolk food frequency questionnaire

| List of fruit items[a] | List of vegetable items[b] | Response categories |
|---|---|---|
| • Apples (1 fruit)<br>• Pears (1 fruit)<br>• Oranges, satsumas, mandarins (1 fruit)<br>• Grapefruit (half)<br>• Bananas<br>• Grapes (medium serving)<br>• Melon (1 slice)<br>• Peaches, plums, apricots (1 fruit)[a]<br>• Strawberries, raspberries, kiwi fruit (medium serving)[a]<br>• Tinned fruit (medium serving)<br>• Dried fruit, eg. Raisins, prunes (medium serving) | • Carrots<br>• Spinach<br>• Broccoli, spring greens, kale<br>• Brussels sprouts<br>• Cabbage<br>• Peas<br>• Green beans, broad beans, runner beans<br>• Marrow, courgettes<br>• Cauliflower<br>• Parsnips, turnips, swedes<br>• Leeks<br>• Onions<br>• Garlic<br>• Mushrooms<br>• Sweet peppers<br>• Beansprouts<br>• Green salad, lettuce, cucumber, celery<br>• Watercress<br>• Tomatoes<br>• Sweetcorn<br>• Beetroot<br>• Coleslaw<br>• Avocado<br>• Baked beans<br>• Dried lentils, beans, peas<br>• Tofu, soya meat, TVP, Vegeburger | • Never or less than once/ month<br>• 1-3 per month<br>• Once a week<br>• 2-4 per week<br>• 5-6 per week<br>• Once a day<br>• 2-3 per day<br>• 4-5 per day<br>• 6+ per day |

[a]Average use estimated when fruit was in season; [b]Medium serving and included fresh, frozen or tinned.

All statistical analyses were conducted using Stata 12.1.[232] Analyses were *a priori* conducted for women and men separately for both conceptual and methodological reasons. Conceptually, societies ascribe different roles to women and men which will determine the impact of, and vulnerability to, the same contextual factors analysed.[180 187] In other words,

gender is a socially constructed characteristic (based on biological sex) that can interact with different economic factors to produce different health effects across social groups.[179] Hence, gender-based differences between women and men were the main focus of empirical investigation of the contribution of economic and social conditions to healthful eating and weight outcomes. For methodological reasons, sex-based differences between women and men were considered in analyses of adiposity outcomes since reproductive status and parity are important biological factors determining the higher burden of obesity among women.[65 78] Biological sex differences, moreover, are also relevant to the health consequences of obesity in older adults as, for example, impairment of mobility and physical functioning is magnified in women.[22 65 76]

# CHAPTER 2 Known economic determinants of diet in older adults

This work was first published in a BMJ journal as: Conklin AI, Maguire ER, Monsivais P. Economic determinants of diet in older adults: systematic review. *Journal of Epidemiology and Community Health* 2013; 67(9):721-7. Authors are referenced below as AC, EM and PM.

## 2.1 Abstract

**Background:** Many economic conditions are associated with diet, yet the evidence is generally cross-sectional. Older people are considered especially vulnerable to poor diets from negative changes to varied economic factors. This review extends current knowledge on known correlates to decipher actual economic determinants of diet in older adults.

**Methods:** Eight bibliometric databases were searched between May and December 2012, supplemented by hand-searches, with no restrictions on publication date or country. Longitudinal studies, or reviews, were eligible when examining diet as a function of change in an economic factor in non-institutionalised adults ≥60 years. Data were extracted using a standardised evidence table and quality assessed before narrative synthesis.

**Results:** Nine original studies were eligible for inclusion, of which eight examined change from work to retirement and one evaluated a food price intervention. Designs were generally pre-post without controls and varying in follow-up. Studies reported mixed impact on food spending and/or food intake. Retirement was shown to both reduce and have no impact on food spending and to have either positive and negative, or positive and no impact on food intake. Subgroup differences were observed, especially between women and men.

**Conclusion:** Despite ample research on economic correlates of older adults' diets, little is still known about actual economic determinants of diet in this population. Studies of retirement suggest divergent effects in some but not all older people. Robust high-quality longitudinal

studies to decipher economic drivers of diet must be prioritised in research and policy as firm conclusions remain elusive.

## 2.2 Introduction

Diet is integral to population-level health promotion and to chronic disease management.[233] Yet, as adults enter older ages, they tend to eat nutritionally suboptimal diets, reduced variety, and fewer vegetables.[234-237] Overall, older adults are not meeting recommendations for healthy diets which are similar to those for younger adults.[238 239] Eating well is therefore a necessary focus for public health and policy in tackling chronic conditions and in supporting wellbeing through older age.[1 8] But, to support eating well, a clear understanding of how choice(s) can be changed and the context of dietary change is fundamental.

Promotion of healthy diets cannot be only through individual choices and supportive psychosocial factors; a supportive context is also key, particularly economic access.[102 112 240] Various economic factors influence diet, including food prices and money available to purchase food.[85 88 112 128 238 241 242] Economic uncertainty might affect older people's food choice and diet variety as foods integral to a healthful diet (e.g. fruit, vegetables, fish) can be perceived as a luxury; while healthier alternatives to common foods often carry a price premium.[242] Modelling studies indicate that constraining food budgets can lower the nutritional adequacy of the diet.[243] Estimates suggest that half of weekly income is needed for an older person on income support to eat a healthy diet;[244] while the considerably higher cost of therapeutic diets places an even greater burden on older people with limited incomes.[244 245] Hence, having an adequate income is likely necessary to ensure a more varied and balanced diet for healthy older people, as suggested by Drewnowski et al (1997).[64]

The economic sensitivity of diet is considered especially salient for older age individuals[110] because they are more likely to be low income,[111] can experience two drops in income (through retirement and out-living savings),[112] and have reduced opportunity to rebound from financial losses or shocks to their economic context as prospects for future employment are limited.[210] For people aged 65 and over in the UK, food and non-alcoholic beverages comprise the greatest proportion of expenditures for basic necessities (e.g. housing, fuel, power and clothing and footwear) compared to younger age groups.[211] The food share of the budget for basic necessities is even larger for older people on low

income,[113] and so it is perhaps not surprising that food is the necessity reduced first when income is restricted.[113 240 244-246] Thus, changes in economic factors related to life transitions might constitute a key food choice determinant for this growing segment of the population.

Despite logical appeal, systematic examination of what happens to older people's diet over time when economic factors change is lacking.[112 124 247] Nutrition and consumer research indicate falling income led adults to reduce the variety and quantity of foods consumed (specifically decreasing intake of fish, rice, pasta, frozen and salad vegetables); conversely, rising income has been associated with the adoption of a more healthful, varied diet.[247 248] Notably, the individuals experiencing a decrease in income imposed more dietary changes than those experiencing an increase.[247 248] Economic models suggest food consumption shifts with a change in relative price,[249 250] with different scenarios of taxation and/or subsidy,[251] and that some social groups are more price responsive in demand for foods/components that are taxed and/or subsidised.[252] But, dietary effects from change(s) in economic factors may not be sustained over time,[250] and immediate effects may counter the expected beneficial direction for social groups most in need of support for healthful eating.[251 253]

This study aimed to systematically review prospective studies, or potential reviews, with data on diet of older adults as a function of change in economic variable(s). This paper extends current knowledge on correlates to decipher actual economic determinants of diet in older adults, to better understand a recurring concern about the potential vulnerability of older people to constraints on their choices in healthful eating.

## 2.3 Methods

### 2.3.1 Search and Selection

Peer-reviewed literature was systematically searched using eight bibliometric databases (PubMed/Medline, SCOPUS, EconLit, PsychInfo, ASSIA, Web of Science, Embase and British Nursing Index); hand-searches (Food Choice Conference abstracts and references in retrieved full-texts); and expert advice. A common approach for systematic reviews was followed, as given by the Cochrane collaboration.[254] Since the Cochrane method for quality assessment (designed for appraising clinical practice) considers observational study evidence as low quality, the Effective Public Health Practice Project tool and the Newcastle-Ottawa scale were employed—both identified by the UK's HTA Programme as 'best' tools for

evaluating observational studies.[255] Free-text and thesaurus terms were applied for "eating behaviour", "economic environment", "change" and "older people" after consulting a medical research librarian (Table 2–1). No limitations were imposed on publication date, country or language, except in SCOPUS (English and French). Subject area was only restricted in SCOPUS and PsychInfo as half of records had unrelated subjects. Searches were performed separately by AC and EM between May 2012 and December 2012.

Table 2–1 Search terms used in 8 databases to identify potentially eligible records for inclusion

| Concept | Search terms ("/" indicating "or") |
|---|---|
| Food | Diet/ food habit*/ food choice*/ eating/ food purchasing behav*/ food purchasing choice*/ food preference |
| Influence(s) | Economic*/ financ*/ income/ resource/ wealth/ socio?economic/ financial resource*/ financial circumstance*/ job/ money/ employment/ pension/ security/ retire*/ debt/ poverty |
| Change | Change/ reduc*/ stress/ strain/ constrain*/ loss/ transition/ fall/ instab*/ fluctuat*/ decrease/ increase/ improve* |
| Population | Ag?ing/ senior/ pensioner/ old* adult/ elder*/ aged AND NOT school/ youth/ adolescent/ child |

### 2.3.2 Inclusion and Exclusion Criteria

This review included as eligible longitudinal studies, or reviews, examining diet in community-dwelling older individuals as a function of change in an economic factor (e.g. income, price, employment). Studies were considered when participants, or subgroup analyses, involved adults aged 60 and over. Criteria for exclusion included: cross-sectional design; exposure of interest lacking; position papers; editorials; institutionalised elderly; non-diet outcomes; unspecified age group; weight management interventions; and measurement validation studies. Intervention studies were excluded unless measuring diet as a function of financial incentives or change in another economic factor(s) (e.g. reduced food price, subsidies, or coupons).

### 2.3.3 Screening

Two reviewers (AC and EM) screened titles and abstracts for potential eligibility and removed records based on exclusion criteria. Abstracts were examined further for full-text retrieval, excluding additional records. Retrieved papers were read in full and references followed up.

### 2.3.4 Quality Assessment, Data Extraction and Analysis

AC and EM independently assessed quality using an adapted checklist of itemised criteria, consisting of 25 questions and 3 response categories ('yes', 'no' and 'can't tell'). Criteria

covered: research question, design, representativeness, sampling, protection against bias and confounding (i.e. comparability), completeness, results, conclusions and generalisability. A study was assessed as of high quality when approximately 80% of responses to checklist questions were 'yes', and of low quality when approximately 20% were 'yes'. Completed assessments were cross-checked between reviewers, with one study additionally appraised by the senior investigator (PM).

Studies were analysed using a standardised evidence table with *a priori* determined headings. AC and EM extracted data on: stated study objective, design, year, population, geographical setting, exposure description, outcome(s) measured, reported findings, author and source. Reported findings were synthesised through a narrative approach while quality assessment helped interpret and explain differences in reported results. Any disagreements on eligibility, quality or synthesis were discussed with the senior investigator (PM) and resolved by consensus.

## 2.4 Results

The study identified 118 original studies and no reviews eligible for inclusion, of which nine met criteria for data extraction and quality review (Figure 2–1 below).[256-264] These mainly reported on work undertaken between early 1990s and mid-2000s in a European context (UK,[256 261] France,[258] Finland,[264] Sweden,[257] and The Netherlands[260]), with some work conducted in the USA.[259 262 263]

### 2.4.1 Study quality

Despite relatively scarce evidence, study quality was generally good. Eight included studies were rated as of high[260 262 264] or medium[256 257 259 261 263] quality; only one[258] was considered low quality (Table 2–2 below). Three studies rated as high quality satisfied most quality criteria on design and comparability.[260 262 264] Compared to these high quality studies, medium studies had less study completeness and poorer reporting of results.

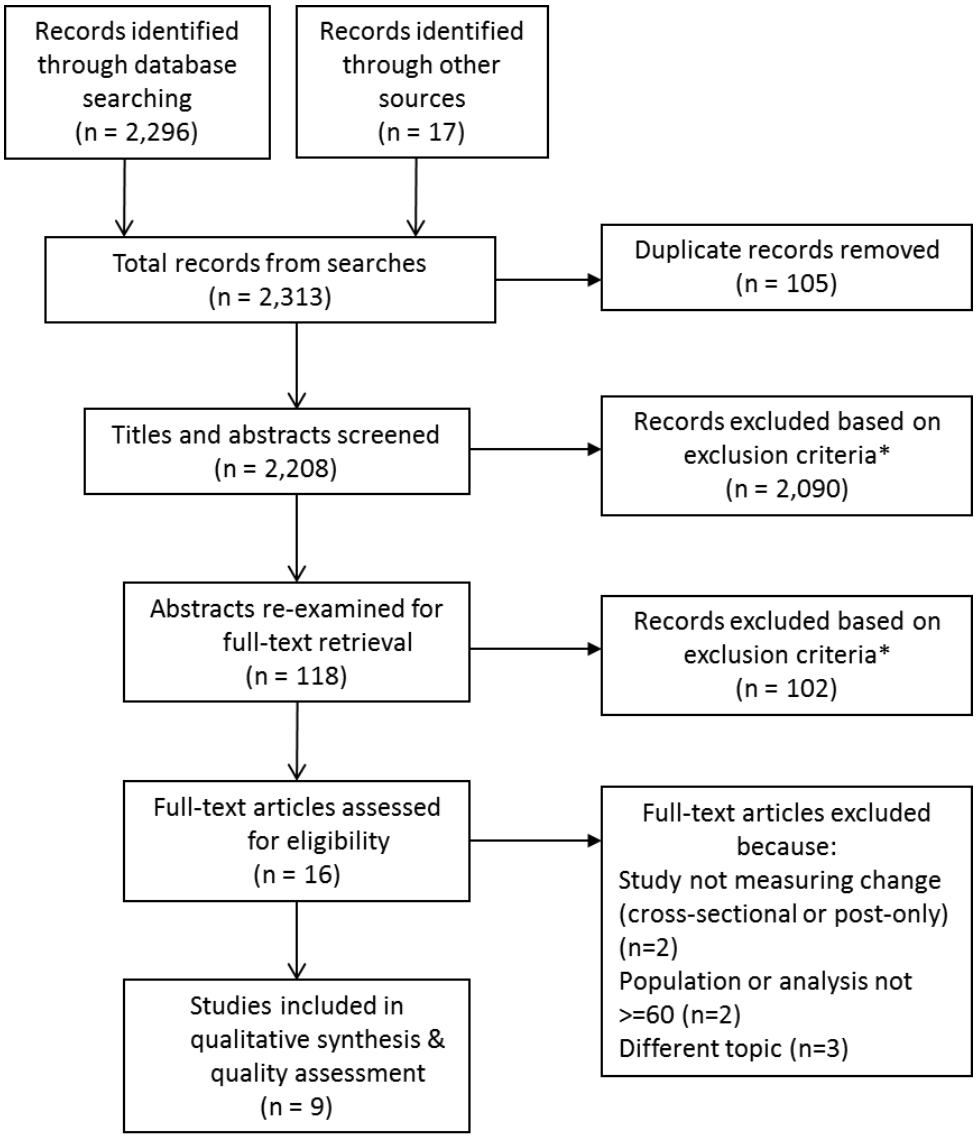



Figure 2-1 Modified PRISMA flow diagram of literature search and study selection.

*Exclusion criteria: cross-sectional design; exposure of interest lacking; position papers; editorials; institutionalised elderly; non-diet outcomes; unspecified age group; weight management interventions; and measurement validation studies

Table 2-2 Quality assessment of included studies

| Quality criteria | Davies et al 1986[256] | Steen et al 1988[257] | Lauque et al 1998[258] | Lundberg et al 2003[259] | Nooyens et al 2005[260] | Smith 2006[261] | Chung et al 2007[262] | Abusabha et al 2011[263] | Helldán et al 2012[264] |
|---|---|---|---|---|---|---|---|---|---|
| Question: Does the paper address a clearly focused issue? (i.e. clear statement of research questions & objectives) | YES | YES | NO | NO | YES | YES | YES | YES | YES |
| Design: Was study design described? | YES | YES | YES | YES | YES | YES | YES | YES | YES |
| Design: Was method chosen & data sources appropriate to the research question? | YES | YES | Can't tell | Can't tell | YES | YES | YES | YES | YES |
| Design: Was data collection & analysis described? | YES | YES | YES / NO | YES | YES | YES | YES | YES | YES |
| Design: Was exposure to change being considered clearly defined and ascertainment operationalised? | Can't tell | YES | Can't tell | YES | YES | YES | YES | YES | YES |
| Design: Was a control group used to compare outcomes? | NO | NO | NO | NO | YES | NO | YES | NO | YES |
| Representativeness: Was group exposed representative of elderly in the community (i.e. not based on convenience sample, occupation-specific, etc.)? | NO | NO | NO | YES | Can't tell | YES | YES | Can't tell | NO |
| Representativeness: Were those not exposed also drawn from the same community (vs. a different source)? | NO | NO | NO | NO | YES | NO | YES | YES | YES |
| Sampling: Was sampling strategy clearly defined & justified | NO | YES | NO | YES | YES | NO | YES | YES | Can't tell |
| Comparability: Did the study control for bias (e.g. secular trends)? | NO | NO | NO | NO | YES | YES | YES | NO | YES |
| Comparability: Were factors possibly related to both exposure and outcome identified? | NO | NO | Can't tell | YES | YES | YES | YES | NO | YES |
| Comparability: Were groups comparable at baseline? | Can't tell | NO | NO | Can't tell | Can't tell | NO | Can't tell | NO | YES |
| Completeness: Was follow-up long enough for study objectives? | YES | Can't tell | YES | YES | YES | YES | Can't tell | NO | YES |
| Completeness: Could all likely effects have appeared in the study's timescale? | YES | YES | YES | YES | YES | NO | Can't tell | Can't tell | YES |

| Quality criteria | Davies et al 1986[256] | Steen et al 1988[257] | Lauque et al 1998[258] | Lundberg et al 2003[259] | Nooyens et al 2005[260] | Smith 2006[261] | Chung et al 2007[262] | Abusabha et al 2011[263] | Helldán et al 2012[264] |
|---|---|---|---|---|---|---|---|---|---|
| **Completeness:** Could the effect be lasting/ not transitory? | NO | NO | Can't tell | Can't tell | Can't tell | Can't tell | Can't tell | NO | YES |
| **Completeness:** Was follow-up sufficiently complete (ideally, >80% participants accounted for)? | YES | Can't tell | NO | YES | YES | Can't tell | YES | NO | YES |
| **Results:** Were main findings reported & do they address the research question? | YES | YES | Can't tell | YES | YES | YES | YES | YES | YES |
| **Results:** Was the choice of statistical analysis appropriate? | YES | YES / NO | Can't tell | YES | YES | Can't tell | YES | YES | YES |
| **Results:** Was the primary outcome measure valid and reliable? | YES | YES | YES | Can't tell | YES | YES | YES | YES | YES |
| **Results:** Were tables/ graphs usefully labelled/ understandable? | YES | NO | NO | NO | YES | YES | YES | YES | YES |
| **Conclusions:** Were results compared with those of other studies, even if contradictory? | YES | YES | YES | NO | YES | YES | YES | NO | YES |
| **Conclusions:** Is the interpretation appropriately based on results & alternative explanations explored? | YES | YES / NO | Can't tell | YES | YES | YES | YES | NO | YES |
| **Conclusions:** Do the findings support the conclusions? | YES | YES | NO | YES | YES | YES | YES | NO | YES |
| **Generalisability:** Can results be applied to other settings? | NO | NO | NO | YES | Can't tell | YES | YES | NO | NO |
| **Generalisability:** Were all important outcomes/ results considered? | YES | YES | NO | NO | YES | NO | NO | NO | YES |
| OVERALL ASSESSMENT | Medium | Medium | Low | Medium | High | Medium | High | Medium | High |

SOURCE: Adapted from Effective Public Health Practice Project and the Newcastle-Ottawa scales as best quality assessment tools[255]

### 2.4.2 Study design and sample characteristics

Studies used before-and-after designs with prospective cohort or panel survey data (Table 2–3). Length of observation varied, ranging from 3-5 months up to 11 years; the oldest studies identified did not report on the period of study.[256-258] Sample sizes also varied widely, from under 50 to over 6,000. Most examined impact in both men and women,[256 258 259 262-264] and one explicitly analysed gender differences.[262] Two focused on men only[260 261] and one on women.[257] Participants tended to be a mix of occupational or educational levels but some studies involved specific occupations, mostly office-based.[256-258 264]

### 2.4.3 Exposure definition

Most studies defined the change in respondents' economic context in terms of retirement from work,[256-262 264] except one intervention study examining change in food price.[263] Generally, retirement was operationalized as a specific (legal) age or individual self-report. Some studies did not report an operational definition.[257 258 260]

### 2.4.4 Outcomes examined

Food spending and/or food intake were the dietary outcomes examined (Table 2–4). Diverse measures were used to assess food intake. Four studies measured total diet based on healthful eating habits or types of foods eaten;[257 258 260 264] two others assessed dietary components (e.g. fibre[256] or fruits and vegetables[263]). Assessment methods also varied, including: diet interview;[257] Food Frequency Questionnaire;[260 263 264] and food record/diary.[256 258] Multiple approaches were employed to examine overall household food spending (weekly, annual)[259 261-263] or individual spending on eating out,[262] often using panel survey data. Additional outcomes measured included anthropometric measures;[257 260 262] physical activity;[258 260] and wellbeing.[258]

### 2.4.5 Main findings

Studies documented a pattern of mixed impact on food spending and consumption as a function of change in the economic context (Table 2–4). Studies examining a shift from employment to retirement found spending decreased (7 to 11%) for certain groups (e.g. co-habiting, involuntary retired) or settings (e.g. eating out) but spending also stayed constant for single-person household, voluntarily retired and home consumption.[259 261 262] Reported effects came from three good quality studies of sufficient follow-up to permit accurate assessment of lasting effects on spending. The intervention study, in which FV prices were reduced by nearly 50%, reported decreased spending of low-income seniors at their most

recent supermarket visit, with greatest impact among seniors using the program weekly. However, the study could not account for substitution in produce spending between supermarket and intervention site.[263]

Six studies examined dietary outcomes and all reported an increase in at least some aspect of food intake as a function of employment transition to retirement (Table 2–4). Two studies revealed slight increases in daily fibre intake in British men and women, particularly when breakfast was consumed,[256] or in consumption of pastry, potato chips and related food items by Swedish women.[257] The study of a 6-month food price intervention found more low-income seniors in New York consumed vegetables and fruits three months after starting the intervention.[263] Finally, two studies documented an increased prevalence of healthy food habits in Finnish women who retired compared to employed,[264] and intakes of fish and vegetables, juice and alcohol in Dutch men.[260]

Some studies showed no impact on food consumption. For example, the main British foods contributing to increased fibre intake and proportion of older people below recommendations stayed constant.[256] Post-retirement improvements in women's healthy food habits were not seen in retired Finnish men compared to employed men.[264] A small French study also found the distribution of nutrients appeared unchanged after retirement.[258] Although this study was assessed as being of low quality, findings corroborate similar results of no impact from other good quality studies.

Finally, two studies reported decreases in food intake. A study of female Swedish municipal employees showed a decreasing tendency in average number of daily meals and in nearly all nutrients.[257] Another study of rural Dutch men also documented reductions in consumption of meat and potatoes and milk, depending on level of occupational activity.[260]

Table 2–3 Characteristics of included studies

| Stated study objective | Study design | Year | Setting | Study population (n) | Description of exposure | Outcome(s) measured | Author | Source |
|---|---|---|---|---|---|---|---|---|
| To fill gap in longitudinal evidence on food habits before and after old age retirement | Pre-post, with control (survey, mean 3 years; adjusted for 7 covariates) | 2000-02 & 2007 | Helsinki, Finland | Municipal employees, males (n=527); females (n=1,824) | Old age retirement (63-68 years in Finland) | Healthy food habits (FFQ, 8-item index) (6/8=healthy) | Helldán et al 2011[264] | PubMed/ Medline |
| (1) To understand how retirement decisions of older Americans influence household food consumption patterns by gender; (2) to examine impact of the change in food consumption on weight | Panel survey (Health and Retirement Study) | 1992-2002 | USA | Population aged 50+ (n=6,012) | Retirement of self & spouse (i.e. not working for pay currently & for past 3 months, and self-reported retired) | Household spending on food at home; individual spending on eating out; BMI | Chung et al 2007[262] | Hand-searched |
| To study the impact of retirement on diet, physical activity, BMI and waist circumference, over a 5-year follow-up | Prospective cohort, with control (retired vs. employed, by job activity) | 1997-2002 | Rural town, Netherlands | Men aged 50-65 (n=288) | Not specifically defined (retirement) | Food intake (FFQ); physical activity; anthropometric measures | Nooyens et al 2005[260] | Web of Science |
| To preliminarily evaluate the impact of the Veggie Mobile [intervention] on the shopping and eating habits of a group of community-dwelling seniors | Pre-post, no control (postal survey) | 2008 | New York, USA | Residents aged 55+ (n=43) | Reduced cost of fruit and vegetable provided weekly through a mobile van | F&V intake (6-item questionnaire, 24 hours); frequency of supermarket visits and amount spent | Abusabha et al 2011[263] | Web of Science |
| To revisit spending on food at retirement and explore the hypothesis that retirement is accompanied by a negative wealth shock that causes people to reduce spending | Panel survey (British Household Panel Survey) (involuntary/ early vs. voluntary retired) | 1991-2002 | UK | Men aged 45-64 (n=2,000) | Retirement (i.e. first year man is both not working & self-reports retired) | Weekly food spending | Smith 2006[261] | Hand-searched |
| (1) To examine the relationship between consumption | Panel survey (Panel Study of | 1979-86 & 1989- | USA | Population aged | Retirement of husband (i.e. latest reported year | Annual household food | Lundberg et | Hand- |

Table 2–3 Characteristics of included studies

| Stated study objective | Study design | Year | Setting | Study population (n) | Description of exposure | Outcome(s) measured | Author | Source |
|---|---|---|---|---|---|---|---|---|
| behaviour and retirement; (2) to test the bargaining model by comparing married couples behaviour at retirement to that of singles | Income Dynamics) (unmarried vs. matched co-habiting pairs) | 2002 | | 45-74 (n=553) | retired) | spending (1985 US$) | al 2003[259] | searched |
| To evaluate dietary habits and body composition in a longitudinal study of municipally employed women before and after retirement | Pre-post, no control (median 5-month interval) | Not reported | Malmo, Sweden | Female municipal employees (n=116) | Not specifically defined (legal old age retirement) | Food intake (diet interview); height; weight; skinfolds; and waist | Steen et al 1988[257] | PubMed/ Medline |
| To examine shifts in fibre intakes between pre- and post-retirement periods | Pre-post, no control (survey) | Not reported | London, UK | Near-retired employees of 2 firms (n=183) | Retirement from work (i.e. minimum 6 months not in work) | Fibre intake (7-day weighed diary) | Davies et al 1986[256] | PubMed/ Medline |
| To investigate the impact of retirement on one's eating habits and food intake | Pre-post, no control (comparison 6 months pre with 19 months post) | Not reported | Toulouse, France | Persons near retirement (n=52), majority teachers | Not specifically defined (retirement) | Food intake (3-day diary); physical activity, perceived wellbeing | Lauque et al 1998[258] | PubMed/ Medline |

FFQ, food frequency questionnaire

Table 2-4 Summary of reported findings from included studies

| Study quality | Author | Food Spending | Food intake | Details |
|---|---|---|---|---|
| High | Helldán et al 2011[264] | | ↑, ≅ | Prevalence of healthy food habits in retired women increased (41% to 53%), compared to still employed women (39% to 45%). No change seen in men after retirement (23% to 29%) vs. remaining employed (24% to 27%). Socio-demographic & health-related factors did not explain difference among women. Retirement accentuated existing gender differences in healthy food habits. |
| High | Chung et al 2007[262] | ↓, ≅ | | Spending on eating out reduced by a mean of $10 per month when after the individual retired and by $7 after the spouse retired. The wife's, but not husband's, retirement decreased the spouse's monthly spending on eating out by $13. Retirement did not affect household spending on food at home. Weight gain was weakly predicted by spending on eating out. |
| High | Nooyens et al 2005[260] | | ↑, ↓ | Men retired from former active jobs consumed less potatoes, more fish, and more juice each week, than older men still working. Men retired from sedentary jobs consumed more alcoholic beverages, more vegetables, less meat, less potatoes and less milk on a weekly basis. |
| Medium | Abusabha et al 2011[263] | ↓ | ↑ | 48% reduced cost of F&V increased vegetable consumption from 33% to 51%; and increased fruit intake from 53% to 63%. Average spending at last supermarket trip decreased by nearly $15 and weekly Veggie Mobile shoppers spent $29 less at last supermarket visit than seniors using the program less often. |
| Medium | Smith 2006[261] | ↓, ≅ | | Involuntary retirement reduced food spending by 7-11% (depending on definition used). Effect greater for involuntarily early retired who have no employer pension and with no educational qualifications. |
| Medium | Lundberg et al 2003[259] | ↓, ≅ | | Co-habiting households decrease their food expenditures, consumed both at and away from home, by about 9% after retirement of male. Retirement in single-person household did not show any significant decrease in food consumption. |
| Medium | Steen et al 1998[257] | | ↑, ↓ | Clear decreasing tendency of intake of energy (by 7%), protein (by 8%), fat (by 10%), calcium (by 12%), and riboflavin (by 11%) from before to after retirement. High-energy food items such as pastry and potato chips increased after retirement. Small changes in other items (not specified) seen after retirement. Average number daily meals decreased after retirement (from 5.2 to 4.8). |
| Medium | Davies et al 1986[256] | | ↑, ≅ | Mean daily fibre intake increased slightly after retirement (from 17.6±6.5 to 18.4±6.1 g/day), especially when breakfast was consumed. Percentage of participants below recommended levels of fibre did not change. Also, the main food groups contributing to dietary fibre intake (e.g. vegetables, breads, breakfast cereals & fruits) remained unchanged. |
| Low | Lauque et al 1998[258] | | ↑, ≅ | Retirement increased the percentage of participants spending over 30 minutes to eat lunch (from 25.5% to 45.5%), and the frequency of eating out and having guests for meals. Men ate more plant protein after retirement. The distribution of nutrients did not change after retirement, staying near recommended daily allowance except low calcium intake which increased slightly (from 750.5±270 to 781±308 mg/day in women; and from 702±186 to 837.6±239.5 mg/day in men). |

↑, increase; ↓, decrease; ≅, no change

## 2.5 Discussion

This review has shown how, despite ample research on economic correlates of diet in older people, robust evidence of actual economic determinants remains scarce and largely framed in terms of employment transition to retirement. No relevant reviews were identified by the searches. However, the study found nine relatively good quality studies reporting mixed impact on food spending and/or food intake. Expenditures decreased and also remained unchanged; food intake increased and also decreased or stayed constant. Studies showed gender differences in impact on food spending and dietary intake. Effects also varied by retirement voluntariness, occupational activity level, living arrangements and point-of-purchase.

Reported results suggest that when an individual and/or their spouse retire, they reduce spending on food eaten away from, but not at, home. Notably, gender differences were observed insofar as spouses reduced away-from-home food spending when the wife, but not the husband, retired. Retirement's impact on food spending differed by living arrangements, with reductions occurring in co-habiting, but not single-person, households. The nature of retirement was also important, as larger decreases in food spending were reported for men retiring involuntarily despite their smaller income drop compared to men voluntarily retiring. The documented expenditure decreases were notably similar to the amount indicated by UK pensioners as sufficient to enable them to improve their diet.[265] However, whose diet is impacted, or by how much, will be a matter of not only employment-related economic change but also psycho-social context; contextual influences that may not be explained by known socio-demographic or health-related factors.[264]

The impact on food intake depended on the dietary aspect measured and in whom, although increases were documented in all six studies reporting this outcome. For example, prevalence of healthful consumption patterns increased after retirement among Finnish women and Dutch men. However, employment-related economic change could also negatively impact women's diets through, for example, limiting number of daily meals—a finding also reported in a recent qualitative study.[266] Given the heterogeneity of food intake measures, reported increases and decreases are difficult to interpret in terms of contributing to dietary healthfulness. Whereas decreases in overall quantity might promote health if optimal nutrition remains high or improves, increased consumption of energy-dense food items after retirement is likely to undermine nutritionally optimal diets.

The observed pattern of mixed impact on older people's diet in reported results could be explained by the complex context of employment-related economic change. The transition from employment to retirement involves diverse interconnected factors that are not only economic, such as those involving social structures, identities and gender roles, and psychological wellbeing.[267] For women at least, Brown et al (2012) illustrated well the complex link of multiple life changes shaping dietary decisions and behaviours although financial changes and constraints most commonly and profoundly impacted their food choice.[266] Another explanation for heterogeneity of documented impact is study differences in follow-up and therefore persistence of effect. Some results more likely reflected short-term impact on food spending or consumption (5-6 months after retirement), while follow-up over several years was perhaps more indicative of long-term behavioural changes. Yet, the average time spent in retirement prior to follow-up was only specified in two out of nine studies reviewed. Finally, between-country variation in policies for welfare, healthcare or mandatory retirement could also explain findings of mixed impact. Future studies should be designed to collect and analyse multi-level data on other socioeconomic characteristics, including length of and reasons for retirement, to clarify the role and relative contribution of multiple intersecting factors as potential economic determinants of older people's diet.

This review may have missed other evidence on economic mechanisms determining diet from grey literature as it focused exclusively on longitudinal studies in peer-reviewed publications. Included studies were also restricted to adults aged 60 years and older which may have biased economic exposures analysed to employment-related change. This review is nevertheless the most comprehensive reported to date, with searches conducted by two reviewers in eight databases covering interdisciplinary literature from a wide range of social sciences, not only the health field. It did not restrict publication date to allow for potentially older studies, and used broad terms to help ensure the widest possible evidence was captured.

The finding of scarce robust studies of economic determinants of older people's dietary habits is not new,[112 124] but one might expect the growth in empirical work on economic influences to advance the evidence base. There still exists a large knowledge gap concerning economic determinants of diet in older ages, other than retirement. Among longitudinal studies of retirement and diet, the use of comparison groups remains underdeveloped and the exposure tends to have unknown duration. What has emerged from existing evidence is

a confirmation of the acknowledged complexity of studying determinants of diet in older ages. This study therefore reaffirms the call to public health researchers to analyse and theoretically account for combined effects and interactions between change in a given economic factor, such as employment, and other dimensions of life transition in older individuals.[11-13]

## 2.6 Conclusion

Despite the well-established view that older people's diets are especially vulnerable to varied economic influences, robust evidence of economic determinants remains scarce. Only a small body of work has developed on the transition from employment to retirement as a dynamic period of economic change. It was clear the direction and size of impact on food spending or habits differed across subgroups analysed, but much less is known about persistence of reported effects. Thus, firm conclusions about economic determinants of diet in older people are difficult to draw.

If public health and policy aim to promote healthful eating and support behaviour change, then greater attention is needed to reproduce and add to this burgeoning evidence base using controlled longitudinal studies, with different exposures of defined periods and multiple dietary follow-up in various subgroups of the older population. Only then can we know whether recurring concerns about increasing inflation and rising food prices have an impact, if any, on eating behaviours, how lasting they are and for which groups of older people.

# CHAPTER 3 Financial hardship and diet quality in older adults

This work is submitted as: Conklin AI, Forouhi NG, Suhrcke M, Surtees P, Wareham NJ, Monsivais P. Variety, more than quantity, of fruits and vegetables varies by multiple economic conditions in 9,580 older British adults. (*Journal of Nutrition*, under review).

## 3.1 Abstract

**Background:** Beyond quantity, variety of fruits and vegetables (FV) prevents chronic conditions and is widely recommended as critical to healthful eating. FV consumption is socially patterned, especially for women, but little is known about diverse economic determinants of variety or whether they differ from those of quantity.

**Methods:** This cross-sectional study examined six economic-related factors, including novel financial hardship measures, in relation to both variety (items/month) and quantity (g/d) of fruit and/or vegetable intake in older British adults. Data came from 9,580 over-50s in the nationally representative EPIC cohort, UK, who responded to a postal Health and Life Experiences Questionnaire (1996-2000) and Food Frequency Questionnaire (1998-2002).

**Results:** No consistent gradients by any economic factor, except education in men, were observed for quantity of fruits or vegetables. By contrast, lower education, lower social class and renting were independently associated with lower fruit variety and vegetable variety in both women and men (p-trend <0.001). Gradients were stronger in men as, for example, mean vegetable variety differed between top and bottom social classes by 2.9 items/month for men but 2.5 for women. Greater financial hardship was also independently associated with lower variety, with gradients stronger in women for fruits and in men for vegetables.

**Conclusion:** British over-50s who reported greater economic disadvantage, including financial hardships, consistently consumed fewer different fruits and/or vegetables, but not lower amounts. Further nutrition studies of the protective effects, and underlying

mechanisms, of fruit variety and vegetable variety are warranted for addressing social inequalities in older adults' diet quality. In addition, dietary guidance should separately emphasise variety, and interventions should aim to address financial barriers to older adults' consumption of diverse FV.

## 3.2 Introduction

Poor diet quality and low consumption of FV are associated with higher mortality and morbidity.[23 27] Variety of foods, particularly FV, is commonly recommended as critical to healthful eating,[31 35-37] and prospective evidence shows that, independent of quantity, a higher variety of fruits and/or vegetables consumed is protective against common chronic conditions.[61-63] Greater variety is important for supporting health because variety improves nutritional adequacy and diet quality by increasing a person's exposure to a wide range of nutrients and phytochemicals necessary to support normal physical functioning.[39 42-48 53] Moreover, greater diversity of foods consumed may also reduce hospitalisations and use of acute medical care among older adults.[56] As older adults comprise more of the UK population (from 17% to 22% by 2032),[3] there is increasing importance for health policy and population-level strategies to support healthy ageing through consumption of more, and varied, FV so as to prevent, and manage, the large and growing global burden of chronic conditions that impose substantial personal and social costs.[26 27 41] Efforts to promote healthful eating, however, must be informed by evidence on the determinants of both quantity and variety of FV consumption since these measures have independent implications for health.

It is known that FV consumption levels are strongly associated with SES as a conventional proxy for economic-related resources measured by income, occupational grade, education, or wealth.[84 268 269] Whole-diet variety is also reported to increase when income increases, and more so among less educated groups;[270] although more food variety is associated with higher cost.[88 271 272] Beyond standard SES measures, an older person's financial situation might also be worth considering among potential economic conditions determining healthful eating.[273] Self-reported FH, such as difficulty paying bills, represents concrete financial strain that is likely to exert a more direct influence on their decisions about purchasing and consuming FV.[127 274 275] One Finnish study of overall economic hardship reported associations with healthy food habits in working women, independent of four SES

indicators.[241] Notably, everyday financial troubles are not sufficiently characterised by conventional SES indicators,[276-278] and thus must be included in a holistic assessment of economic factors influencing diet among older populations which others have neglected.[124] Doing so will also add new evidence to current research on FH and health behaviours which has examined FH using a summary measure that combined different types of hardship.[241 279] Existing literature is therefore limited for this reason since older people may experience some hardships more than others, particularly difficulty paying bills and affording adequate food and clothing.[211] To fill this gap, this study investigated six different economic-related factors in relation to both variety and quantity of fruits and/or vegetables in older British women and men.

## 3.3 Methods

### 3.3.1 Study population

This study used data on over-50s from EPIC-Norfolk (detailed in 1.5.2), who were similar to the full cohort in terms of entry measures of socio-demographic characteristics and health behaviours (Appendix B, Table B–1).

### 3.3.2 Measures

*Economic exposures*

Factors describing participants' economic context as the exposure of interest were operationalised using three conventional SES indicators (education, occupational social class and home-ownership, as a wealth proxy), and three novel measures of FH (money for needs, frequency of insufficient money for food/clothing and difficulty paying bills). The maximum number of categories for each economic-related factor were used rather than dichotomised variables, so as to avoid obscuring important gradients in diet quality outcomes that may be present across the entire social spectrum.[179] However, FH responses 'often' and 'always', or 'great' and 'very great', were combined for analysis due to low numbers in these bottom categories. Completed responses for the three FH measures from over-50s ranged between 17,953 and 17,998 depending on the individual question. Over-50 responders and non-responders to FH questions showed small differences in socio-demographics measured at cohort entry, although similar differences were seen between the responders and non-responders in the full cohort (Appendix B, Table B–2).

*Dietary outcomes*

Two main outcomes were examined as proxies for diet quality. The first was a continuous variable for the quantity of intake of fruits, vegetables or both reported as consumed by over-50s completing the EPIC-Norfolk Food Frequency Questionnaire (FFQ) at the second clinical assessment. Quantity was calculated by summing the total amount (g/day) of fruits and/or vegetables. The second outcome was a continuous score derived for the variety of reported intake of fruits and/or vegetables (see 1.5.2). Those over-50s who responded to the FFQ in the analytic sample did not differ from those in the sample who did not respond to the FFQ (Appendix B, Table B–3).

*Socio–demographic variables*

Concurrent socio-demographic variables included: self-reported general health status (excellent, good, moderate, poor); smoking status (current, former, never); and marital status (married/living as married, single, widowed, separate, divorced); BMI ($kg/m^2$) calculated from measured height and weight. Regular car use (yes/no) was self-reported in the Environment and Physical Activity questionnaire during the period of this study (1998-2000). Age (continuous) and gender (male, female) were measured at entry.

The process of selecting the eligible sample is given in Figure 3–1, with those analysed having near-complete (99%) information and including over-50s who responded to FH questions, had key covariates and plausible diet data at follow-up (range: 8,413—8,425) (averaging 18 months after FH exposures).

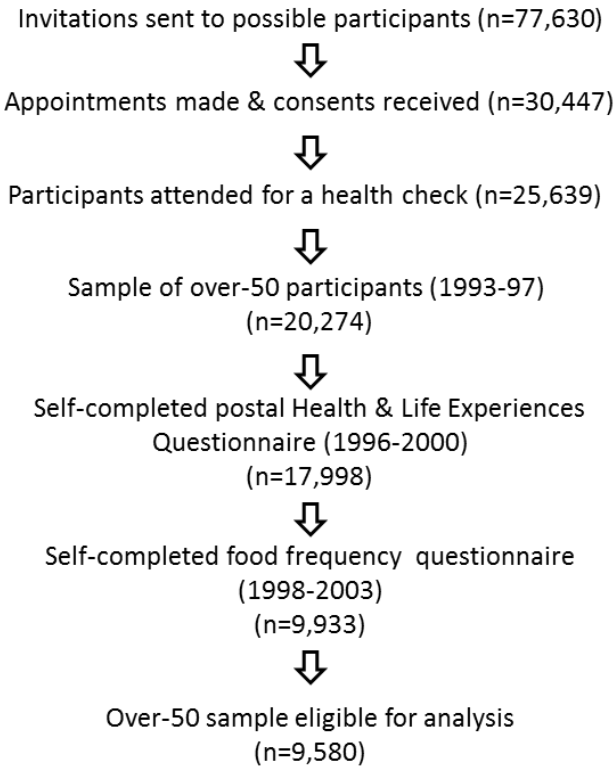



Figure 3-1 Process of sample selection from the EPIC-Norfolk cohort

### 3.3.3 Data analysis

Descriptive statistics summarised socio-demographic characteristics and crude mean variety or quantity of combined FV, across levels of novel FH measures. Multivariable linear regression models assessed cross-sectional associations between each economic variable and dietary outcome, adjusting for energy intake, age, and marital status. As known confounders, each is associated with economic factors and independently with diet.[46 280 281] Regression coefficients were then used for post-estimation calculation of adjusted means and 95 percent confidence intervals (CI95) (Model A). Independent effects of a given economic factor on mean variety or quantity of fruits and/or vegetables were examined by further adjusting for all FH measures in analyses of each indicator of SES, and for all SES variables in analyses of each FH variable (Model B). In addition, mean intakes of fibre (g), vitamin A (µg), magnesium (mg), potassium (mg), vitamin C (mg) and zinc (mg) across gender-specific quintiles of variety and quantity of fruit or vegetable intake were examined in post-estimation of stratified regression models adjusting for energy, age and quantity (for variety) or variety (for quantity).

Models used a cross-product term between gender and exposure of interest to calculate gender-specific adjusted means and assess any statistically significant difference ($p<0.05$).

Linear contrast in coefficients from gender-stratified covariate-adjusted models of ordered categorical independent variables evaluated significance of linear trend; formulae were specific to each variable's number of levels (e.g. 5 for difficulty paying bills). For the unordered home-ownership variable, overall F statistic evaluated differences in group-specific means. Sensitivity analyses of both covariate- and SES-adjusted models included additional conditioning on: quantity (for variety as the independent variable); variety (for quantity as the independent variable); or other concurrent lifestyle factors (total alcohol (continuous); physical activity and energy expenditure (continuous); and smoking status (categorical)).

## 3.4 Results

The sample of 55% women averaged age 62 y, with 83% reporting good/excellent general health and 51% having ever smoked. For the whole sample 13% were educated to degree-level, although 15% of men and 11% of women reported degree-level education. The top-two social classes comprised 46% of the sample; more women (4%) than men (2%) had unskilled occupations. Men and women were generally overweight at follow-up (26.8 $kg/m^2$ (SD 3.3), and 26.7 $kg/m^2$ (SD 4.4), respectively). Women reported consuming fewer total calories than men (1,850 versus 2,087 kcal/d). Variety scores were normally distributed, with women consuming greater variety and more quantity of fruits and/or vegetables than men (24.2 items/month and 582 g/d versus 22.6 and 496, respectively). Few over-50s reported no consumption (0 g/d) of any fruit (n=55) or vegetable (n=6) item and therefore scored zero for variety.

Monotonic associations were observed between gender-specific quintiles of fruit variety and adjusted mean intakes of fibre, vitamin C, zinc, vitamin A, potassium, and magnesium. Results were similar, with magnitudes higher, for fruit quantity except regarding vitamin A which showed no monotonic association with fruit quantity (Appendix B, Table B–4). Higher mean intakes of vitamin C, magnesium and potassium were associated with higher gender-specific quintiles of vegetable variety. Gradients were strongest for gender-specific quintiles of vegetable quantity (Appendix B, Table B–4).

### 3.4.1 Sample characteristics across FH levels

Socio-demographic characteristics were generally evenly distributed across levels of FH, but large differences were observed in marital status, education, social class, and home-

ownership (Table 3–1). There were higher proportions of women reporting the greatest hardship regarding insufficient money for food/clothing and difficulty paying bills. Crude mean scores for FV variety decreased across increasing levels of hardship, while quantity was consistently lowest only for the greatest hardship category.

### 3.4.2 FV intake by conventional SES groupings

Three of the economic exposures examined using conventional SES indicators, showed a consistent gradient in the mean scores for fruit variety (Table 3–2, Model A). Thus, higher education, higher social class, and home-ownership were each associated with higher variety scores, after accounting for known confounders. However, the relationship between conventional SES indicators and fruit quantity did not reveal a consistent pattern of inverse association as statistically significant gradients in both genders were observed for only education and social class. Clear and strong gradients by SES were also observed for both women and men in relation to vegetable variety, but not to quantity (Table 3–3, Model A). The only exception was gradients by education in vegetable quantity for men only. At any level of an SES indicator, women consumed greater variety and quantity of fruits or vegetables than men.

In additional models that further adjusted for all three FH measures, the relationship of each SES variable with each dietary outcome remained similar to the associations adjusted for covariates (Table 3–2 and Table 3–3, Model B). Only one gender-specific exception was noted: the relationship of vegetable quantity became near-significantly graded by home-ownership categories in women ($p=0.05$).

Results for covariate- and FH-adjusted associations were repeated when FV intake was combined (Appendix B, Table B–5).

Table 3-1 Characteristics of older adults in the EPIC-Norfolk study across levels of FH

| | Women | Not married | Lower education[a] | Lower social class[b] | Renter[c] | Poor/ moderate health | Ever smoker | Irregular car use | Mean (SD) FV quantity (g/d) | Mean (SD) FV variety score (0-27 items/m) |
|---|---|---|---|---|---|---|---|---|---|---|
| Having enough money for needs (n=8,413) | | | | | | | | | | |
| More than enough (n=1,640) | 53% | 16% | 28% | 7% | 1% | 10% | 46% | 82% | 539 (243) | 24.4 (5.4) |
| Just enough (n=6,011) | 56% | 20% | 48% | 16% | 8% | 16% | 51% | 78% | 547 (262) | 23.5 (5.5) |
| Less than enough (n=762) | 53% | 31% | 53% | 23% | 23% | 28% | 62% | 83% | 530 (282) | 22.4 (5.9) |
| Frequency of insufficient money for food or clothing (n=8,417) | | | | | | | | | | |
| Never (n=5,197) | 54% | 18% | 42% | 12% | 4% | 13% | 49% | 81% | 545 (258) | 23.7 (5.5) |
| Seldom (n=1,869) | 56% | 21% | 48% | 18% | 8% | 18% | 52% | 77% | 549 (253) | 23.9 (5.5) |
| Sometimes (n=1,005) | 59% | 24% | 53% | 23% | 16% | 21% | 53% | 74% | 546 (284) | 23.3 (5.7) |
| Often/ Always (n=346) | 61% | 36% | 55% | 27% | 26% | 32% | 59% | 74% | 502 (257) | 21.4 (6.2) |
| Difficulty paying bills (n=8,425) | | | | | | | | | | |
| None (n=5,151) | 55% | 17% | 44% | 12% | 5% | 13% | 50% | 79% | 547 (257) | 23.6 (5.5) |
| Very little (n=1,991) | 54% | 21% | 45% | 17% | 8% | 17% | 52% | 79% | 544 (257) | 23.9 (5.4) |
| Slight (n=602) | 56% | 22% | 44% | 20% | 14% | 21% | 55% | 75% | 544 (270) | 23.7 (5.8) |
| Some (n=571) | 60% | 33% | 52% | 26% | 23% | 28% | 56% | 75% | 524 (275) | 22.9 (6.0) |
| Great/ Very great (n=110) | 60% | 35% | 54% | 25% | 27% | 35% | 68% | 79% | 531 (307) | 21.4 (6.3) |

FV, combined intake of fruit and vegetable. Measurement time-points were: gender, education, and occupational class (1993-1997); home-ownership, FH measures and regular car use (1996-2000); self-rated general health, smoking status, marital status and dietary intake (1998-2002). [a]No qualification or O-level. [b]Partly skilled (class IV), or unskilled (class V) occupations. [c]Council, private and furnished, or private and unfurnished accommodation.

Table 3-2 Adjusted mean quantity and variety of fruit intake in older adults in the EPIC-Norfolk study by levels of SES

| | Fruit quantity (g/d) | | | | Fruit variety (items/m) | | | |
|---|---|---|---|---|---|---|---|---|
| | Women | | Men | | Women | | Men | |
| | *Model A* | *Model B: + FH* | *Model A* | *Model B: + FH* | *Model A* | *Model B: + FH* | *Model A* | *Model B: + FH* |
| Social class | | | | | | | | |
| Professional | 320 (300, 339) | 321 (301, 342) | 264 (244, 283) | 263 (243, 283) | 8.0 (7.8, 8.3) | 8.0 (7.7, 8.2) | 7.4 (7.2, 7.7) | 7.4 (7.1, 7.6) |
| Managerial and Technical | 306 (235, 253) | 306 (297, 314) | 244 (235, 253) | 242 (233, 252) | 8.0 (7.9, 8.1) | 8.0 (7.9, 8.1) | 7.0 (6.9, 7.2) | 7.0 (6.9, 7.1) |
| Skilled non-manual | 295 (284, 306) | 292 (281, 304) | 236 (220, 251) | 234 (218, 250) | 7.6 (7.4, 7.7) | 7.5 (7.4, 7.7) | 6.6 (6.4, 6.8) | 6.6 (6.4, 6.8) |
| Skilled manual | 295 (284, 306) | 294 (282, 306) | 225 (214, 237) | 227 (215, 240) | 7.5 (7.3, 7.6) | 7.5 (7.3, 7.7) | 6.4 (6.2, 6.5) | 6.4 (6.3, 6.6) |
| Partly skilled | 295 (280, 309) | 297 (282, 313) | 228 (212, 243) | 232 (215, 248) | 7.5 (7.3, 7.6) | 7.5 (7.3, 7.7) | 6.2 (6.0, 6.4) | 6.4 (6.2, 6.6) |
| Unskilled | 287 (260, 313) | 281 (252, 310) | 209 (173, 246) | 211 (172, 250) | 7.0 (6.7, 7.4) | 7.1 (6.7, 7.4) | 6.1 (5.6, 6.5) | 6.1 (5.6, 6.6) |
| *P-trend* | *0.021* | *0.019* | *0.001* | *0.006* | *<0.001* | *<0.001* | *<0.001* | *<0.001* |
| Education | | | | | | | | |
| Degree | 318 (303, 333) | 317 (302, 333) | 261 (247, 275) | 258 (244, 273) | 8.2 (8.1, 8.4) | 8.2 (8.0, 8.4) | 7.5 (7.3, 7.6) | 7.4 (7.2, 7.6) |
| A-level | 307 (299, 315) | 306 (297, 314) | 233 (225, 241) | 233 (225, 242) | 8.0 (7.9, 8.1) | 7.9 (7.8, 8.1) | 6.8 (6.7, 6.9) | 6.8 (6.7, 6.9) |
| O-level | 291 (277, 306) | 291 (276, 307) | 239 (220, 257) | 234 (215, 254) | 7.8 (7.6, 8.0) | 7.8 (7.6, 7.9) | 6.7 (6.5, 7.0) | 6.7 (6.4, 6.9) |
| No qualification | 292 (284, 299) | 291 (282, 299) | 231 (221, 241) | 233 (223, 244) | 7.3 (7.2, 7.4) | 7.4 (7.2, 7.5) | 6.3 (6.2, 6.4) | 6.3 (6.2, 6.5) |
| *P-trend* | *0.001* | *0.002* | *0.001* | *0.01* | *<0.001* | *<0.001* | *<0.001* | *<0.001* |
| Home-ownership | | | | | | | | |
| Owner occupier | 300 (294, 305) | 299 (294, 305) | 239 (233, 245) | 238 (232, 245) | 7.8 (7.7, 7.8) | 7.8 (7.7, 7.8) | 6.8 (6.7, 6.9) | 6.8 (6.7, 6.9) |
| Renter, private | 293 (260, 326) | 296 (263, 328) | 224 (187, 260) | 225 (188, 262) | 7.2 (6.8, 7.6) | 7.3 (6.9, 7.7) | 6.1 (5.6, 6.6) | 6.2 (5.7, 6.6) |
| Renter, public | 299 (277, 320) | 302 (280, 324) | 225 (197, 252) | 229 (201, 257) | 7.0 (6.7, 7.3) | 7.1 (6.9, 7.4) | 5.9 (5.6, 6.3) | 6.0 (5.7, 6.4) |
| *P-difference* | *0.924* | *0.947* | *0.468* | *0.654* | *<0.001* | *<0.001* | *<0.001* | *<0.001* |

Gender-specific means (CI95) obtained by multivariable linear regression analysis adjusted for total energy intake (kcal/d), baseline age (continuous), and concurrent marital status (categorical) (Model A); then for FH (money for needs; frequency of insufficient money for food/clothing; difficulty paying bills) (Model B). Model B numbers were: social class (8,535); education (8,678); home-ownership (8,538).

Table 3-3 Adjusted mean quantity and variety of vegetable intake in older adults in the EPIC-Norfolk study by levels of SES

| | Vegetable quantity (g/d) | | | | Vegetable variety (items/m) | | | |
|---|---|---|---|---|---|---|---|---|
| | Women | | Men | | Women | | Men | |
| | *Model A* | *Model B: + FH* | *Model A* | *Model B: + FH* | *Model A* | *Model B: + FH* | *Model A* | *Model B: + FH* |
| Social class | | | | | | | | |
| Professional | 278 (264, 291) | 280 (266, 294) | 261 (248, 274) | 259 (246, 273) | 17.6 (17.2, 18.0) | 17.6 (17.2, 18.0) | 17.2 (16.7, 17.6) | 17.1 (16.6, 17.5) |
| Managerial and Technical | 291 (285, 297) | 293 (287, 298) | 266 (260, 272) | 267 (261, 274) | 17.2 (17.1, 17.4) | 17.2 (17.1, 17.4) | 16.6 (16.5, 16.8) | 16.6 (16.4, 16.8) |
| Skilled non-manual | 278 (270, 285) | 279 (271, 286) | 253 (243, 263) | 254 (243, 265) | 16.3 (16.1, 16.5) | 16.3 (16.1, 16.5) | 15.7 (15.3, 16.0) | 15.7 (15.3, 16.0) |
| Skilled manual | 287 (279, 294) | 284 (275, 292) | 255 (247, 263) | 254 (246, 263) | 15.9 (15.7, 16.2) | 15.9 (15.7, 16.2) | 15.0 (14.8, 15.3) | 15.1 (14.8, 15.4) |
| Partly skilled | 272 (262, 282) | 271 (261, 281) | 257 (247, 268) | 256 (245, 267) | 15.8 (15.5, 16.1) | 15.8 (15.5, 16.1) | 14.9 (14.5, 15.2) | 15.0 (14.7, 15.3) |
| Unskilled | 278 (260, 296) | 267 (249, 288) | 246 (221, 271) | 244 (217, 271) | 15.1 (14.5, 15.7) | 15.2 (14.6, 15.8) | 14.3 (13.5, 15.1) | 14.4 (13.6, 15.2) |
| *P-trend* | *0.393* | *0.077* | *0.156* | *0.155* | *<0.001* | *<0.001* | *<0.001* | *<0.001* |
| Education | | | | | | | | |
| Degree | 282 (272, 292) | 281 (271, 292) | 263 (254, 273) | 263 (253, 273) | 17.7 (17.4, 18.0) | 17.6 (17.3, 17.9) | 17.1 (16.8, 17.4) | 17.0 (16.7, 17.3) |
| A-level | 288 (282, 293) | 288 (282, 294) | 264 (258, 269) | 264 (258, 269) | 17.1 (17.0, 17.3) | 17.1 (17.0, 17.3) | 16.1 (15.9, 16.3) | 16.2 (16.0, 16.3) |
| O-level | 277 (267, 287) | 278 (267, 288) | 254 (241, 266) | 254 (240, 267) | 16.7 (16.4, 17.0) | 16.7 (16.4, 17.0) | 16.3 (15.9, 16.7) | 16.2 (15.8, 16.6) |
| No qualification | 283 (277, 288) | 281 (275, 287) | 253 (246, 260) | 254 (247, 261) | 15.6 (15.5, 15.8) | 15.7 (15.5, 15.8) | 14.8 (14.6, 15.0) | 14.9 (14.7, 15.2) |
| *P-trend* | *0.662* | *0.638* | *0.019* | *0.050* | *<0.001* | *<0.001* | *<0.001* | *<0.001* |
| Home-ownership | | | | | | | | |
| Owner occupier | 285 (281, 288) | 285 (281, 289) | 261 (257, 265) | 261 (257, 265) | 16.7 (16.6, 16.8) | 16.7 (16.6, 16.8) | 16.0 (15.9, 16.2) | 16.1 (15.9, 16.2) |
| Renter, private | 283 (261, 306) | 283 (260, 305) | 247 (222, 272) | 248 (222, 273) | 16.0 (15.3, 16.7) | 16.1 (15.4, 16.8) | 15.2 (14.5, 16.0) | 15.4 (14.6, 16.1) |
| Renter, public | 267 (253, 282) | 264 (249, 279) | 251 (233, 270) | 250 (231, 269) | 14.8 (14.4, 15.3) | 15.0 (14.5, 15.5) | 13.9 (13.3, 14.5) | 14.0 (13.4, 14.6) |
| *P-difference* | *0.111* | *0.050* | *0.308* | *0.276* | *<0.001* | *<0.001* | *<0.001* | *<0.001* |

Gender-specific means (CI95) obtained by multivariable linear regression analysis adjusted for total energy intake (kcal/d), baseline age (continuous), and concurrent marital status (categorical) (Model A), then for FH (money for needs; frequency of insufficient money for food/clothing; difficulty paying bills) (Model B). Model B numbers were: social class (8,535); education (8,678); home-ownership (8,538).

### 3.4.3 FV intake by FH levels

In covariate-adjusted models, the relationship between FH and quantity of fruits also did not show a clear gradient or differences by gender (Table 3–4, Model A). By contrast, an inverse association between all measures of FH and mean fruit variety was seen in women and men. Results were similar for vegetable intake (Table 3–5, Model A). Notably, women appeared to have stronger associations between FH and fruit variety; whereas men showed stronger hardship differences in relation to vegetable variety.

Further adjustment for conventional SES indicators minimally attenuated the associations between FH and mean scores for fruit variety (Table 3–4, Model B), or vegetable variety (Table 3–5, Model B). Attenuation of associations between difficulty paying bills and variety scores occurred more for men than women. Nonetheless, all three FH measures showed an inverse trend in mean fruit variety for both genders after considering conventional SES indicators, although it appeared stronger for women. By contrast, gradients by FH measures in mean vegetable variety lost significance after additionally adjusting for education, social class and home-ownership, with two exceptions in men (frequency of insufficient money for food/clothing and difficulty paying bills).

Differences between the highest and lowest mean scores for combined FV variety scores were generally greater in men for each FH measure, overall (Model A) and independent of SES (Model B) (Appendix B, Table B–7).

Table 3-4 Adjusted mean quantity and variety of fruit intake in older adults in the EPIC-Norfolk study by levels of FH

| | Fruit quantity (g/d) | | | | Fruit variety (items/m) | | | |
|---|---|---|---|---|---|---|---|---|
| | Women | | Men | | Women | | Men | |
| | *Model A* | *Model B: + SES* | *Model A* | *Model B: + SES* | *Model A* | *Model B: + SES* | *Model A* | *Model B: + SES* |
| Enough money for needs | | | | | | | | |
| More than enough | 299 (287, 311) | 295 (283, 308) | 241 (228, 254) | 237 (224, 250) | 8.0 (7.8, 8.1) | 7.8 (7.6, 7.9) | 7.1 (6.9, 7.3) | 6.9 (6.8, 7.1) |
| Just enough | 300 (294, 306) | 301 (295, 307) | 236 (229, 243) | 239 (232, 246) | 7.7 (7.6, 7.8) | 7.7 (7.7, 7.8) | 6.7 (6.6, 6.8) | 6.7 (6.7, 6.8) |
| Less than enough | 297 (280, 315) | 297 (279, 315) | 237 (219, 256) | 238 (219, 257) | 7.2 (7.0, 7.4) | 7.4 (7.1, 7.6) | 6.3 (6.1, 6.6) | 6.5 (6.3, 6.8) |
| *P-trend* | *0.754* | *0.961* | *0.766* | *0.912* | *<0.001* | *0.001* | *<0.001* | *0.023* |
| Frequency of insufficient money for food/clothing | | | | | | | | |
| Never | 301 (295, 308) | 302 (295, 308) | 241 (234, 248) | 241 (234, 248) | 7.8 (7.7, 7.9) | 7.7 (7.7, 7.8) | 6.8 (6.7, 6.9) | 6.8 (6.7, 6.8) |
| Seldom | 299 (288, 309) | 300 (289, 311) | 233 (220, 245) | 236 (224, 249) | 7.8 (7.7, 7.9) | 7.9 (7.7, 8.0) | 6.8 (6.6, 6.9) | 6.9 (6.7, 7.0) |
| Sometimes | 300 (286, 315) | 300 (285, 315) | 226 (209, 243) | 229 (211, 247) | 7.5 (7.3, 7.7) | 7.6 (7.4, 7.8) | 6.6 (6.4, 6.8) | 6.8 (6.5, 7.0) |
| Often/ Always | 269 (245, 293) | 268 (242, 293) | 233 (203, 262) | 230 (199, 261) | 6.9 (6.6, 7.2) | 7.1 (6.8, 7.4) | 6.1 (5.7, 6.5) | 6.3 (5.9, 6.7) |
| *P-trend* | *0.019* | *0.017* | *0.472* | *0.397* | *<0.001* | *<0.001* | *<0.001* | *0.039* |
| Difficulty paying bills | | | | | | | | |
| None | 303 (297, 310) | 303 (296, 310) | 242 (234, 249) | 242 (235, 250) | 7.8 (7.7, 7.8) | 7.7 (7.6, 7.8) | 6.8 (6.7, 6.9) | 6.7 (6.7, 6.8) |
| Very little | 294 (283, 305) | 294 (283, 305) | 233 (221, 244) | 235 (223, 247) | 7.8 (7.7, 8.0) | 7.9 (7.7, 8.0) | 6.8 (6.6, 6.9) | 6.8 (6.7, 7.0) |
| Slight | 300 (281, 320) | 302 (282, 322) | 227 (205, 249) | 227 (205, 249) | 7.6 (7.3, 7.8) | 7.7 (7.4, 7.9) | 6.9 (6.6, 7.2) | 6.9 (6.6, 7.2) |
| Some | 290 (271, 309) | 292 (273, 312) | 218 (194, 241) | 221 (197, 245) | 7.4 (7.1, 7.6) | 7.5 (7.3, 7.8) | 6.4 (6.1, 6.7) | 6.5 (6.2, 6.8) |
| Great/ Very great | 261 (218, 304) | 253 (209, 298) | 248 (196, 301) | 244 (190, 298) | 6.6 (6.0, 7.1) | 6.7 (6.1, 7.2) | 6.3 (5.7, 7.0) | 6.6 (5.9, 7.2) |
| *P-trend* | *0.045* | *0.027* | *0.997* | *0.914* | *<0.001* | *<0.001* | *0.104* | *0.488* |

Gender-specific means (CI95) obtained by multivariable linear regression analysis adjusting for energy intake (continuous), baseline age (continuous), concurrent marital status (categorical) (Model A), then for SES (education, social class and home-ownership) (Model B). Model B numbers were: money for needs (8,413); insufficient money for food/clothing (8,417); difficulty paying bills (8,425).

Table 3–5 Adjusted mean quantity and variety of vegetable intake in older adults in the EPIC–Norfolk study by levels of FH

| | Vegetable quantity (g/d) | | | | Vegetable variety (items/m) | | | |
|---|---|---|---|---|---|---|---|---|
| | Women | | Men | | Women | | Men | |
| | *Model A* | *Model B: + SES* | *Model A* | *Model B: + SES* | *Model A* | *Model B: + SES* | *Model A* | *Model B: + SES* |
| Enough money for needs | | | | | | | | |
| More than enough | 279 (271, 287) | 276 (268, 285) | 256 (247, 265) | 253 (244, 262) | 17.0 (16.7, 17.2) | 16.5 (16.2, 16.7) | 16.6 (16.3, 16.9) | 16.1 (15.9, 16.4) |
| Just enough | 285 (281, 289) | 286 (282, 290) | 261 (256, 266) | 262 (257, 267) | 16.5 (16.4, 16.6) | 16.6 (16.5, 16.7) | 15.9(15.7, 16.0) | 16.0 (15.8, 16.1) |
| Less than enough | 280 (268, 292) | 279 (266, 291) | 262 (250, 275) | 265 (252, 278) | 15.9 (15.6, 16.3) | 16.4 (16.0, 16.7) | 15.2 (14.8, 15.6) | 15.6 (15.2, 16.0) |
| *P-trend* | *0.904* | *0.776* | *0.396* | *0.106* | *<0.001* | *0.545* | *<0.001* | *0.057* |
| Frequency of insufficient money for food/clothing | | | | | | | | |
| Never | 281 (277, 286) | 281 (276, 285) | 260 (255, 264) | 259 (254, 264) | 16.6 (16.5, 16.8) | 16.5 (16.3, 16.6) | 16.0 (15.9, 16.2) | 15.9 (15.8, 16.1) |
| Seldom | 287 (279, 294) | 289 (281, 297) | 262 (254, 270) | 263 (255, 272) | 16.7 (16.4, 16.9) | 16.8 (16.6, 17.1) | 16.0 (15.7, 16.3) | 16.1 (15.9, 16.4) |
| Sometimes | 286 (276, 296) | 288 (278, 298) | 262 (251, 274) | 264 (251, 276) | 16.3 (16.0, 16.6) | 16.7 (16.4, 17.0) | 15.8 (15.4, 16.2) | 16.2 (15.8, 16.5) |
| Often/ Always | 283 (267, 299) | 284 (267, 301) | 246 (226, 266) | 252 (231, 273) | 15.6 (15.1, 16.1) | 16.0 (15.5, 16.5) | 14.1 (13.5, 14.7) | 14.6 (14.0, 15.3) |
| *P-trend* | *0.884* | *0.750* | *0.183* | *0.470* | *<0.001* | *0.054* | *<0.001* | *<0.001* |
| Difficulty paying bills | | | | | | | | |
| None | 282 (278, 287) | 282 (278, 287) | 258 (253, 263) | 258 (253, 263) | 16.5 (16.4, 16.7) | 16.4 (16.3, 16.6) | 16.0 (15.8, 16.1) | 15.9 (15.7, 16.1) |
| Very little | 287 (280, 294) | 288 (280, 295) | 265 (257, 273) | 266 (258, 274) | 16.8 (16.6, 17.1) | 16.9 (16.7, 17.1) | 16.0 (15.8, 16.3) | 16.1 (15.9, 16.4) |
| Slight | 290 (277, 303) | 294 (280, 307) | 259 (244, 274) | 260 (245, 275) | 16.5 (16.1, 16.9) | 16.8 (16.4, 17.2) | 16.2 (15.7, 16.6) | 16.3 (15.8, 16.7) |
| Some | 272 (259, 285) | 273 (260, 286) | 252 (237, 268) | 255 (238, 271) | 16.0 (15.6, 16.4) | 16.4 (16.0, 16.9) | 15.4 (14.9, 15.9) | 15.8 (15.3, 16.3) |
| Great/ Very great | 283 (254, 312) | 283 (253, 314) | 278 (242, 313) | 286 (249, 323) | 15.4 (14.5, 16.4) | 15.8 (14.9, 16.7) | 14.0 (12.9, 15.1) | 14.6 (13.5, 15.7) |
| *P-trend* | *0.635* | *0.652* | *0.453* | *0.213* | *0.001* | *0.054* | *<0.001* | *0.019* |

Gender-specific means (CI95) obtained by multivariable linear regression analysis adjusting for energy intake (continuous), baseline age (continuous), and concurrent marital status (categorical) (Model A), then for SES (education, social class and home-ownership) (Model B). Model B numbers were: money for needs (8,413); insufficient money for food/clothing (8,417); difficulty paying bills (8,425).

Sensitivity analyses of independent associations between each economic exposure and dietary outcomes are given in Table B–6, Table B–8 and Table B–9 in Appendix B. Inclusion of other lifestyle factors or quantity of fruit and/or vegetable intakes did not alter the relationship between any economic factor examined and variety outcomes. Additional adjustment for variety in analyses of quantity either attenuated or amplified associations with a given economic exposure in no clear pattern for both genders.

## 3.5 Discussion

### 3.5.1 Synopsis of results

Quantity and variety of FV intake were differentially associated with multiple economic factors. Clear gradients in variety of fruit and/or vegetable were observed across three conventional SES indicators and three types of FH, whereas inverse associations for quantity outcomes were less consistent. For conventional SES indicators, gradients in fruit variety and vegetable variety appeared steeper in men. For FH measures, however, the association with fruit variety appeared somewhat stronger in women while the association with vegetable variety was stronger in men. Among the different hardships, difficulty paying bills showed the greatest difference in mean variety between extreme categories. Statistically significant associations between FH and variety outcomes remained after considering SES. Conversely, gradients in variety by SES were independent of FH.

### 3.5.2 Methodological considerations

Some study weaknesses are acknowledged. Exposure and outcome variables were self-reported and may be subject to recall, social desirability or same-source bias. Interpretation of the meaning of FH can also vary widely across a population; equivalent levels of financial strain can be perceived and experienced as *status quo* for some groups but as deprivation for others.[282] Thus, participants' responses about their economic conditions, either positive or negative, may be systematically influenced by an overall view of life. Nevertheless, precedent exists for the FH measures used here as findings of independent associations are consistent with other studies of self-reported and objective health outcomes in similarly-aged groups.[282-284] Furthermore, subjective levels of FH deserve investigation as perceived resources might impact diet variety more than actual levels.[128] Hardship was measured once approximately 18 months before diet; thus duration or transitions could not be ascertained. Thus, there may be misclassification of exposures stemming from changes to participants'

hardship levels in the interval between surveys. However, this would have biased results towards the null since any misclassification would be unrelated to dietary outcomes and thus non-differential.

Since low income is associated with low intakes of FV in older adults,[127] results may be subject to residual confounding from income, which was not collected in the cohort. While the unobserved influence of income cannot be discounted, current income is not consistently associated with diet quality and does not fully characterise a person's financial situation; it is also not the only structural resource used by older adults to fund their expenses.[115 276 277 281] Residual confounding is also possible from not examining other types or functions of social relationships (e.g. existence of a trusted confidant) that can be important factors influencing diet quality[285] or variety,[286] and might also contribute to SES-based health inequalities.[287] Future research should explore how both social and economic aspects of older individuals' life circumstances interact to influence dietary behaviours as called for in the public health research and policy literature.[13 20]

Notwithstanding such limitations, this study has several strengths: a large sample size, gender-specific analyses, adjustment for known confounders including multiple lifestyle factors, and six factors describing older people economic conditions. Multiple economic factors were examined, including potentially important variables of the financial situation. The examination of three separate FH measures was important for providing unique information on whether different types of this economic domain might be associated with diet quality.[288] This study also included a proxy for wealth which was employed as a unique SES measure since a review of evidence on SES indicators showed home-ownership is a measure of wealth in older populations,[219] and wealth is known to be associated with diet in UK elderly.[220] Additionally, it further specified as many relevant economic factors as possible (rather than SES overall) for women and men separately to avoid assuming economic comparability of individuals who are similar on a single factor (e.g. education).[179] As recommended, this study used multiple categories for specified economic factors which helps to uncover important gradients in diet quality that could apply across the social spectrum.[179] Finally, this study examined multiple economic influences on two separate measures of healthful dietary behaviours. Variety of foods, specifically of FV intake, has several unique attributes: it is a good marker of overall diet quality;[44 46 64] counting the

number of different FV items has proven utility for chronic disease aetiology;[53 61 63 289] and, it is an established concept in dietary recommendations,[40 41] including for older adults.[39]

### 3.5.3 Relationship to previous work

The finding of differential social patterning between quantity and variety of fruit or vegetable consumption highlights the need to study them separately, given the separate health implications of variety and quantity for lowering risk of prominent chronic conditions.[61-63] On the one hand, FV are low in energy and high in fibre and thus *quantity* may benefit health by reducing the overall energy content of a diet.[61] On the other hand, *variety* of FV intakes will also have a specific role for health by ensuring a balance of the multitude of micronutrients, dietary fibre and other bioactive compounds necessary for maintaining physical functioning.[44 46] A higher vegetable variety may provide individuals with specific vegetable sub-groups that contain high concentrations of flavonoids and carotenoids which have known health benefits.[290] While the biological mechanisms for the protective effects of variety are not fully elucidated, the health benefits of FV are likely to stem from both individual and synergistic effects of a range of nutritive and non-nutritive food components.[43 61] It is possible that eating a wide variety of fruits or vegetables benefits health by ensuring a diverse composition of intestinal microbiota as diet-driven losses in the range of gut microbes are associated with increased frailty and health decline in older adults.[291]

As this study showed that FV quantity mattered more than variety for promoting higher intakes of some beneficial nutrients in the diet, higher variety might be more beneficial in terms of providing other nutrients and phytochemicals that are more specific to certain fruit or vegetable items that are consumed preferentially by those with more varied intakes.[292] Nutritional science would therefore benefit from research aimed at elucidating the unique health benefits of fruit variety and vegetable variety. Some suggest that a diet adequate in essential nutrients requires consuming a minimum of 15 different foods per week,[43 293 294] but further work is also needed to establish what, if any, threshold of variety is needed *within* the fruit and vegetable food categories to support healthy ageing.[24] Despite a body of epidemiological evidence in different settings favouring a varied diet among older adults,[48 50-55 289 295] current recommendations[31 35 36] remain limited in specifying thresholds for between versus within fruits and vegetables. They also lack clear distinction and emphasis on variety of intake which was more influenced by diverse economic factors than quantity.

In the full EPIC-Norfolk cohort, social class and education levels were associated with FV quantity, with educational differences stronger in women and social class differences stronger in men.[296] In the present sample of EPIC over-50s, significant linear associations of education and social class were found with fruit quantity for both women and men, after adjustment for FH measures, in a pattern consistent with wider literature.[101] For vegetable quantity, independent associations were borderline significant for education in men and wealth in women. Linear associations between all conventional SES indicators and variety of either fruits or vegetables were significant in both genders, although gradients were somewhat stronger in men which have no clear explanation. Moreover, compared to men, older women's fruit variety was more strongly associated with each of the novel FH measures which is consistent with known gender differences in the worse financial status and experience of women.[206 297]

The independent association of FH with variety, and not quantity, of FV is similar to results from a Finnish occupational study which examined overall FH in relation to a score of food habits recommended as healthy, and adjusted for education, occupational class, income and home-ownership.[241] Wider consumer economic literature also supports the observation that FH was independently associated with variety, more than quantity, of fruits and/or vegetables. Several consumer studies show that individuals who shop for food under financial pressure tend to economise by limiting the variety of products before reducing the quantity of foods purchased, with the cheapest food items chosen within each food category.[243 298-300] Everyday financial troubles were expected to show stronger associations with dietary behaviours than SES because they would plausibly exert a more direct influence on older people's decisions to purchase FV. Yet, in this cohort, conventional SES indicators showed slightly larger differences in mean variety of fruits and/or vegetables than gradients observed for FH measures. This finding might be explained by a phenomenological difference between SES and FH as the latter might have a relatively more transient nature than more time-invariant factors such as education, social class or home-ownership. Nonetheless, FH measures offered additional explanatory power for understanding variation in fruit variety and vegetable variety among older women and men as inverse associations remained significant after SES adjustment. Others have also reported independent effects of FH on weight[301-304] which has known associations with FV consumption.[23 72 305]

Given independent associations between SES, or FH, and diet quality, there are likely two sets of pathways linking an older person's economic circumstances to healthful eating behaviours. Overall, SES may influence FV consumption through mechanisms involving dietary knowledge and health literacy as well as social roles and cultural norms related to health, food habits, and good nutrition.[116 306] Concurrently, FH may influence variety through mechanisms that also involve material resources and spending power.[84] In particular, FH gradients observed for fruit variety and vegetable variety may be explained by the cost constraint of expensive types of FV as older individuals with greater hardships in paying bills, for example, may avoid more costly diverse diets since a higher proportion of their budgets is spent on housing and utility costs.[243 272 274]

Preliminary investigation of diet information reported at entry by the same over-50s indicated a difference of £0.62/d (16%) and £0.86/d (23%) in mean diet cost between the highest and lowest tertiles of fruit variety and vegetable variety, respectively (means adjusted for age, gender and total energy intake). The role of price is potentially universal, as results from an RCT in New Zealand indicated no variation by ethnicity, income or education in the association of price discounts with purchasing of healthful foods.[307] This mechanism may apply across cultures as studies of older Australians and older Taiwanese found higher variety of overall diets (total count of unique food items/groups) was associated with higher total food expenditure.[272 274] However, caution in generalising findings from studies of non-European elderly is needed as analyses did not adjust for known confounders, particularly total energy intake.

Future research should formally explore potential mediators to determine shared and separate pathways that link SES and FH with diet quality. Given that older adults are especially vulnerable to FH for multiple reasons,[208 209] public health efforts to promote healthful eating among older adults may benefit from a greater consideration of their current economic conditions. Reducing financial barriers to healthful eating is essential for older people whose greater need to manage chronic illnesses with healthful diets[2] imposes a higher cost.[308] Strategies might focus on helping their management of bill payment, and on improving reach to seniors of existing financial assistance and money management programs.[309 310]

## 3.6 Conclusion

This study found that variety, more than quantity, of FV intake among older adults in this UK cohort was consistently patterned by conventional SES and novel FH measures. Different types of FH each provided additional explanatory power for understanding variation in the variety of fruits and vegetables consumed by over-50s beyond education, social class or home-ownership. However, gradients by education, social class and wealth appeared somewhat stronger. Health promotion and interventions to increase FV consumption among older adults will need to explicitly call out the importance of variety and account for the multiple economic barriers that might limit the uptake of this advice. Moreover, a focus is needed to improve fruit variety in women and vegetable variety in men.

# CHAPTER 4 Social ties and diet quality in older adults

This work is published as: Conklin AI, Forouhi NG, Surtees P, Khaw K-T, Wareham NJ, Monsivais P. Social relationships and healthful dietary behaviour: evidence from over-50s in the EPIC cohort, UK. *Social Science & Medicine* 2014; 100:167-75.

## 4.1 Abstract

**Background:** Social relationships are an important aspect of a person's social environment that can protect against a wide range of chronic conditions and facilitate recovery from disease. Social relationships have also been linked to dietary behaviour which may be an important pathway through which social circumstances exert their influence on health. Yet, questions remain about which structural aspects of social relationships most affect healthful dietary behaviours and whether different structural components interact to produce a combined effect.

**Methods:** Using data from 9,580 adults (≥50 years) in the European Prospective Investigation of Cancer-Norfolk study (1996—2002), marital status, living arrangement and social isolation were examined in relation to scores for variety of fruit and vegetable intakes as a marker of diet quality associated with adverse health outcomes. Data were analysed with multivariable linear regression models for gender-specific and interaction associations.

**Results:** Being single or widowed was associated with a lower variety score, particularly vegetable variety, and associations were enhanced when combined with male gender, living alone or infrequent friend contact. Lower variety scores for lone-living were also observed, especially for men. Infrequent friend contact interacted with living arrangement to amplify negative associations of lone-living with variety, with statistically significant differences in contact frequency for vegetable variety. Lower levels of friend contact were associated with reduced variety of fruits and vegetables in a graded trend for both genders; the trend was more pronounced among men. Family contact appeared to have limited association with

vegetable variety in men; among women, weekly contact was significantly and positively associated with vegetable variety compared to daily family contact.

**Conclusion:** Results highlighted the importance of considering living arrangement and/ or frequency of social contact when assessing whether widowed, single or lone-living older adults are at risk of lower variety of fruits and vegetables.

## 4.2 Introduction

Social relationships are known to affect health and survival to an extent comparable with smoking.[311] Women and men differ in the number and size of different types of social relationships,[312] and in the health impacts.[313-315] Several health-related behaviours are likely to mediate this link for some, but not all, aspects of a person's social context.[316] Diet is a strong candidate for systematic examination along the pathway between social relationships and health so as to better inform chronic disease prevention and promotion of healthy ageing.

A person's social circumstances can influence the type and variety of foods consumed in multiple ways and thereby impact health. Psychosocial mechanisms involved include social support, social influence, social engagement and attachment, and access to resources and material goods.[306] Physiological experiments demonstrate the theory of social facilitation in food intake by showing how the number of people present determines meal size[317] irrespective of time, place, alcohol or snack consumption.[318] More specifically, more food is consumed when a person eats in the presence of family and friends than when eating around less familiar people such as acquaintances.[319] Others also find that, regardless of personal taste, a social context in which people eat in the presence of others can influence not only the volume[320] but also the variety[101] of foods consumed. Among older people, having fewer social contacts or living alone is associated with consuming fewer calories, a less varied diet and fewer portions of FV.[116] Food-related behaviours may be particularly influenced by these social factors in widowed men and seniors with limited support.[321]

Regarding close relationships, spouses and friends appear to be most concordant in their dietary patterns and, over time, concordances are strongest in spouses.[322] However, spousal or friend influences on dietary behaviours are likely gendered. For example, wives contribute more to husbands' diet quality than the reverse[158] such that married older men have reported higher intakes of fruits, vegetables and energy-adjusted intakes of antioxidant

vitamins and fibre.[323] By contrast, friend support appears to contribute more to women's dietary behaviours, particularly when change is needed to make improvements.[324 325] Similar gender differences are reported in other work on stress and emotions associated with food intake: marital status best predicts stress-related eating in men while lack of emotional support predicts it in women.[326] Separate psycho-biological mechanisms involving neuro-endocrine pathways might also link social relationships to dietary behaviours depending on the type (acute or chronic) and perceived severity (threat or challenge) of stress.[327 328]

Structural and functional components of social relationships likely impact health and diet in different ways.[306 311] Structural components represent the existence and interconnections of differing social relationships and roles possessed by an individual; this more objective characteristic indicates how relationships are organised and makes support functions possible.[311 329] Structural underpinnings of a person's social context are a pathway of influence on diet quality that contains many different types of relationships which remain to be examined for their joint effects.[306 329 330] This study aimed to provide new evidence on synergistic influences on healthful dietary behaviours from multiple social relationships.

This study proposes that structural social relationships comprise unique elements acting independently and synergistically to influence the healthfulness of individual dietary behaviour. One hypothesis was that partnership, co-living and frequent social contact would be independently associated with FV variety, with effects of marital status and living arrangement greater for men and social contact stronger for women. Frequent social contact or co-living was also hypothesised to mitigate the negative association of being single or widowed or having rare family contact with variety. Similarly, frequent friend contact was expected to lessen the negative association of living alone with variety.

## 4.3 Methods

### 4.3.1 Study population

Similar to Chapter 3, this study included the 20,274 over-50s from the population-based EPIC-Norfolk cohort. The sample selection process was the same as that indicated in Figure 3–1 above. For this study, social relationships were assessed in 50-71% of cohort participants using the HLEQ instrument. Responses to individual questions from over-50s ranged between 10,352 and 14,494.

### 4.3.2 Measures

*Structural social relationship exposures*

Structural social relationships were studied using three types of connections: marital status, living arrangement, and social isolation. Marital status (n=6,257) had five response categories (married/living as married, single, widowed, divorced and separated) and four were used in analyses (partnered, single, widowed, divorced/separated), with 'partnered' (married/living as married) as the reference group. The binary question "does anyone live in your household besides you?" (n=8,816) was analysed for living arrangement with co-living as the reference. Social isolation was indicated by the pervasive lack of social contact or communication (including visits, phone calls or letters) with any friend, or with an immediate family not living with a respondent.[311] Two questions concerned social isolation: participants were asked how often in the past year they had been in contact with any friend (friend contact, n=8,442), and with immediate family not living with them (family contact, n=8,388). Both questions had seven response categories (daily, several time/week, about once/week, 2-3 times/month, about once/month, less than once/month, never or hardly ever) which were combined into four categories for analyses (daily, weekly, monthly, never/rare) with daily contact as reference. The full cohort and the analytic sample were similar in characteristics between responders to social exposure questions and between non-responders (Appendix C, Table C–1). Small differences were seen between responders and non-responders in the sample and were also observed in the full cohort, suggesting there were no unequal probabilities of selection and non-response rate.

*Dietary outcomes*

This study used the same continuous scores for fruit variety (0-11) and vegetable variety (0-26) as in Chapter 3. Again, outcome data from over-50s (n=9,933) was restricted to FFQ respondents for whom plausible total daily energy (kcal/d) could be derived and hence the available sample included over-50s who responded to social relationship questions, had covariates and follow-up dietary data (n=9,580).

*Socio-demographic variables*

Concurrent socio-demographic variables included: self-reported general health status (categorical) and smoking status (categorical); and, clinically measured BMI (continuous). Some variables were assessed at entry but are generally time-invariant: education (categorical), age (continuous), gender (dichotomous) and social class (categorical).

### 4.3.3 Data analysis

Descriptive statistics summarised socio-demographic characteristics and crude mean variety scores in relation to social exposure variables. Multivariable linear regression models assessed cross-sectional associations between each social relationship and the fruit or vegetable variety score. The *a priori* strategy for main analyses was to examine (1) gender-stratified associations, and (2) inter-relations among different social relationships. The aim was to investigate whether overall associations of, for example, different categories of marital status differed when a second structural measure was considered (e.g. friend contact, living arrangement). The following interaction terms were used: marital status by living arrangement and by friend contact; family contact by living arrangement and by friend contact; and living arrangement by friend contact. Friend contact was dichotomised into 'frequent' (daily, weekly, and several times a month) and 'infrequent' (about once a month, less than once a month and never/hardly ever) for interaction analyses; significance for analyses of inter-relations was set at $p<0.10$. Gender differences were tested for statistical significance ($p<0.05$) using a sex interaction term. All analyses adjusted for total daily energy intake (kcal/d), age, education and (as appropriate) gender. As known confounders, each is associated with the exposure and independently with diet.[132 281 331]

Sensitivity analyses additionally adjusted for quantity of fruit (for fruit variety) and vegetable (for vegetable variety) since higher variety is associated with increased quantity of these foods and with more energy intake.[63] Separate models also controlled for social class to determine whether observed estimates changed. To control for poor health as a potential confounder of daily family contact in women, pre-existing self-reported general health, high blood pressure, stroke and cancer, were added to gender-specific models of family contact. Gender-specific associations were also adjusted for other lifestyle and potential confounders. Findings were based on regression coefficients and CI95.

## 4.4 Results

The sample's average age was 62 years, with 55 percent female. A majority (83%) reported being in excellent/good general health and 51% were ever smokers. Over half were educated to degree/A-level, although more men (62%) than women (48%) had degree/A-level education. Those in the top-two social classes comprised 46 percent of the sample, and more women (4%) than men (2%) had unskilled occupations. Both men and women

were generally overweight at follow-up, with mean BMI of 26.8 and 26.7 respectively. Women, however, reported consuming fewer total calories than men (1,850 versus 2,087 kcal/d). Variety scores were normally distributed and crude means for fruit variety and vegetable variety were higher in women than men (7.7 and 16.5 versus 6.7 and 15.9, respectively). Few over-50s reported no average daily consumption of fruits (n=55) or vegetables (n=6) and therefore scored zero.

Table 4–1 below shows the socio-demographic characteristics across categories of each social relationship measure. There were higher proportions of women in non-partnered, lone-living, and daily contact categories. A higher proportion of ever smokers were found at greater levels of social isolation (from friend and family). Lower levels of friend contact had increasing proportions of lower educated participants, whereas decreasing family contact was associated with decreasing proportions of lower education.

### 4.4.1 Gender-specific associations

Men and women differed in associations between marital status and both dietary outcomes (Table 4–2). The negative dietary associations with all non-partnered categories were stronger in men. For example, compared to partnered men, widowed men had a -2.17 unit difference ($p<0.001$) in vegetable variety which was significantly different ($p=0.005$) from widowed women who had a -0.79 unit difference ($p<0.001$) in score compared to partnered women. Single men and women differed significantly ($p=0.018$) in lower vegetable variety scores compared to partnered counterparts. Negative associations between lone-living and variety scores were also stronger in men: lone-living men had a -1.46 unit difference ($p<0.001$) in vegetable variety score which was significantly different ($p=0.001$) from the unit difference of -0.66 ($p<0.001$) in score for lone-living women, compared to co-living counterparts.

Women and men with decreasing friend contact had lower variety scores. Notably, associations with fruit variety appeared more smoothly graded in women and slightly more pronounced in men having rare/no contact. The relationship between family contact and variety scores was less consistently patterned. Lower frequencies of family contact were associated with lower fruit variety scores and rare/no contact was similarly negative for both genders. By contrast, decreasing family contact seemed to have limited association with vegetable variety in men whereas weekly contact had a 0.56 unit difference ($p=0.001$) in score in women compared with daily family contact.

Table 4-1 Characteristics of older adults in the EPIC-Norfolk study across categories of structural social relationships

| | Mean (SD) age | Women | Lower education[a] | Lower social class[b] | Poor/moderate health | Ever smoker | Mean (SD) BMI | Mean (SD) fruit variety score (0-11) | Mean (SD) vegetable variety score (0-26) |
|---|---|---|---|---|---|---|---|---|---|
| Marital Status (n=6,257) | | | | | | | | | |
| Partnered (n=5,040) | 62 (7) | 52% | 44% | 16% | 15% | 50% | 26.7 (3.8) | 7.3 (2.4) | 16.4 (3.9) |
| Single (n=270) | 62 (7) | 62% | 41% | 14% | 19% | 45% | 26.7 (4.8) | 6.9 (2.6) | 14.3 (4.6) |
| Widowed (n=597) | 67 (7) | 84% | 55% | 19% | 22% | 50% | 26.8 (4.4) | 7.4 (2.4) | 15.1 (4.3) |
| Divorced/separated (n=350) | 60 (7) | 73% | 38% | 18% | 21% | 52% | 26.6 (4.5) | 7.4 (2.6) | 16.4 (4.1) |
| Living arrangement (n=8,816) | | | | | | | | | |
| Shared (n=7,243) | 61 (7) | 52% | 45% | 15% | 16% | 52% | 26.7 (3.8) | 7.3 (2.4) | 16.4 (3.9) |
| Alone (n=1,573) | 65 (7) | 71% | 47% | 16% | 19% | 50% | 26.8 (4.3) | 7.2 (2.5) | 15.4 (4.3) |
| Friend contact (n=8,442) | | | | | | | | | |
| Daily (n=431) | 63 (7) | 68% | 39% | 14% | 16% | 49% | 27.6 (4.2) | 7.8 (2.4) | 16.7 (4.1) |
| Weekly (n=5,277) | 62 (7) | 58% | 44% | 14% | 15% | 49% | 26.7 (3.9) | 7.4 (2.4) | 16.5 (3.9) |
| Monthly (n=2,005) | 62 (7) | 53% | 46% | 17% | 18% | 52% | 26.7 (3.9) | 7.2 (2.4) | 16.2 (3.9) |
| Rare/never (n=729) | 62 (7) | 41% | 48% | 19% | 19% | 58% | 26.8 (3.9) | 6.5 (2.6) | 15.2 (4.3) |
| Family contact (n=8,388) | | | | | | | | | |
| Daily (n=875) | 61 (7) | 65% | 55% | 17% | 19% | 48% | 27.3 (4.0) | 7.5 (2.3) | 16.1 (4.0) |
| Weekly (n=5,849) | 62 (7) | 57% | 44% | 15% | 15% | 50% | 26.7 (3.9) | 7.4 (2.4) | 16.5 (4.0) |
| Monthly (n=1,148) | 63 (7) | 47% | 42% | 16% | 17% | 55% | 26.7 (3.8) | 7.0 (2.5) | 16.0 (4.1) |
| Rare/never (n=516) | 63 (7) | 40% | 43% | 16% | 21% | 56% | 26.9 (3.6) | 6.7 (2.5) | 15.6 (4.1) |

Measurement time-points were: gender, age, education, class (1993-1997); marital status, living arrangement, friend contact and family contact (1996-2000); diet, health and smoking status (1998-2002). [a]No qualification or O-level; [b]Partly skilled (class IV) or unskilled (class V) occupations.

Table 4–2 Associations between structural social relationships and variety of fruits or vegetables by gender

| | Fruit variety (items/m) | | Vegetable variety (items/m) | |
|---|---|---|---|---|
| | Women | Men | Women | Men |
| Marital Status | | | | |
| Partnered | – | – | – | – |
| Single | -0.44 (-0.78, -0.09) | -0.80 (-1.29, -0.32) | -1.85 (-2.44, -1.25)[a] | -3.01 (-3.77, -2.25)[a] |
| Widowed | -0.05 (-0.27, 0.17) | -0.49 (-0.99, 0.02) | -0.79 (-1.18, -0.41)[b] | -2.17 (-2.96, -1.37)[b] |
| Divorced/ Separated | 0.02 (-0.27, 0.30) | -0.44 (-0.94, 0.06) | -0.21 (-0.70, 0.28) | -0.65 (-1.44, 0.13) |
| Living arrangement | | | | |
| Shared | – | – | – | – |
| Alone | -0.18 (-0.33, -0.03) | -0.34 (-0.58, -0.09) | -0.66 (-0.92, -0.39)[c] | -1.46 (-1.84, -1.08)[c] |
| Social isolation – friend contact | | | | |
| Daily | – | – | – | – |
| Weekly | -0.12 (-0.38, 0.14) | -0.32 (-0.75, 0.10) | -0.11 (-0.56, 0.35) | -0.02 (-0.68, 0.65) |
| Monthly | -0.35 (-0.64, -0.07) | -0.37 (-0.81, 0.07) | -0.33 (-0.82, 0.16) | -0.26 (-0.95, 0.43) |
| Rare/ never | -0.76 (-1.11, -0.41) | -1.00 (-1.47, -0.52) | -1.12 (-1.73, -0.50) | -1.23 (-1.98, -0.49) |
| Social isolation – family contact | | | | |
| Daily | – | – | – | – |
| Weekly | 0.01 (-0.18, 0.21) | -0.27 (-0.56, 0.03) | 0.56 (0.23, 0.90) | 0.01 (-0.45, 0.47) |
| Monthly | -0.17 (-0.43, 0.09) | -0.48 (-0.82, -0.14) | 0.05 (-0.40, 0.50) | -0.22 (-0.76, 0.31) |
| Rare/ never | -0.58 (-0.93, -0.23) | -0.53 (-0.92, -0.13) | -0.60 (-1.21, 0.01) | -0.30 (-0.92, 0.31) |

Gender differences in variety score are illustrated as beta-coefficients (CI95) adjusted for total energy intake, age and education. Numbers analysed for marital status (Women: n=3,523; Men: n=2,729), living arrangement (Women: n=4,892; Men: n=3,918), contact with any friend (Women: n=4,729; Men: n=3,708), and contact with immediate family not living with participant (Women: n=4,661; Men: n=3,721). Significant gender difference: [a]single: p=0.018; [b]widowed: p=0.005; [c]alone: p=0.001)

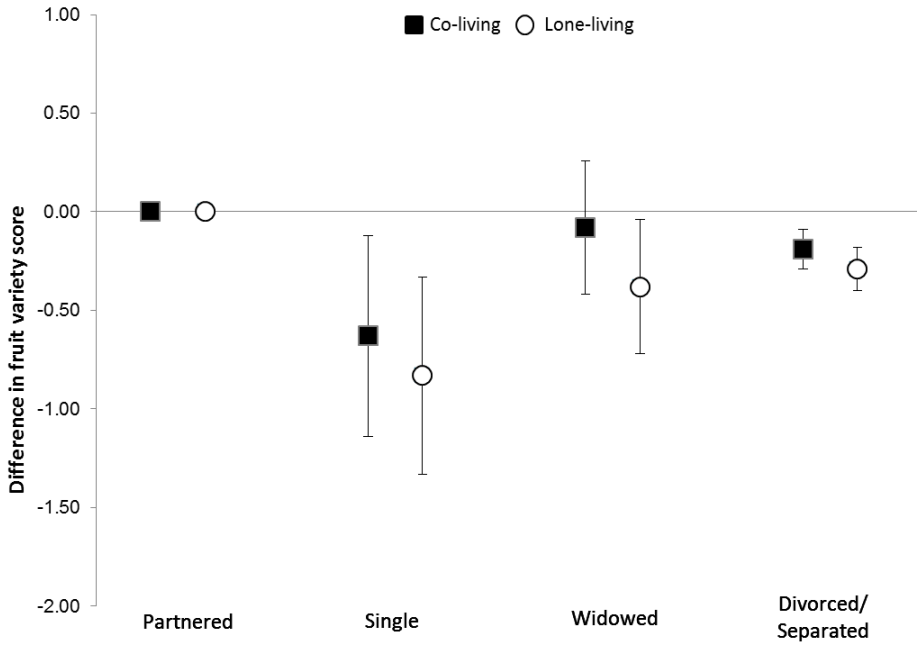
The pattern of associations was similar after considering fruit quantity (for fruit variety) or vegetable quantity (for vegetable variety) in gender-specific covariate-adjusted models (Appendix C, Table C–2). Sensitivity analyses that included additional adjustment for social class resulted in no material difference in observed associations (Appendix C, Table C–3). Given the unexpected direction of family contact and variety associations, models were further adjusted for prior chronic physical conditions to determine whether daily family contact was due to women's poor health. Consistent with other studies,[332] additional correction minimally attenuated observed estimates and did not substantially alter gender-specific results (Appendix C, Table C–4). Other lifestyle factors and potential confounders also did not change reported results for women and men (Appendix C, Table C–5).

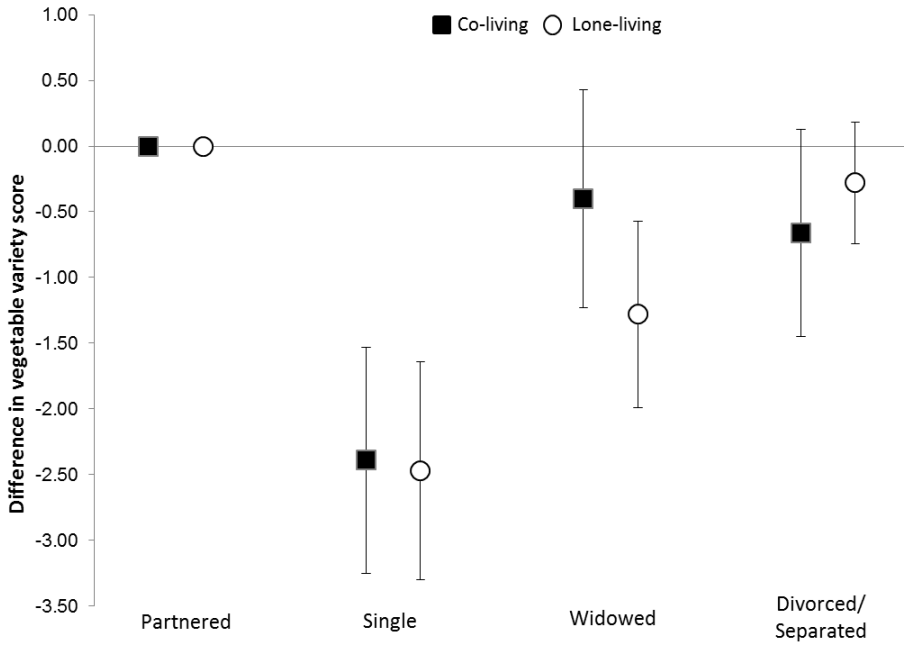
### 4.4.2 Marital status and healthful eating, by living arrangement or friend contact

Figure 4–1 illustrates how associations between marital status and variety differ by living arrangement or friend contact (values in Appendix C, Table C–6). Lone-living single and widowed over-50s had, respectively, a -0.83 ($p=0.001$) and -0.38 ($p<0.05$) unit difference in fruit variety scores, which were slightly lower than unit differences for those in shared accommodation (single: −0.63, $p<0.05$; widowed: -0.08, $p>0.05$), compared to partnered counterparts (Panel A in Figure 4–1). Differences in living arrangement, however, were non-significant. For vegetable variety, we found widowed over-50s living alone had a -1.28 unit difference ($p<0.001$) compared to partnered counterparts whereas the association for co-living over-50s was limited (Beta= −0.40, $p>0.05$); again living arrangement differences were non-significant. For divorced/separated over-50s, differences in variety scores between co- and lone-living were reversed (Figure 4–1, A): those living alone had a -0.28 unit difference ($p>0.05$) in vegetable variety versus a -0.66 unit difference ($p>0.05$) for those co-living (compared to partnered counterparts).

Panel B in Figure 4–1 shows the generally negative association between non-partnered categories and fruit or vegetable variety was larger when friend contact was infrequent. Widowed over-50s with infrequent friend contact showed a significantly ($p=0.034$) lower unit difference of -0.71 ($p<0.05$) in fruit variety scores than the -0.05 unit difference ($p>0.05$) for those with frequent contact (compared to partnered counterparts). Similarly, unit differences in vegetable variety scores were significantly lower ($p=0.026$) for widowed over-50s with infrequent friend contact than for those with frequent contact (−2.02 versus -0.87; both $p<0.001$) compared to partnered counterparts—a difference of 1.15 items over at least a month. Non-significant differences in friend contact were also observed in variety scores of single over-50s (Figure 4–1, B).

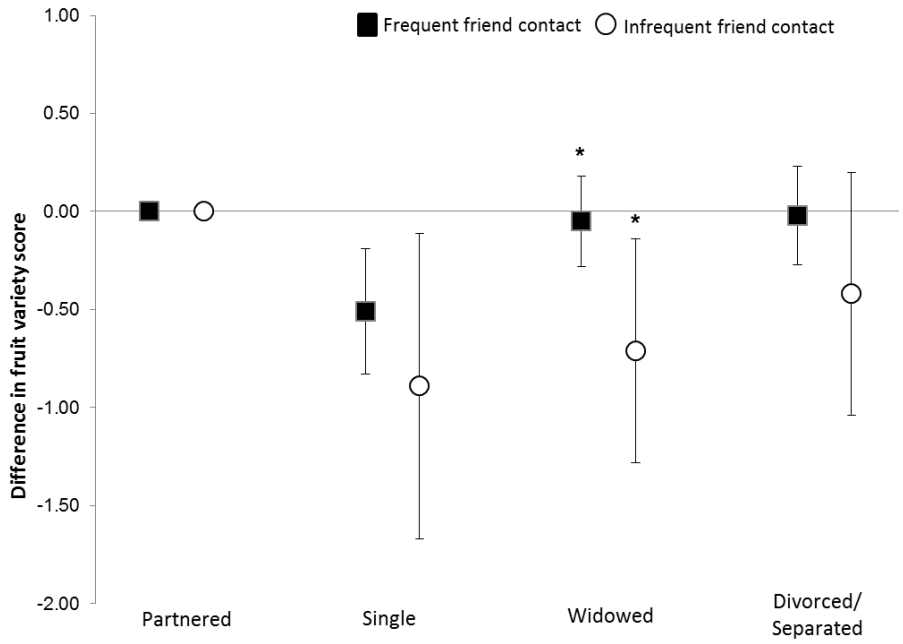
The pattern of association was similar after considering quantity of intake (Appendix C, Table C–7), or social class (Appendix C, Table C–8) in covariate-adjusted models.

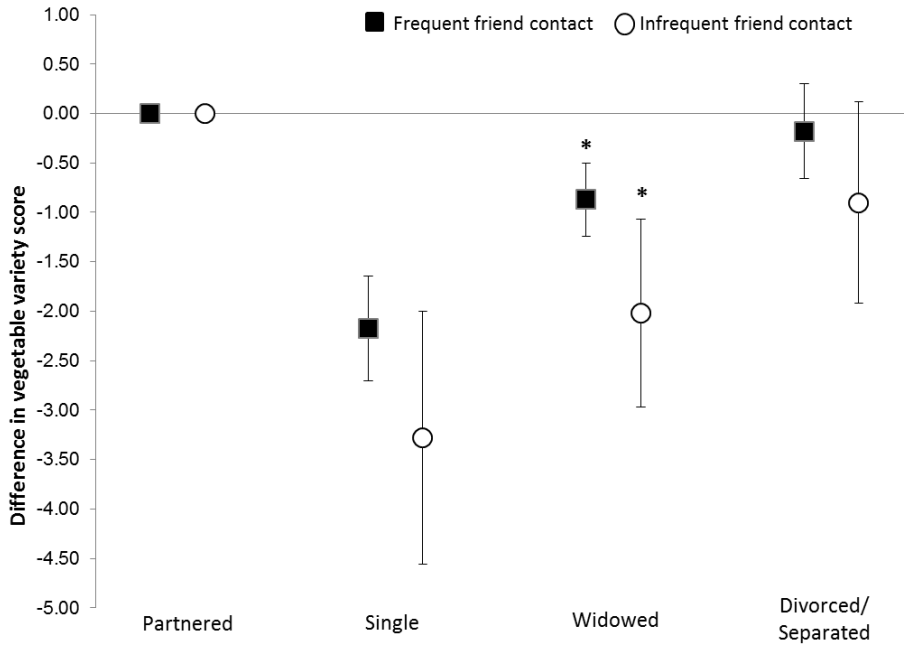



A

Figure 4-1 Association between marital status and variety of fruits or vegetables by living arrangement (A) and by friend contact (B)




B

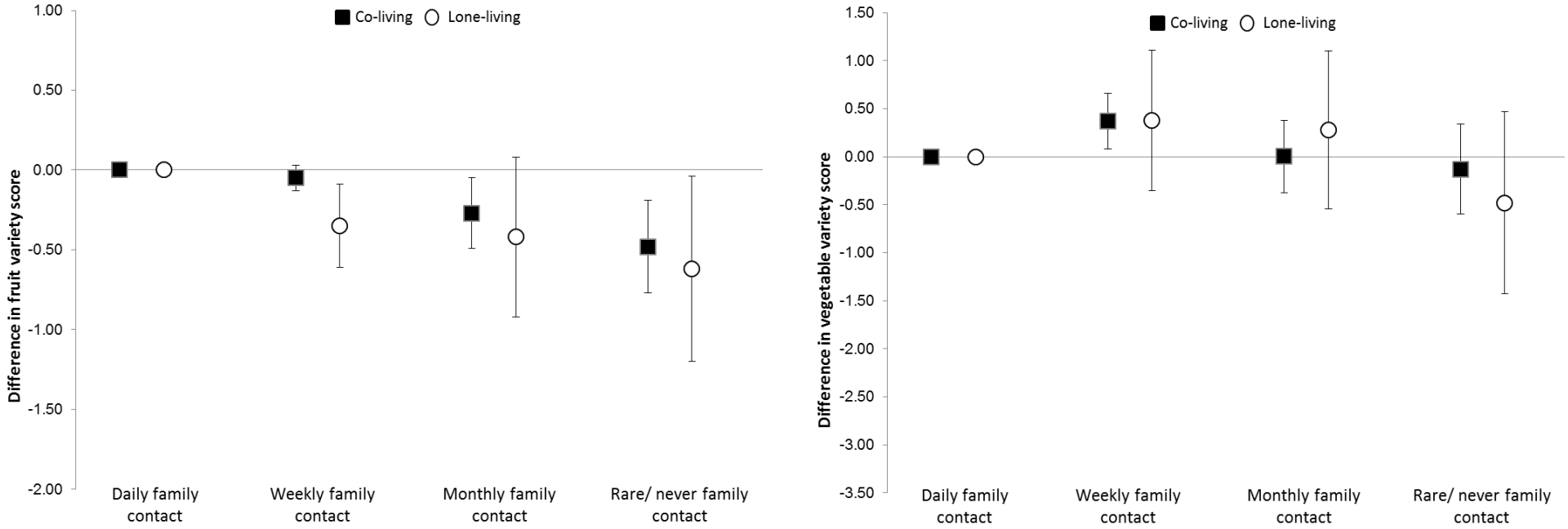
Figure 4-1 Association between marital status and variety of fruits or vegetables by living arrangement (A) and by friend contact (B)

*significant interaction between friend contact and widowed status (fruit variety, p=0.034; vegetable variety, p=0.026)

### 4.4.3 Family contact and healthful eating, by living arrangement or friend contact

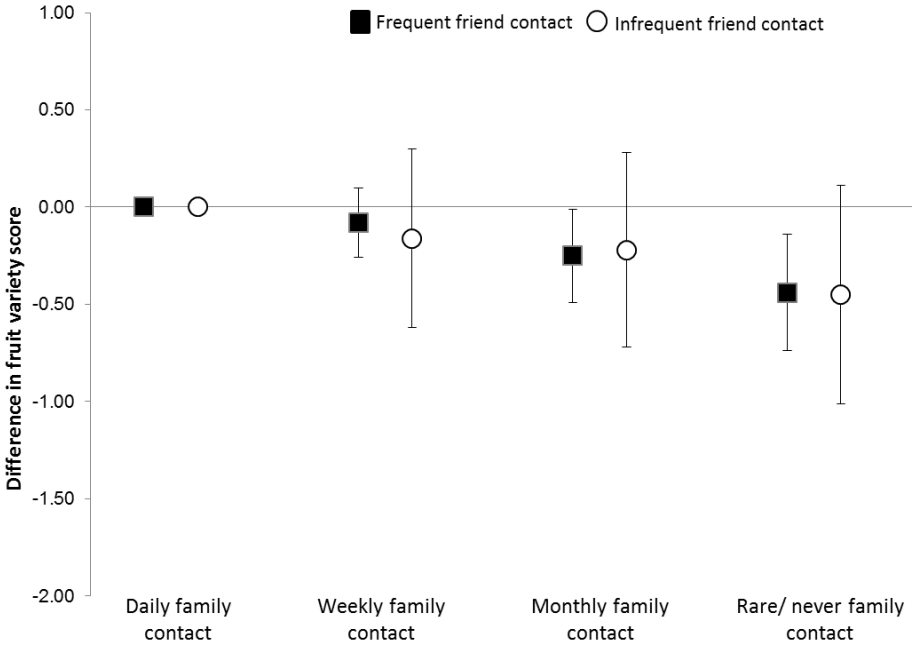
Family contact and variety scores showed differences by living arrangement and friend contact (Figure 4–2; values in Appendix C, Table C–9). In Figure 4–2 below, Panel A shows fruit variety decreased as family contact decreased when over-50s lived alone. Compared with daily family contact, lone-dwellers with rare/no family contact had a -0.62 unit difference ($p<0.05$) in score and those in shared accommodation had a -0.48 unit difference ($p=0.001$). Decreasing family contact had limited association with vegetable variety for co- and lone-living over-50s, apart from weekly contact (versus daily) appearing protective in co-living over-50s. Differences by friend contact frequency were observed only for associations of family contact with vegetable variety (Figure 4–2, B). Weekly and monthly family contact among over-50s with frequent friend contact showed, respectively, a 0.46 ($p<0.05$) and 0.14 unit difference in vegetable variety but rare/no contact did not (reference daily contact). By contrast, decreasing family contact was associated with lower scores among over-50s with infrequent friend contact such that rare/no contact showed a -1.01 unit difference ($p<0.05$) compared to daily contact. Differences in frequency of friend contact were significant for vegetable variety ($p=0.056$) for those reporting rare/ no family contact.

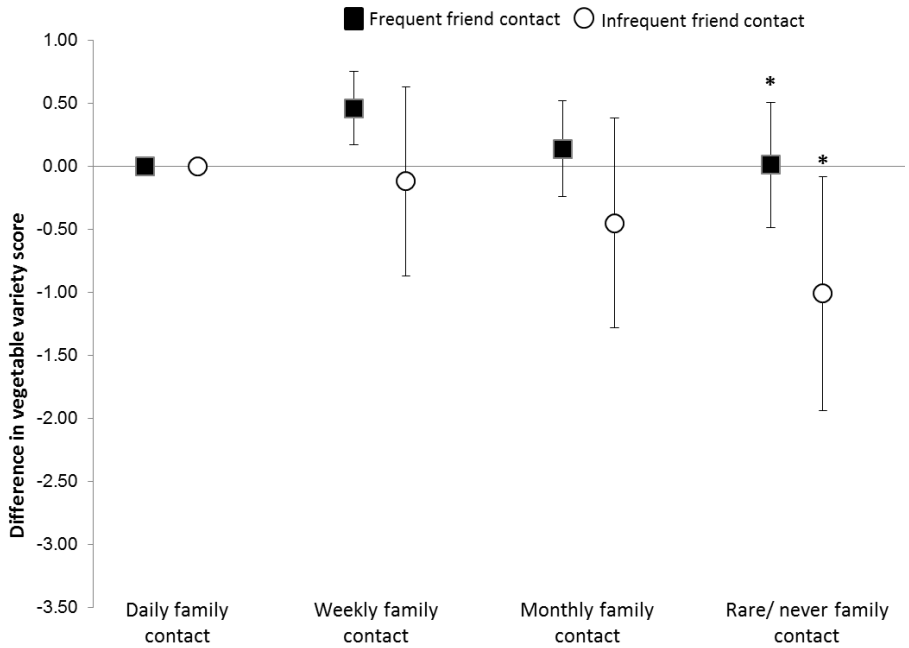
Results were largely unaltered by quantity of intake, or social class (see Appendix C, Table C–10 and Table C–11).




A

Figure 4-2 Association between family contact and variety of fruits or vegetables by living arrangement (A) and by friend contact (B




B

Figure 4-2 Association between family contact and variety of fruits or vegetables by living arrangement (A) and by friend contact (B)

*significant interaction between friend contact and rare/never family contact (p=0.056)

### 4.4.4 Living arrangement and healthful eating, by friend contact

A significant negative association of lone-living with both scores appeared amplified when friend contact was infrequent (Figure 4–3; values in Appendix C, Table C–12). Compared with co-living, lone-dwellers with infrequent friend contact had a -0.48 unit difference ($p<0.05$) in fruit variety which was not significantly different from the -0.20 unit difference ($p<0.05$) for lone-dwellers with frequent friend contact. The association of lone-living with vegetable variety revealed significant differences ($p=0.007$) between infrequent and frequent friend contact (−1.62 versus -0.80; both $p<0.001$), representing 0.82 different vegetable items consumed over at least a month.

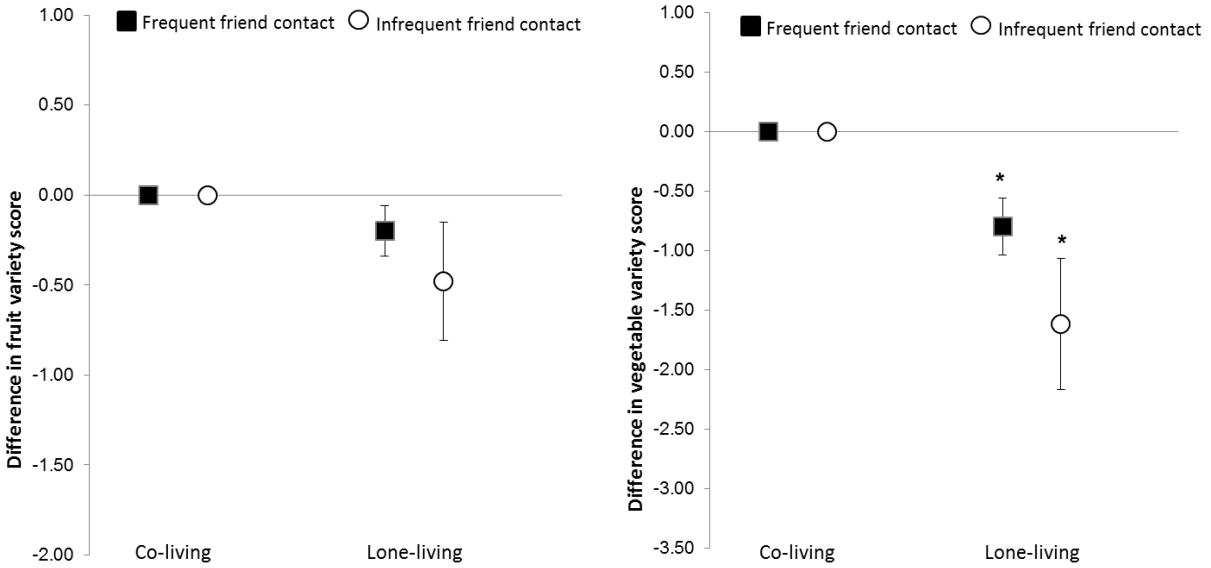



Figure 4–3 Association between living arrangement and variety of fruits or vegetables by friend contact

*significant interaction between friend contact and lone-living ($p=0.007$)

Sensitivity analyses again resulted in no material difference in reported associations (Appendix C, Table C–13 Table C–14).

## 4.5 Discussion

### 4.5.1 Synopsis of results

The association of social relationships with diet quality is well characterised in the literature but less is known about combined influences of structured social experiences. These findings demonstrated that men fared worse than women in the negative associations of non-partnered, lone-living and rare/no friend contact with variety of fruits or vegetables. Associations between family contact and variety by gender were less clear. The observation

that over-50s who are widowed, lone-living or had rare/no family contact reported consuming, respectively, 1.15, 0.82 and 1.00 fewer different vegetable products (over at least a month) when friend contact was infrequent versus frequent is clinically meaningful. It was shown previously in this cohort that consuming three additional vegetable items per week lowered diabetes risk by 13%, independent of quantity and other potential confounders, and that the inverse association with diabetes was linear within the normal range of variety of intake (5.5-11.4 items/week).[61] Across 10 EPIC study countries, increasing variety in vegetable and/or fruit consumption over two weeks on average, reduced the risk of certain cancers.[62 63] Many national and international bodies recommend eating a variety of FV without specifying targets for adequate/optimal variety.[35 36] Nevertheless, this cohort compares with mean vegetable variety in US community-dwelling elderly (11 items/week).[333] These results have public health implications for supporting healthy ageing since over-50s are more likely to experience transitions in the structure of their social relationships, moving from multiple to more limited or no ties.

### 4.5.2 Methodological considerations

Exposures and outcomes were self-reported and like all such variables may be subject to recall or social desirability bias. For example, older ages or lack of food preparation involvement may reduce recall of the full range of items consumed. Social desirability favouring variety may be associated with more social ties and falsely increased outcomes. Lower education and social class of widows, or stress from recent bereavement, may affect reported variety. Errors in diet recall ability have previously been shown to be greater in relation to education and income but not age.[334] Adjustment for education and social class in sensitivity analyses will mitigate any effects of bias in outcome ascertainment on observed estimates. Poor diet recall may be less than expected as the FFQ may perform better in measuring the set food repertoires and meal structure of the British diet which was unchanged in the study time-frame,[335] and which people develop as habits by constructing food choice strategies and rules-of-thumb.[107 108 201 202]

It is important to investigate self-reported relationships which measure perceived food-related resources since perceptions might impact variety more than actual resources.[128] Future work could examine measures not included here such as other types of relationship structures (e.g. social networks, social integration), functional components, quality/satisfaction of a relationship, or quantity (e.g. number of friends). Moreover, social

relationship measures were assessed as a state but different relationship transitions can change dietary behaviour in opposite directions. For example, becoming divorced or widowed may decrease vegetable intake, compared to remaining married; while men and women who remarry may increase vegetable consumption compared to unmarried counterparts.[336 337] Thus there may have been misclassification of exposures stemming from changes to participants' relationship category/level in the interval between the questionnaire assessment of social relationships and subsequent diet. Such misclassification would be non-differential since it was unlikely to have been related to the outcomes examined and hence would bias results towards the null.

The study's findings are subject to residual confounding from income which was not collected in the cohort and might potentially result in observed associations being larger than true associations. Although low income can be a barrier to consuming fruits and vegetables, income is not consistently associated with elderly consumption and has not been found to explain associations between living arrangement and diet.[124 127 338] By contrast, education is consistently associated with elderly diet quality and shows stronger gradients than income.[281] Furthermore, as the sample differed from the full cohort only in greater prevalence of higher education and social class, findings cannot be generalised to lower SES populations. More work is also needed on non-white or younger groups and might examine other dietary components or patterns.

This study has several strengths: a large sample size, gender analyses, effect modification, multiple known confounders, and four separate measures of three relationship types. The particular strength of this work was in considering interactions of social relationships in relation to diet. In doing so, research begins to capture the complex reality of an individual's heterogeneous life circumstances wherein multiple roles and shared norms interact and mutually reinforce to produce unique social environments.[14] Future research must continue to examine how structural aspects of social relationships connect with each other to produce a combined effect across different configurations of an older person's lived experience to influence healthful dietary behaviours, as called for by public health and policy researchers.[13] A further strength was the use of variety scores with unique attributes: they are a good marker of diet quality;[44 46 64] have shown utility for chronic disease aetiology;[61-63] and variety of fruits and vegetables is long recommended as critical to healthful eating.[40 41] Finally, apart from fewer smokers and minimal ethnic minorities, this cohort has similar

characteristics to the general UK population.[212] Thus, findings from this sample could be generalised to other white European-origin higher socioeconomic status over-50s.

### 4.5.3 Relationship to previous work

*Gender-specific findings and potential mechanisms in the context of previous studies*

Overall, the results support gender differences in the roles of marital status, living arrangement and social isolation, in healthful dietary behaviours. Results confirm the hypotheses that marital status and living arrangement influences on fruit or vegetable variety were greater for men. Findings were mixed for the relationship between social isolation and variety. Consistent with previous research,[313] women had more frequent social contact than men in the sample. Although the associations of friend and family contact were stronger in men for fruit variety, we did find clearer patterning in women. Thus, findings did not concur with pre-specified hypotheses and may be explained by the fact that social isolation, defined by limited structures, affects men more whereas women may be more influenced by functional aspects, including emotional support.[287] Results for family contact and vegetable variety were most surprising: weekly contact (versus daily) was significantly positively associated in women, but men showed limited associations.

Previous research supports the finding that isolation from friends or family, lone-living and no intimate partnership are each associated with diets limited in variety and/or low in nutritional quality.[120 128 339] Other US and UK studies indicate that older men living or eating alone are at greater risk of poor diets,[280 340] with living arrangement influencing FV consumption to significant levels in older British men but not women.[132] One reason living or eating alone might reduce fruit, or vegetable, variety is there are no economies of scale in food procurement and preparation. A qualitative study of recently bereaved older women in Sweden found they perceived the financial constraints associated with lone-living to affect their management of food shopping and cooking.[341] Since older single women are typically more disadvantaged financially than men,[297] stronger negative associations for women were expected but this was not observed.

Study results might be explained instead by lack of motivation to prepare a meal when living/eating alone since the psycho-social mechanism of social engagement is absent.[306] A substantial body of research indicates older people derive social meaning from cooking for others and from sharing a meal, as eating is both a food event and a social practice.[97 116] Lack of motivation to cook due to the effort involved would more likely affect the

consumption of vegetables which generally require more preparation than fruits. This is consistent with the finding of a greater negative association with the variety score for vegetables than for fruits among single and widowed versus partnered over-50s.

Poor motivation might further explain the greater negative associations seen in men. Men may be less motivated to prepare a meal when living alone because they are less equipped than women regarding cooking skills and being self-reliant while in a partnership.[116 342] A study comparing single and married elderly men and women found that single elderly women (87% widows) made food decisions independent of others and had better quality diets than the other groups.[157] Lack of motivation to eat a variety of vegetables or fruits is also more likely among men who commonly perceive cooking as burdensome particularly when widowhood demands they adopt new food-related tasks and consequent social roles, rather than as freedom which women can experience in widowhood.[343] Finally, personal motivation has been reported as the main influence on men aiming to improve dietary behaviours, rather than socio-ecological resources.[324 325]

*Combined influence of social relationships*

Combinations of different social relationships were notable in differentially influencing on healthful dietary behaviours of over-50s. Results showed synergy of action between marital status and living arrangement, and between marital status and friend contact, thus confirming hypotheses that negative associations of being single or widowed with variety may be mitigated by shared accommodation or frequent social contact. They clearly indicated that friend contact played a significant role in the extent to which being widowed showed reduced variety, suggesting that widowed persons at risk of consuming fewer different fruit or vegetable products are those with infrequent contact. Equally, infrequent friend contact amplified the extent of reduced variety among older lone-dwellers. In addition, over-50s having rare/no family contact ate fewer different vegetables when friend contact was infrequent but not when contact was frequent.

These findings suggested further that co-living might mitigate the potentially negative association of being widowed with variety, particularly of vegetables. Others have also reported that living alone, versus co-living, limited FV variety (and number of meals) eaten by single older adults compared to married counterparts.[132 344] One interpretation for these interaction results might be the buffering role that occurs from companionship availability separate from social engagement provided through intimate partnership. Physiological

studies of elderly suggest the existence of a confidant relationship can mitigate the general response to stressful stimuli[328] and also stress-related loss of appetite.[345]

The role of living arrangement in healthful dietary behaviours was also modified by friend contact, supporting the hypothesis that frequent friend contact would lessen the negative association of lone-living with variety. The combination of lone-living and infrequent friend contact was notably worse than the combination of lone-living and frequent friend contact for reducing intake of different fruit and especially vegetable products. This study concurs with previous work indicating lower variety of healthful foods may be caused not solely by living alone but by loneliness, since frequent friend contact provides the opportunity for social interaction at mealtimes which is known to improve the diets of lone-living elderly.[116]

It is also possible that friend contact modified associations through functional support. Stronger effects of functional components have been found over structural measures in predicting mental health,[312] or diet quality.[346] Yet, others have not found support functions explained the independent associations between social isolation and higher mortality risk.[347] It is argued that participation in social relationships itself results in health behaviours because of the opportunities for sociability, meaningful roles and shared norms which do not result from social support per se.[306] Since structural and functional components might activate similar psychological mechanisms,[329] future research should examine mediation of functional components in associations between relationship structures and diet quality, using behaviour-specific measures of perceived social support as they are more predictive than generic indicators.[348]

## 4.6 Conclusion

This study confirms the gender-specific associations of social relationships with variety of intake of fruits and/or vegetables in a UK population, and contributes new evidence on the combined influence of structural components of relationships. Variety scores of men were more influenced than those of women by marital status, living arrangement or friend contact. Thus, structural interventions aimed at increasing availability of social relationships by reducing social isolation or supporting recent widows are likely important for promoting healthful dietary behaviours, particularly among men. Results also highlight the importance of considering living arrangement and friend contact when assessing whether widowed or single over-50s are at risk of eating fewer different fruits or vegetables. The influence of

frequent friend contact in combination with either lone-living or rare/no family contact should also be considered for supporting healthful eating among older people. Future research needs to analyse potential mediation of functional components in the association between structured social experiences and diet quality. Further examination of men's and women's physiological responses to the type and quality of social relationships will also be useful to inform psycho-biological mechanisms of social life influences on healthful dietary behaviours.

# CHAPTER 5 Combined economic and social conditions, and diet quality in older adults

This work is submitted as "Conklin AI, Forouhi NG, Surtees P, Wareham NJ, Monsivais P. Gender, diet quality and the double burden of economic and social disadvantages on diet quality in older adults" (*Journal of Epidemiology and Community Health*, submitted)

## 5.1 Abstract

**Background:** Multiple economic and social factors determine diet quality, but the influence of inter-relations between determinants is unknown. This cross-sectional study examined diverse combinations of economic and/or social disadvantages on healthful eating in British older women and men.

**Methods:** Data came from 9,580 over-50s in the population-based EPIC-Norfolk cohort who responded to a postal Health and Life Experiences Questionnaire (1996-2000) and Food Frequency Questionnaire (1998-2002). Multivariable linear regression examined gender-specific associations of six economic factors and three social relationships, independently and in combination, in relation to fruit variety and vegetable variety as proxies for diet quality.

**Results:** Lower education, social class and renting were associated with lower variety in both genders, independent of social relationships. Independent associations of three financial hardships were consistently seen with fruit variety in women. All social relationships were independently associated with both variety outcomes in men and vegetable variety in women. Much lower variety was found for all combinations of both economic and social disadvantages than for either disadvantage alone, with men faring worse in the majority of dual disadvantages. The greatest unit differences were observed for vegetable variety in non-married men of low social class (β -4.1, [-4.8, -3.4]), and in non-married women with

insufficient money for food/clothing (β -2.8, [-3.8, -1.8]). Lower variety was also seen in economically advantaged men without social relationships.

**Conclusion:** The double burden of economic and social disadvantage suggests they are potentially joint determinants, particularly in older men, and that simultaneous improvements in older adults' economic and social conditions are needed to improve diet quality.

## 5.2 Introduction

It is known that older age correlates with both poorer economic and social conditions that are associated with poorer diets.[116 128] In particular, variety of FV is lower in non-married, lone-living and socially isolated older adults, particularly men (see Chapter 4).[286] Variety is also lower among older adults reporting multiple economic disadvantages, including everyday financial troubles (see Chapter 3). Yet, individuals vary considerably in the economic and social categories they occupy and no studies of older adults have investigated how multiple economic circumstances might interact with different social structures to influence healthful eating.[124] Moreover, the independent effects of single factors (e.g. social class or marital status) do not fully describe the influence of interrelated and intersecting categories.[14-16 18] Rather, Intersectionality Theory suggests that social relationships constitute an asset that generates economic resources and vice versa and thus absence of both creates a 'double', or composite, burden of intersecting disadvantages that would uniquely impact on diet quality. In the buffering model,[349] resources in one context, e.g. social capital (as a by-product of social relationships), are postulated to protect against the adverse impact of stressors in another context, e.g. material deprivation. A small US study of older adults supports this notion as those with greater financial stress experienced poorer appetite, with negative effects on dietary intake that were buffered by companionship.[345] Others have shown more generally that the availability of a confidant relationship can mitigate an older person's response to stressful stimuli.[328]

Furthermore, women and men differ in exposure to adverse economic or social conditions, and vulnerability to poor outcomes.[350] Older women are typically more disadvantaged economically and report greater material deprivation than men,[206 297] which in turn may constrain older women's food procurement and preparation.[341] Older men living or eating alone are more at risk of poor diets than women and this risk is compounded by material

deprivation.[280 340] Older single and married men are also more dependent on others for food-related decision-making than are older women.[157] Thus, either gender may be especially vulnerable to poor diet quality from being doubly disadvantaged. Alternatively, men may be more vulnerable to unhealthful eating from specific combinations of economic and social adversities while other combinations may affect women's diets more. As shown in Chapter 3 and Chapter 4, women and men differ in which types of economic conditions, or social relationships, were more strongly associated with some aspects of FV variety. How the interplay of diverse economic and social conditions influences healthful eating behaviours therefore deserves further exploration in older women and men.

The following study assessed the inter-relations of multiple economic and social conditions on variety of fruits or vegetables, as proxies of healthful eating, in British older adults. It was hypothesized that lack of social relationships would amplify associations between economic disadvantage and low variety. The effects of inter-relations on diet were also hypothesised to differ by gender: the combination of lower social class or education, and lone-living or non-married, will show the strongest associations in men; and, combinations of material deprivation and infrequent friend contact will show the strongest associations in women.

## 5.3 Methods

### 5.3.1 Study population

This cross-sectional study used data from EPIC-Norfolk participants who entered the cohort at age 50 or more, similar to Chapter 3 and Chapter 4.

### 5.3.2 Measures

*Economic exposures*

Economic conditions were analysed using three conventional SES measures and three FH indicators as examined in Chapter 3 and detailed in 1.5.2. Unlike earlier chapters, this study used dichotomised variables to enable the ease of generating new variables for analyses of the inter-relation of economic and social exposures. High social class was dichotomised using the top three social class categories comprising non-manual occupations (versus manual occupations). High education was defined by degree and A-level responses (versus O-level or no qualification). Home-owners were distinguished from renters of public and private accommodation types. Having more than enough money for needs was compared to 'just enough' and 'less than enough' responses. Sufficient money to afford clothing/food

included 'never' and 'seldom' response categories (versus 'sometimes', 'often' and 'always'). Finally, ability to meet the payment of bills comprised responses 'none', 'slight', and 'a little' (versus 'some', 'great' and 'very great'). Characteristics of dichotomised economic variables are given in Appendix D (see Table D–1).

*Social relationship exposures*

This study used binary variables for three questions pertaining to structural aspects of social relationships as examined in the interaction analyses of Chapter 4: namely, married (yes/no); co-living (yes/no); and frequent friend contact (yes/no) (see 4.3.3).

*Dietary outcomes*

Scores for fruit variety and vegetable variety were dietary outcomes examined as proxies for diet quality, as previously described (1.5.2) and studied (Chapter 3 and Chapter 4).

*Sample characteristic variables*

Again, age, concurrent self-rated general health status (categorical), smoking status (categorical), regular car use (binary), and BMI (continuous) were used to characterise the sample.

### 5.3.3 Data analysis

Descriptive statistics (mean (SD) or prevalence) characterised our sample across categories of economic-marital status combinations. Three sets of multivariable linear regression analyses examined gender-specific associations of economic, social and combined exposures with dietary outcomes. First, each economic or social variable was entered separately into models adjusting for age and total energy intake which included an interaction term between sex and exposure variables. Second, analyses of economic exposures were additionally adjusted for social exposures, and vice versa. Third, analyses explored how economic conditions varied in associations with variety when a social relationship was considered. Thus, combination variables were constructed by defining, for example, high education and married/high education and non-married/low education and married/low education and non-married; the reference category was strong economic and social conditions (e.g. high education and married). The sample analysed included over-50s who responded to economic and social questions, had covariates and follow-up dietary data (range: 5,810—6,252). Results are presented as regression coefficients and CI95.

## 5.4 Results

The general characteristics of the over-50 sample in the EPIC-Norfolk cohort were presented in results sections 3.4 and 4.4 above. Among the four categories of combined variables, between 175 and 959 over-50s reported dual disadvantages, such as low education and non-married status; although, most older adults in EPIC-Norfolk were in the reference group of economic advantage and married (Appendix D, Table D–2). Characteristics of the over-50s differed across the four categories, except for mean BMI. For example, proportions of women were greatest in the non-married categories with or without economic disadvantage. Furthermore, in the category of economic disadvantage and non-married, up to 40% of older adults had poor/moderate self-rated health and up to 58% were ever smokers compared to 14% and 50% in the reference groups, respectively.

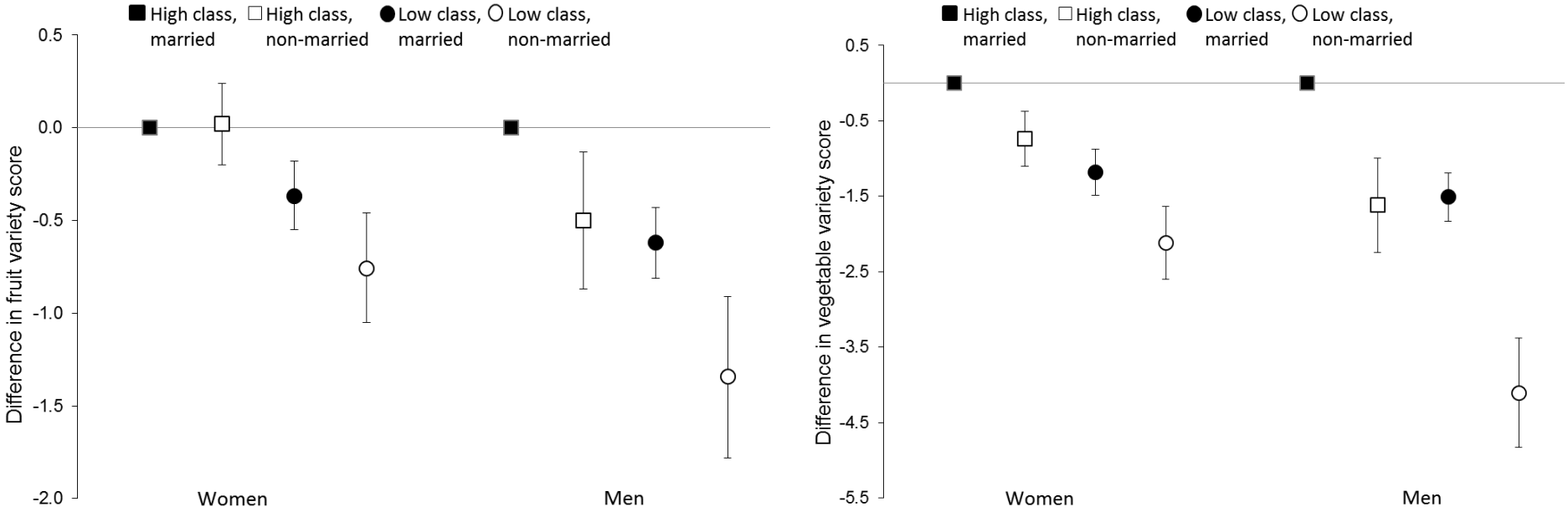
### 5.4.1 Independent associations between economic influences, or social relationships, and healthful eating

Overall and independent associations of each exposure variable with variety scores are presented in Appendix D (Table D–3 and Table D–4). Table D–3 shows all three conventional SES measures were associated with both dietary outcomes in both genders, independent of social relationships. Low education was more negatively associated with variety in women, while low social class was more negatively associated with variety in men. Only one financial hardship variable was independently associated with both dietary outcomes in women and men; although all three financial hardships were independently associated with fruit variety in women. Each social relationship was also independently associated with variety in men but only with vegetable variety in women (Table D–4). Only friend contact was independently associated with fruit variety in women. Magnitudes of independent association were somewhat higher in men and lower in women than those observed for the economic variables.

### 5.4.2 Effect of inter-relations between economic and social conditions on diet quality

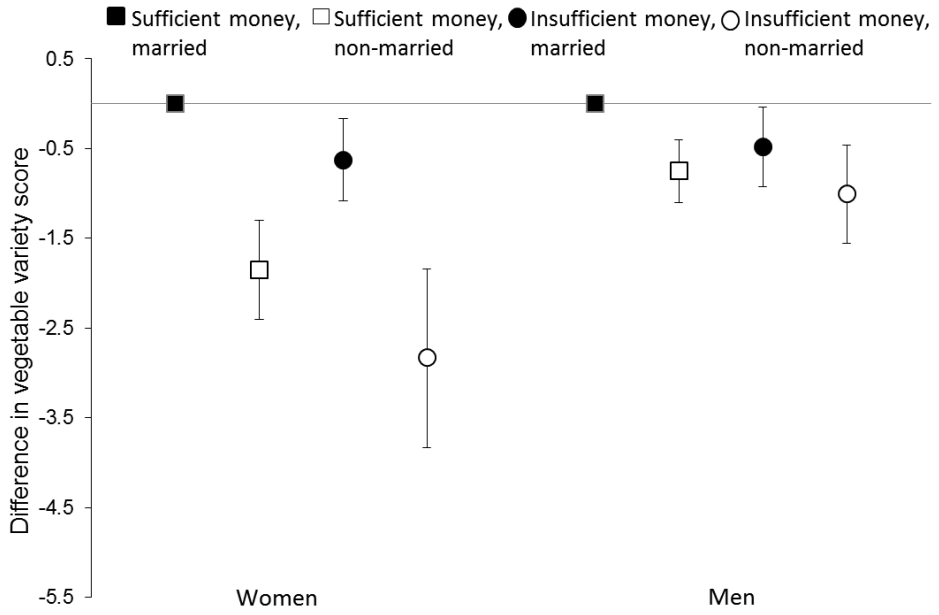
Marital status combined with each economic variable to alter independent associations with diet quality (Figure 5–1 and Table 5–1). Figure 5–1 illustrates how results for social class (upper panels, A) or affording food/clothing (lower panels, B) in combination with married/non-married show heterogeneity in dietary outcomes across categories. Overall, compared to reference groups, fruit variety was much lower in women and men reporting

both economic disadvantage and non-married status than in those reporting only economic disadvantage. Lower fruit variety was also observed in non-married men with strong economic conditions. Results were similar for vegetable variety which was lowest in those reporting both economic disadvantage and non-married status than in over-50s reporting either economic or social disadvantage. For two financial hardship variables, non-married men with strong economic conditions showed the greatest unit difference in vegetable variety of the three categories compared to reference. Notably, variety appeared disproportionately lower for men reporting both low education and non-married statuses. In addition, the magnitudes of associations for all dual disadvantage categories (Figure 5–1 and Table 5–1), were generally larger than those observed for the independent associations of single economic factors which simply adjusted for marital status (Appendix D, Table D–3).




**A**

Figure 5-1 Association between social class (A), or sufficient money to afford food/clothing (B), and variety of fruits or vegetables by marital status


**B**

Figure 5-1 Association between social class (A), or sufficient money to afford food/clothing (B), and variety of fruits or vegetables by marital status

Numbers analysed were: social class (n=6,151), and sufficient money for food/clothing (n=5,836).

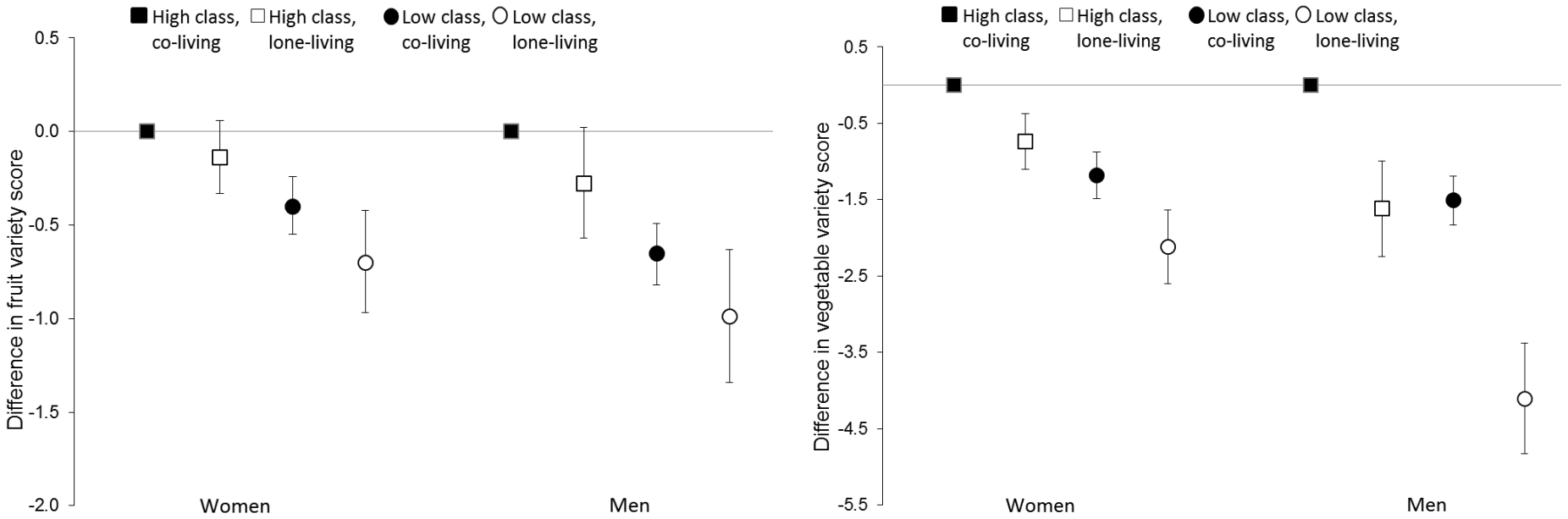
Table 5-1 Association of inter-relations between economic conditions and marital status with variety of fruits or vegetables in older women and men in the EPIC-Norfolk study

| | Fruit variety | | | |
|---|---|---|---|---|
| | Women | | Men | |
| | *Married* | | *Married* | |
| | *Yes* | *No* | *Yes* | *No* |
| High education (n=6,252) | | | | |
| Yes | reference | 0.03 (-0.21, 0.28) | reference | -0.37 (-0.74, -0.01) |
| No | -0.54 (-0.72, -0.37) | -0.80 (-1.06, -0.55) | -0.38 (-0.57, -0.19) | -1.30 (-1.72, -0.87) |
| Home-owner (n=5,810) | | | | |
| Yes | reference | -0.00 (-0.20, 0.19) | reference | -0.40 (-0.73, -0.08) |
| No | -0.58 (-0.92, -0.18) | -0.75 (-1.15, -0.35) | -0.82 (-1.24, -0.40) | -1.07 (-1.69, -0.44) |
| More than enough money for needs (n=5,830) | | | | |
| Yes | reference | 0.11 (-0.34, 0.57) | reference | -1.14 (-1.79, -0.48) |
| No | -0.28 (-0.50, -0.05) | -0.37 (-0.63, -0.10) | -0.50 (-0.73, -0.26) | -0.85 (-1.22, -0.49) |
| Able to meet payment of bills (n=5,839) | | | | |
| Yes | reference | 0.02 (-0.18, 0.21) | reference | -0.51 (-0.82, -0.20) |
| No | -0.46 (-0.85, -0.08) | -0.67 (-1.06, -0.27) | -0.16 (-0.53, 0.21) | -0.66 (-1.44, 0.11) |
| | Vegetable variety | | | |
| | Women | | Men | |
| | *Married* | | *Married* | |
| | *Yes* | *No* | *Yes* | *No* |
| High education (n=6,252) | | | | |
| Yes | reference | -0.70 (-1.11, -0.29) | reference | -1.34 (-1.95, -0.72) |
| No | -1.50 (-1.80, -1.20) | -2.48 (-2.90, -2.06) | -0.94 (-1.26, -0.62) | -3.89 (-4.60, -3.18) |
| Home-owner (n=5,810) | | | | |
| Yes | reference | -0.57[j] (-0.90, -0.24) | reference | -1.86 (-2.41, -1.32) |
| No | -1.68 (-2.34, -1.02) | -2.07 (-2.74, -1.40) | -1.60 (-2.31, -0.90) | -2.74 (-3.80, -1.69) |
| More than enough money for needs (n=5,830) | | | | |
| Yes | reference | -1.21 (-1.97, -0.45) | reference | -3.40 (-4.51, -2.30) |
| No | -0.71 (-1.09, -0.33) | -1.34 (-1.78, -0.90) | -1.17 (-1.57, -0.78) | -2.77 (-3.39, -2.15) |
| Able to meet payment of bills (n=5,839) | | | | |
| Yes | reference | -0.65 (-0.98, -0.32) | reference | -2.08 (-2.60, -1.56) |
| No | -0.25 (-0.89, 0.40) | -1.32 (-1.99, -0.66) | -0.75 (-1.38, -0.12) | -1.56 (-2.87, -0.26) |

Gender-specific beta coefficients (CI95) obtained by linear regression models adjusting for age and energy intake.

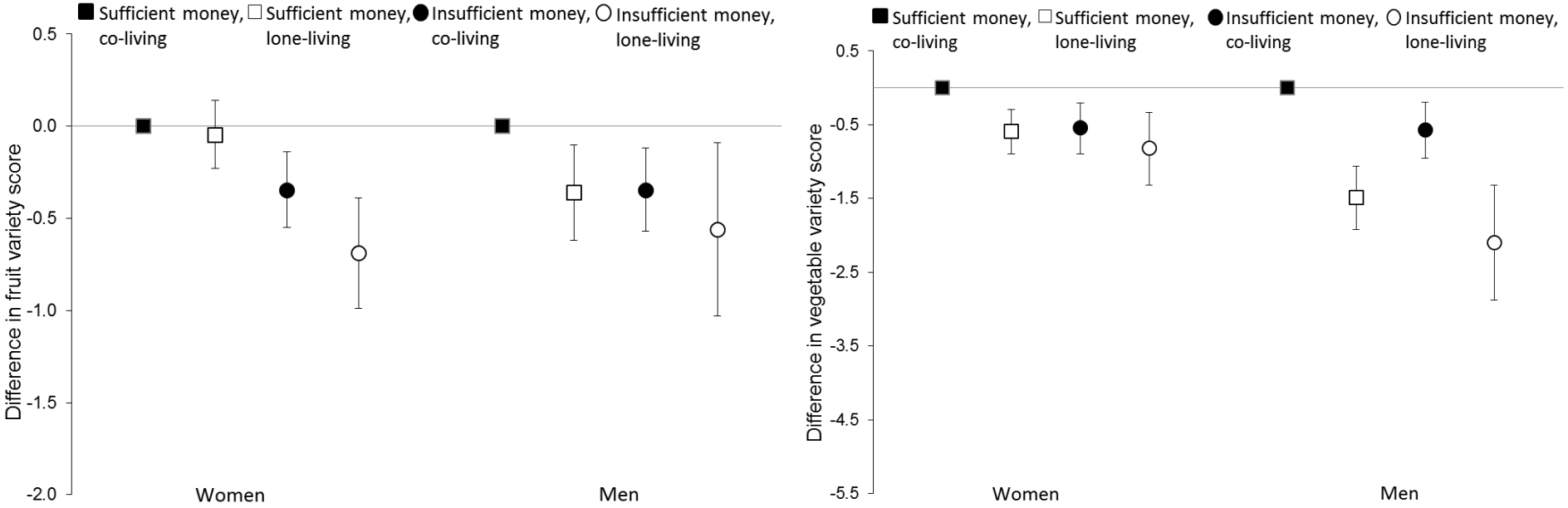
The pattern of results was similar when economic factors were combined with living arrangement, with much lower variety observed among over-50s reporting both economic disadvantage and lone-living than economic disadvantage alone (Figure 5–2 and Table 5–2). Disproportionately lower scores for fruit variety were seen in women reporting low education and lone-living, and for vegetable variety in men in the same category. Again, only men who were lone-living in strong economic conditions showed lower fruit variety.

Finally, results revealed heterogeneous associations of diverse economic conditions with variety when combined with friend contact (Figure 5–3 and Table 5–3). Notably, this was the only social relationship consistently associated with lower fruit variety when absent in women with strong economic conditions. Thus, women and men reporting disadvantage in either economic or social condition had lower variety of fruits or vegetables compared to reference groups. Again, much lower variety was seen among individuals in dual disadvantage categories, with a few combinations showing disproportionately lower variety.




**A**

Figure 5-2 Association between social class (A), or sufficient money to afford food/clothing (B), and variety of fruits or vegetables by living arrangement




**B**

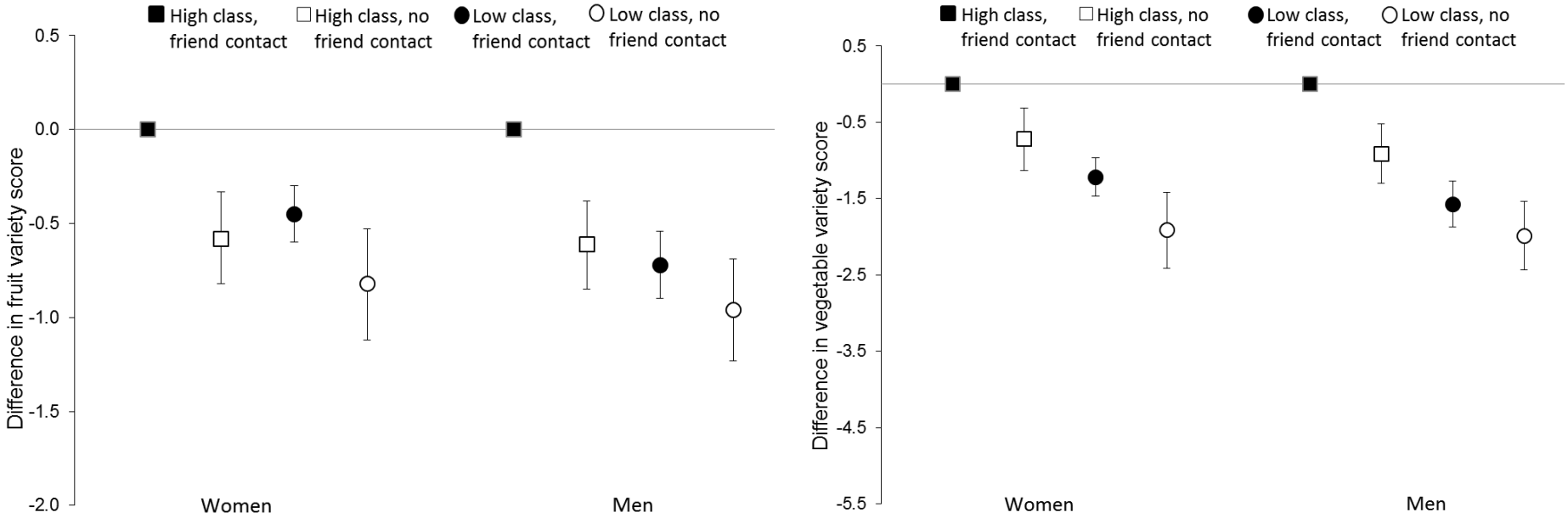
Figure 5-2 Association between social class (A), or sufficient money to afford food/clothing (B), and variety of fruits or vegetables by living arrangement

Numbers analysed were: social class (n=8,663), and sufficient money for food/clothing (n=8,715).

Table 5-2 Association of inter-relations between economic conditions and living arrangement with variety of fruits or vegetables in older women and men in the EPIC-Norfolk study

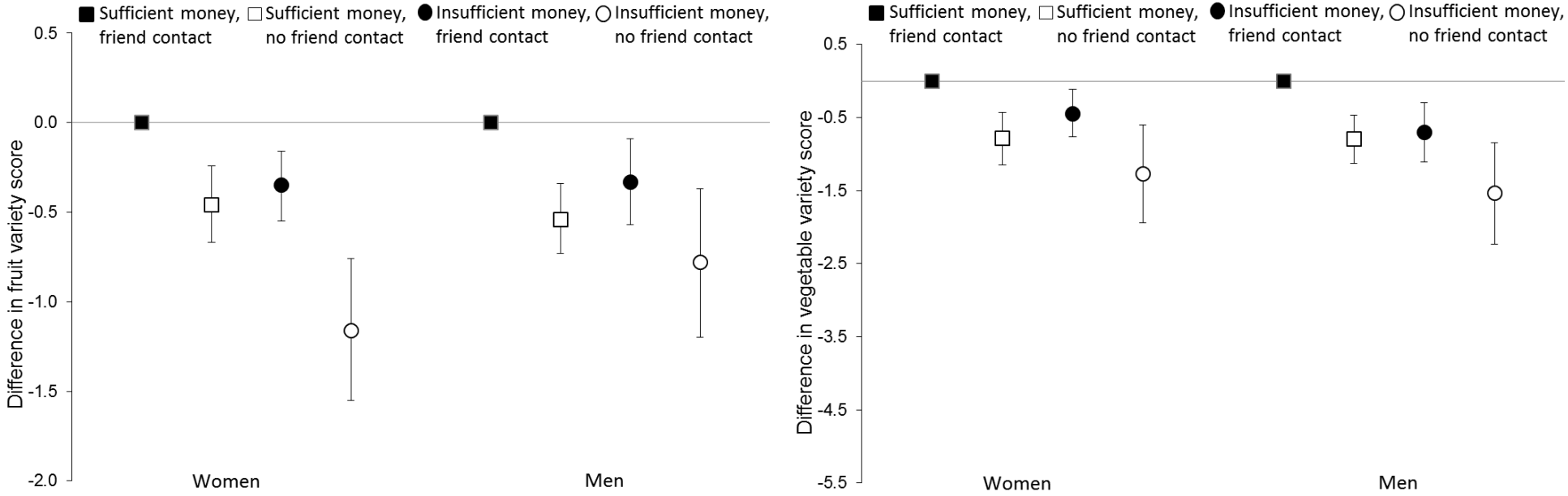
| | Fruit variety | | | |
|---|---|---|---|---|
| | Women | | Men | |
| | *Co-living* | | *Co-living* | |
| | *Yes* | *No* | *Yes* | *No* |
| High education (n=8,810) | | | | |
| Yes | reference | -0.04 (-0.26, 0.18) | reference | -0.26 (-0.56, 0.03) |
| No | -0.54 (-0.69, -0.39) | -0.90 (-1.13, -0.67) | -0.50 (-0.66, -0.34) | -0.92 (-1.26, -0.58) |
| Home-owner (n=8,681) | | | | |
| Yes | reference | -0.10 (-0.27, 0.08) | reference | -0.28 (-0.54, -0.03) |
| No | -0.66 (-0.96, -0.35) | -0.83 (-1.19, -0.47) | -0.85 (-1.20, -0.50) | -0.85 (-1.36, -0.35) |
| More than enough money for needs (n=8,709) | | | | |
| Yes | reference | -0.10 (-0.49, 0.30) | reference | -0.55 (-1.07, -0.03) |
| No | -0.31 (-0.50, -0.12) | -0.47 (-0.70, -0.24) | -0.49 (-0.68, -0.29) | -0.80 (-1.10, -0.50) |
| Able to meet payment of bills (n=8,724) | | | | |
| Yes | reference | -0.13 (-0.30, -0.04) | reference | -0.35 (-0.60, -0.11) |
| No | -0.58 (-0.86, -0.29) | -0.54 (-0.93, -0.15) | -0.41 (-0.71, -0.10) | -0.65 (-1.33, 0.02) |
| | Vegetable variety | | | |
| | Women | | Men | |
| | *Co-living* | | *Co-living* | |
| | *Yes* | *No* | *Yes* | *No* |
| High education (n=8,810) | | | | |
| Yes | reference | -0.52 (-0.89, -0.15) | reference | -0.94 (-1.43, -0.44) |
| No | -1.40 (-1.65, -1.16) | -2.20 (-2.57, -1.83) | -0.99 (-1.25, -0.72) | -3.17 (-3.73, -2.60) |
| Home-owner (n=8,681) | | | | |
| Yes | reference | -0.57 (-0.85, -0.28) | reference | -1.48 (-1.90, -1.06) |
| No | -1.81 (-2.32, -1.30) | -1.35 (-1.95, -0.75) | -1.77 (-2.35, -1.19) | -2.10 (-2.95, -1.25) |
| More than enough money for needs (n=8,709) | | | | |
| Yes | reference | -1.08 (-1.74, -0.41) | reference | -2.03 (-2.90, -1.17) |
| No | -0.61 (-0.93, -0.30) | -1.08 (-1.46, -0.69) | -0.88 (-1.20, -0.55) | -2.32 (-2.82, -1.83) |
| Able to meet payment of bills (n=8,724) | | | | |
| Yes | reference | -0.52 (-0.80, -0.23) | reference | -1.64 (-2.40, -1.23) |
| No | -0.65 (-1.13, -0.18) | -1.16 (-1.81, -0.51) | -0.88 (-1.39, -0.37) | -1.44 (-2.56, -0.31) |

Gender-specific beta coefficients (CI95) obtained by linear regression models adjusting for age and energy intake.




**A**

Figure 5-3 Association between social class (A), or sufficient money to afford food/clothing (B), and variety of fruits or vegetables by friend contact frequency




**B**

Figure 5-3 Association between social class (A), or sufficient money to afford food/clothing (B), and variety of fruits or vegetables by friend contact frequency

Numbers analysed were: social class (n=8,298), and sufficient money for food/clothing (n=8,388).

Table 5-3 Association of inter-relations between economic conditions and friend contact frequency with variety of fruits or vegetables in older women and men in the EPIC-Norfolk study

| | Fruit variety | | | |
|---|---|---|---|---|
| | Women | | Men | |
| | *Frequent friend contact* | | *Frequent friend contact* | |
| | *Yes* | *No* | *Yes* | *No* |
| High education (n=8,437) | | | | |
| Yes | reference | -0.40 (-0.70, -0.11) | reference | -0.48 (-0.71, -0.25) |
| No | -0.55 (-0.69, -0.41) | -1.06 (-1.31, -0.81) | -0.47 (-0.65, -0.30) | -1.02 (-1.29, -0.74) |
| Home-owner (n=8,300) | | | | |
| Yes | reference | -0.46 (-0.66, -0.25) | reference | -0.55 (-0.74, -0.37) |
| No | -0.54 (-0.80, -0.27) | -1.59 (-2.16, -1.01) | -0.85 (-1.18, -0.51) | -1.11 (-1.75, -0.47) |
| More than enough money for needs (n=8,381) | | | | |
| Yes | reference | -0.80 (-1.34, 0.27) | reference | -0.60 (-1.03, -0.18) |
| No | -0.33 (-0.51, -0.15) | -0.80 (-1.05, -0.55) | -0.45 (-0.65, -0.24) | -0.94 (-1.19, -0.68) |
| Able to meet payment of bills (n=8,396) | | | | |
| Yes | reference | -0.50 (-0.71, -0.30) | reference | -0.52 (-0.71, -0.33) |
| No | -0.47 (-0.73, -0.21) | -1.16 (-1.70, -0.62) | -0.39 (-0.72, -0.06) | -0.95 (-1.50, -0.41) |
| | Vegetable variety | | | |
| | Women | | Men | |
| | *Frequent friend contact* | | *Frequent friend contact* | |
| | *Yes* | *No* | *Yes* | *No* |
| High education (n=8,437) | | | | |
| Yes | reference | -0.56 (-1.05, -0.06) | reference | -0.72 (-1.10, -0.34) |
| No | -1.38 (-1.62, -1.14) | -2.10 (-2.52, -1.69) | -1.06 (-1.35, -0.77) | -1.99 (-2.45, -1.53) |
| Home-owner (n=8,300) | | | | |
| Yes | reference | -0.64 (-0.98, -0.30) | reference | -0.84 (-1.15, -0.53) |
| No | -1.25 (-1.69, -0.80) | -2.76 (-3.73, -1.80) | -1.75 (-2.32, -1.19) | -2.36 (-3.42, -1.29) |
| More than enough money for needs (n=8,381) | | | | |
| Yes | reference | -0.99 (-1.89, -0.10) | reference | -0.61 (-1.32, -0.10) |
| No | -0.48 (-0.78, -0.18) | -1.22 (-1.63, -0.80) | -0.74 (-1.09, -0.40) | -2.32 (-2.82, -1.83) |
| Able to meet payment of bills (n=8,396) | | | | |
| Yes | reference | -0.87 (-1.21, -0.53) | reference | -0.81 (-1.12, -0.49) |
| No | -0.84 (-1.28, -0.41) | -0.92 (-1.83, -0.01) | -0.80 (-1.35, -0.24) | -1.54 (-2.45, -0.63) |

Gender-specific beta coefficients (CI95) obtained by linear regression models adjusting for age and energy intake.

## 5.5 Discussion

### 5.5.1 Synopsis of results

This study revealed that three classical SES indicators and three FH measures were associated with older people's diet quality in terms of fruit variety and vegetable variety, independent of their social relationships. It also revealed independent associations between three structural social relationships and variety. Of greatest novelty was the demonstration that variety was much lower for each measure of economic disadvantage when individuals also lacked a social relationship. As hypothesised, women and men differed in the specific configurations of economic and social categories that most influenced healthful eating. Regardless of economic conditions, the study also found that only men had lower variety when non-married or lone-living.

### 5.5.2 Methodological considerations

As in previous studies, several forms of bias may affect the self-reported exposures and outcomes examined here. As previously argued (3.5.2 and 4.5.2), perceptions of economic or social resources are worth investigating since subjective levels may better predict diet variety than objective levels,[128 351] and set meal routines and consumption patterns may mitigate potential diet recall bias.[107 108 335] Nevertheless, the study design did not account for transitions in, or cumulative economic or social disadvantage that could alter associations in opposing directions. Any misclassification of exposures from changes to participants' economic/social conditions between surveys would be unrelated to dietary outcomes and non-differential; thus biasing results towards the null. In addition, residual confounding by income not collected in this cohort might bias observed associations to be larger than true associations. Although low income can be a barrier to consuming fruits and vegetables and the unobserved influence of income cannot be discounted, current income is not the only structural resource used by older adults to fund their expenses which could explain why income is inconsistently associated with their diet.[115 124 126 127 281] As noted above in 4.5.2, residual confounding might also occur from unexamined aspects of social relationships including existence of a confidant relationship. Finally, findings cannot be generalized to lower SES populations, or to non-white or younger groups.

Many study strengths are also acknowledged which included: a large sample size, gender analyses, six economic factors, three social structures and two dietary outcomes. A proxy

for wealth was included among the conventional SES indicators strongly associated with diet quality,[84] and older adults' financial situation was also examined using three measures of FH which can be experienced regardless of income or SES level.[273 276-279 352] It is recommended that studies of economic determinants examine multiple potentially relevant factors in relation to key socio-demographic factors, such as gender, not least because people who are similar on a single factor may not be economically comparable and different types of economic exposure may have unique associations with diet quality.[179 219 288] Several social relationships also have distinct associations with older adults' healthful eating (as shown in Chapter 4),[286] thus reflecting how their lived experiences are characterised by highly differentiated social categories.[124 207] But, the particular strength of this work was in considering combinations of diverse economic and social conditions in relation to two dietary outcomes and taking a gender perspective, thereby addressing a critical knowledge gap on the determinants of healthful eating among older adults.[124] In doing so, this study begins to capture the complex reality of an older individual's heterogeneous life circumstances wherein multiple social roles and diverse economic resources intersect to produce unique configurations that are specific to women and men and have distinct influences on healthful eating.[14 124 180]

### 5.5.3 Relationship to previous work

Factors related to both economic and social conditions are known to play an important role in the diet quality of older adults.[85 116 121 123 124 128 286 304] Yet, the potential linkages between economic influences and social structures as unique determinants of healthful eating in older populations remain an identified evidence gap.[124] This study is therefore the first to my knowledge to investigate different combinations of multiple economic factors with several social relationships in relation to two markers of diet quality in older women and men.

Limited research indicates that the interplay between economic and social factors had a unique impact on health.[353-358] A prospective US study showed employment status altered the influence of cohabitation on 6-year weight gain in young men.[355] In cross-sectional studies of Swedish or UK populations, social capital (including contact with friends) modified adverse effects of economic deprivation on mental health;[354 356 357] and similar results were found in urban Chinese for self-rated general health.[353] However, it is likely that the apparent buffering effects of social structures occurred only when an individual perceived

the availability of such interpersonal resources as being commensurate with the needs that economic stresses elicited.[349] Overall, evidence is strongest for the notion of a synergy of action resulting in an interlocking disadvantage of low social resources being more concentrated in economically poorer groups.[358-361] In other words, lower status persons experience a pervasive disadvantage in exposure and vulnerability to poor health from undesirable life events including marital termination.[362]

This study of diet quality in older adults showed much lower variety of fruits or vegetables was associated with the combination of all forms of economic and social disadvantages than with either considered alone. That lack of a social structure appeared to magnify the inverse associations between economic disadvantages and healthful eating, parallels the synergy effects reported for health outcomes. This study also found consistent associations of adverse social conditions and lower variety among men with strong economic conditions. Although some report associations of low social resources with poorer health only among people in deprived circumstances,[353 356] the results here concur with other work showing that social disadvantage can have poor health outcomes regardless of poor economic conditions.[354 357 358]

More importantly, the study examined inter-relations of multiple dimensions of economic disadvantage and different social relationships which is deemed necessary to account for highly differentiated life circumstances which produce the risk factors of cardio-metabolic conditions.[363] Given the consistent stronger associations of dual disadvantages observed across the broad set of indicators, results can be interpreted as the constraint on older persons' life choices about healthful eating from either a lack of capabilities in several areas,[354 364] or a composite inequality of intersecting and mutually reinforcing disadvantages.[14 18 180] Several results were consistent with Intersectionality Theory, suggesting that disadvantage in one context limits the realization of status/resources in another context to create a net effect that is greater than the sum of individual disadvantages.[14 15 17 18] Results indicated that disadvantageous economic and social conditions should not be viewed as exclusive or separate determinants of diet quality in older groups. Rather, their combined associations with variety reflected the unique constellation of economic and social categories that older people occupy,[207] and therefore requires a novel public health approach to account for this complex reality.[18]

Moreover, the results confirmed women and men were differentially vulnerable to poor diet quality from distinct forms of economic and/or social disadvantage.[350] Overall, findings demonstrated that men, particularly non-married or lone-living, fared worse in the associations between dual economic-social disadvantages and healthful eating. For example, economically disadvantaged non-married men ate 1.30 fewer different vegetables (over at least a month) than women counterparts; economically disadvantaged lone-living men ate 1.0 less unique vegetable than similarly disadvantaged women. Results support our hypothesis that, in men, all measures of SES combined with non-married or lone-living showed stronger inverse associations with variety, particularly vegetable variety. Economic disadvantages combined with infrequent friend contact were also generally worse for men's vegetable variety. However, in terms of fruit variety, women fared worse than men since women ate 0.5 fewer different fruits than men when they reported both economic disadvantage and infrequent friend contact. Thus, the hypothesis that combinations of material deprivation and infrequent friend contact will show the strongest associations with variety in women was true regarding fruit intake when comparing to material deprivation combined with other social relationships, and partly true when comparing to combinations of SES and infrequent friend contact.

Other work examining social relationships and diet indicated that marital status and living arrangement were stronger determinants in men,[132 157 280 286 323 340] while friendship relations were more influential in women.[286 324 325] Women are known to have a larger network of friends who provided more of their social support than do other relationships as seen in men.[312] Friends also appeared to explain why women and men differed in their vulnerability to the emotional impact of life adversities such as job loss or death of a spouse.[350] Since women tend to have more frequent social contact than men as reported for this cohort and elsewhere,[286 313] it is perhaps unsurprising that infrequent friend contact was the one social relationship associated with lower fruit variety in women regardless of economic conditions. Furthermore, a review of evidence on SES and diet indicated stronger gradients in women,[84] which this study found in a third to half of the observed associations between economic disadvantage alone and variety. Notably, the strongest associations for either gender differed by economic indicator but included at least one SES and one financial hardship measure. Finally, it is possible the double burden of economic and social disadvantages was worse in men because they perceived intersecting disadvantages as deprivation while women experienced equivalent levels as *status quo*.[282]

## 5.6 Conclusion

In conclusion, multiple economic disadvantages, including everyday financial troubles, as well as lack of social structures were independently associated with lower diet quality in older British women and men. Moreover, when combined, diet quality was even lower, suggesting dual economic and social disadvantages potentiated the burden on healthful eating. The results indicated that efforts to increase variety and promote healthful eating in older adults will benefit from a simultaneous focus on improving their financial situation and encouraging their social connectivity. Findings further demonstrated that not all combinations of economic and social disadvantage had the same salience for diet quality in women and men; future strategies and interventions may therefore need to be tailored to each gender.

# CHAPTER 6 Known economic determinants of obesity

This chapter serves as a transition in focus on adiposity as another risk factor for chronic conditions, and the main outcome of interest for the remaining two empirical studies in this dissertation. It therefore provides some additional background through a brief summary of the literature on factors describing the economic environment which are associated with obesity and weight gain. It is largely based on existing systematic reviews of cross-sectional and prospective evidence on the economic determinants of obesity. Information specific to older populations was obtained through additional targeted searches of PubMed, Embase, Web of Science and Scopus, and through snowball sampling of references in reviews and relevant records.

## 6.1 Conventional economic determinants of obesity and weight gain

Multiple economic determinants of obesity have been suggested,[66 165 365] particularly SES which is strongly and inversely related to obesity,[101 176 178] and weight gain.[177 366] While SES gradients are conventionally measured by education, occupational grade, income, or their combination,[176 177] differences in obesity are also associated with employment status, home-ownership, food security, area deprivation and other environmental factors, such as food prices or residential property values.[66 161 171 355 365 367 368]

In England, for example, lower quintiles of equivalised household income are associated with a higher age-standardised prevalence of general and central obesity, compared to higher income quintiles.[70] The 2011 Health Survey for England also shows greater levels of obesity among individuals reporting greater levels of relative deprivation: 25% of men and 30% of women in the most deprived quintile are obese compared to, respectively, 22% and 19% in the least deprived quintile.[70] Similar figures are found in the 2012 US National Health Interview Survey, with 32% of adults in poor families being obese compared to 26% in non-

poor families.[369] Differences by SES are also observed in the rates of increase in either obesity or weight gain, with higher rates in lower SES groups.[73 78 79]

However, in the UK and elsewhere, specific indicators of SES do not consistently relate to obesity or predict weight gain, most notably income.[70 176 177] More importantly, the set of factors contributing to social patterns in obesity or weight gain differs by affluence[165] and especially by gender.[75 167 181-186 370] As illustrated in the Foresight Report,[165] similar factors have different pathways of influence between affluent and less affluent groups, while some factors and pathways of influence are unique to each group. Education is an example of shared factors with divergent pathways: it influences food literacy for both groups, but the consequent pathways of influence radically diverge because processes of social selection mean that the education received by affluent groups is qualitatively and quantitatively different from that received by less affluent groups.[207]

An example of a pathway unique to less affluent groups is the inter-relation between financial constraints and time poverty.[371] Healthier diets are related to higher dietary costs,[372 373] and food work increases with healthy dietary change.[271 374 375] Low-income groups have a dual restriction on their resources as they have less money to spend and less time available.[376] This unique interplay is considered to be one of the economic features driving low income groups to consume less healthy diets comprising cheaper foods that provide more energy for monetary value and also require less work.[376] The interaction's effects, however, will disproportionately affect women because women are both more time poor and have lower incomes than men.[377]

### 6.1.1 Gender, SES and adiposity

Women and men differ in many of the factors describing the economic (and social) contexts of adiposity, as evidenced by stronger SES gradients in women and gender-specific SES differences in BMI or weight gain. Education is a key example of a shared SES factor consistently associated with obesity-related outcomes that is observed to be more strongly graded in women.[70 101] Moreover, the observed widening of educational differences in obesity over time is greater in women.[79] Although some researchers find education-BMI associations are not shared with men, such contradictory findings can be explained by methodological considerations of response bias in that study which may have limited education differences and thereby underestimated true relationships.[183]

Gender-specific differences by SES in weight-related outcomes have also been reported. For example, a cross-sectional study of neighbourhoods and obesity in older adults concluded that factors describing their economic and social environments were more influential on men's body weight, whereas aspects of the built environment appeared more salient for women.[370] Food security is possibly another gender-specific determinant of obesity as correlations between food insecurity and weight status were also observed repeatedly in women only.[367] There is more evidence for the gender-specific role of low SES in childhood. In an early population-based study of obesity and mental health in white US adults, a seven-fold higher prevalence of obesity was observed only among women reporting low social status of origin, measured by father's occupation and education combined.[378] Many studies since have consistently reported strong associations between early-life SES and current adiposity, or long-term weight gain, in women at any age but not in men,[75 78 167 184 186 363] with few exceptions.[178 379] Little is known about this gender-specific factor among older adults as most longitudinal studies of childhood and adult SES focus on younger age groups.[363] Nevertheless, one prospective study of Dutch middle-aged adults of both genders found childhood SES, measured by father's occupation, was associated with general and central obesity, and long-term weight gain, in women only, independent of adulthood SES.[186]

Another aspect of the gendered phenomenon of SES differences in obesity concerns the potential mechanisms of influence. A few studies reveal that women and men differed either in the lifestyle factors that explained some of the SES gradients in obesity, or in the inter-relations between mediators and determinants.[182 183 185] A large cross-sectional study of the Australian population found that only smoking behaviour interacted significantly with home-ownership and family status to influence BMI (from clinical measures) in men, whereas several other additional behaviours, including physical activity levels and use of low-fat dairy foods, interacted with employment status to explain BMI differences in women.[182] Similarly in Finnish adults, diet and sitting in men and women were consistent mediators of associations between SES and objectively measured BMI, but leisure time physical activity was also a mediator in women.[185] A smaller cross-sectional study in Ontario indicated that FV intake mediated education differences in high-risk adiposity among women but not men.[183] Another small study of Australian youth found that SES gradients in adiposity were not mediated by dietary intake, physical activity or TV viewing in girls, whereas fat intake mediated the relationship in boys.[380] For women, moreover, there may also be other pathways linking SES to BMI beyond lifestyle factors. Sleep was proposed in

one Finnish study as an explanation for the finding that educational differences in BMI in men were fully explained by the mediating effects of lifestyle factors, but partially in women.[185]

## 6.2 Beyond SES: novel measures of economic inequalities in obesity

Conventional SES indicators are not the only, or arguably the best, way to understand how variation in people's economic conditions is associated with adiposity,[70 301] or weight gain.[302 381] Many studies of obesity demonstrate that conventional SES indicators do not fully capture people's material resources and spending power.[301-303 381] It is likely that everyday financial troubles may be a stronger antecedent to obesity and weight gain, than income, occupational status, or education.

Self-reported economic difficulties, such as having enough money for needs, represent a person's concrete financial strain that is only moderately correlated with income-based measures of material deprivation.[276 277 381-383] Moreover, some evidence indicated that FH was more strongly related to depression and other mental health outcomes than current income, and when specific hardships were assessed, difficulty paying bills had the most prominent impact on depression.[276 383] A person's subjective financial situation may also be more strongly related to dietary changes than objective income measures.[351]

Various cross-sectional and prospective studies support the notion that FH has independent effects on health beyond education, social class, income, home-ownership, or childhood SES.[198 241 279 282-284 301-304 352 381 383-389] Limited research suggests that even high-income groups showed FH differences in lifestyle factors, such as for smoking,[279] and that variation in FH was constant across income categories.[381] Since individuals at all income levels can experience FH with consequent health effects, the implications for public health and policy are that income (or other standard SES indicators) should not be seen as the sole criteria for targeting obesity interventions aimed at supporting healthy ageing.[179 282 284 384]

Despite wider research on poverty highlighting the added value of FH measures to concepts of inequality,[278] current obesity research and policy has tended to neglect everyday financial troubles as a unique domain of economic determinants that deserves specific attention.[179] Existing literature on FH and obesity amounts to six published papers[301-304 381] of which three were longitudinal,[184 302 381] and four were population-based.[184 303 304 381] One of the longitudinal studies examined FH in childhood, based on a single retrospective measure of at

least a year of money shortage, in relation to self-reported obesity in adult French women and men.[184] Notably, a Dutch study focused on mediators of SES differences in CVD also found strong associations between overall FH and obesity.[390] However, among the six FH-obesity studies, only one cross-sectional study used objectively measured anthropometry and examined both general and central obesity.[304] With two exceptions,[303 304] most studies of FH in adulthood lacked attention to gender-specific associations either because available data were restricted to an occupational cohort of all females or because gender was simply included as a confounder. Without a gender perspective, research cannot improve our understanding of the extent to which women and men differ in the FH associations with adiposity, and for which types of FH. Filling this knowledge gap is necessary given there is evidence for women's greater vulnerability to, and impact from, FH,[127 206 297] and for unique processes of economic differentiation that underlie gender differences in SES-obesity associations.[207 391]

Finally, in the same way that separate indicators of SES are inadequate proxies for one another,[288] different types of FH should be examined separately from one another (and from conventional SES). Specific forms of hardship can arise for different reasons that are specific to a person's life-stage and differentially impact weight-related outcomes.[303] A cross-sectional study of item-specific hardships in US adolescents found that difficulty paying bills was a possible cause of obesity among female youth only.[303] A prospective study of eight types of FH in Australian households found three specific items were associated with a 20% higher adjusted risk of being obese: namely, difficulty paying bills and heating one's home, and asking for financial help from friends.[381] Older adults are likely to experience some hardships more than others,[208 209 282] specifically difficulty in paying bills and affording adequate food/clothing as these comprise some of the largest drains on disposable income in this age group.[211] Hence it is important to examine different hardships so as to uncover variation in older people's financial situation and thereby provide unique information that helps to identify opportunities for intervention.[179 288]

## 6.3 Next steps: filling the gap on specific types of hardship, older populations, and gender

To date, examination of separate hardships is still rare in studies of obesity,[303 304 381] and there is even less focus on different types among older adults.[304] None of the existing

studies explored the contribution of lifestyle or other factors that might participate in the pathway between FH and obesity. Consequently, evidence remains limited regarding which type of FH most strongly determines obesity in older adults who comprise a growing population. And, more critically, knowledge is limited as to whether, and to what extent, women and men differ in which types of FH are more strongly associated with obesity, or in the potential mechanisms of the relationship between FH and weight-related outcomes.

The next two chapters aimed to contribute new evidence to the existing literature by addressing some of the knowledge gaps and limitations identified above. Chapter 7 therefore examined three types of FH in relation to measured general and central obesity, in a general population of older adults, while considering conventional SES indicators and examining women and men separately. This cross-sectional study was complemented by longitudinal analysis of women and men employed in the British civil service in Chapter 8, which had the objective of ascertaining the independent relationship between two types of cumulative FH over 11 years and subsequent excess weight gain. It also investigated a range of factors that might change over that time period and might act as putative mediators of the observed associations.

# CHAPTER 7 Financial hardship and obesity in older adults

This work is published as: Conklin AI, Forouhi NG, Surtees P, Wareham NJ, Monsivais P. Socioeconomic status, financial hardship and measured obesity in older adults: a cross-sectional study of the EPIC-Norfolk cohort. *BMC Public Health* 2013; 13(1):1039-49.

## 7.1 Abstract

**Background:** SES is strongly associated with obesity, but current economic circumstances are also independently associated with self-reported weight status in Finnish civil servants. This study aimed to examine three types of financial hardship (FH) in relation to measured general and central obesity in a general population of older adults, while considering conventional socioeconomic indicators.

**Methods:** Data came from 10,137 participants (≥50 years) in the EPIC-Norfolk cohort who responded to a postal Health and Life Experiences Questionnaire (1996–2000) and attended a clinical assessment (1998–2002). Multivariable logistic regression models assessed likelihood of BMI≥30 kg/$m^2$ and high WC specific to women (WC≥88 cm) and men (WC≥102 cm), calculated from measured anthropometrics.

**Results:** Obesity prevalence was consistently patterned by standard socioeconomic indicators, with over-50s in the lowest social class being twice as likely to be obese than those in the highest class (women: 2.10 [CI95: 1.41—3.13]; men: 2.36 [1.44—3.87]). After SES adjustment, reporting *having less than enough money for one's needs* (compared to more than enough) was associated with obesity in women (2.04 [1.54—2.69]) and men (1.83 [1.34—2.49]). Similar associations were demonstrated between obesity and *always or often insufficient money for food/clothing* (women: 1.40 [1.03—1.90]; men: 1.81 [1.28—2.56]), compared to reporting this never occurred. The strongest independent associations were seen for obesity and reported greatest level of *difficulty paying bills* (women: 2.20 [1.37—

3.55]; men: 2.40 [1.38—4.17]), compared to having no difficulties. Findings for central obesity were slightly higher in women and lower in men.

**Conclusion:** Obesity in British over-50s was more likely in study participants who reported greater FH, even after education, social class and home ownership were taken into account. Public health policies need to consider the hitherto neglected role of FH in older people, especially difficulty paying bills, as part of strategies to prevent or reduce obesity.

## 7.2 Introduction

An older person's experience of material hardship is a valuable way to understand inequality in obesity.[278] Evidence from two occupational cohorts supports the notion that FH reflects a distinct set of economic factors that independently impact health beyond the reported influence exerted by conventional SES indicators.[283 301 302 384 385 387] FH is closely correlated, but not interchangeable, with conventional SES and therefore deserves specific attention.[179] FH deserves specific attention, furthermore, because individuals at any income or other SES level can vary in the experiences of material hardships. A study of smoking behaviours found significant associations with FH even within high-income groups,[279] and another prospective study found differences in prolonged FH were constant across income categories.[381] Since individuals at all income levels can experience FH with consequent health effects, the implications for public health and policy are that income (or other standard SES indicators) should not be seen as the sole criteria for targeting obesity interventions aimed at supporting healthy ageing.[179 282 284 384]

As the disposable income of older people is especially stressed by paying bills and affording adequate food and clothing,[211] it is surprising that research and policy has neglected everyday financial troubles as a unique domain of economic determinants of obesity. Consequently, little is still known about the relationship between FH and obesity, particularly whether specific types of hardship are associated with differences in obesity among older adults who comprise a growing population.[209 282 301] Older adults with greater hardships may purchase less food and have lower weights due to fewer calories; equally, they may also purchase cheaper food high in energy density which could contribute to excess weight.

This study therefore investigated the gender-specific associations between three types of self-reported FHs and obesity measured objectively in adults aged 50 and older. It was hypothesised that greater levels of FH may be associated with greater odds of obesity,

overall and centrally, with gender differences in magnitude of associations. Furthermore, associations were expected to remain significant after adjusting for conventional SES.

## 7.3 Methods

### 7.3.1 Study population

Participants for this study were the over-50s from EPIC-Norfolk, as described in 1.5.2 above. Similar to Chapter 3, the main exposures were the three FH measures assessed by the HLEQ. Completed responses from over-50s ranged between 17,953 and 17,998, depending on the question. Study outcomes used data on BMI (n=11,982) and WC (n=12,000) which were measured objectively during EPIC-Norfolk's second clinical assessment. Figure 7–1 shows the eligible sample therefore included over-50s who responded to FH questions, had covariates and follow-up anthropometry (range: 10,113—10,137), with 99% complete data.

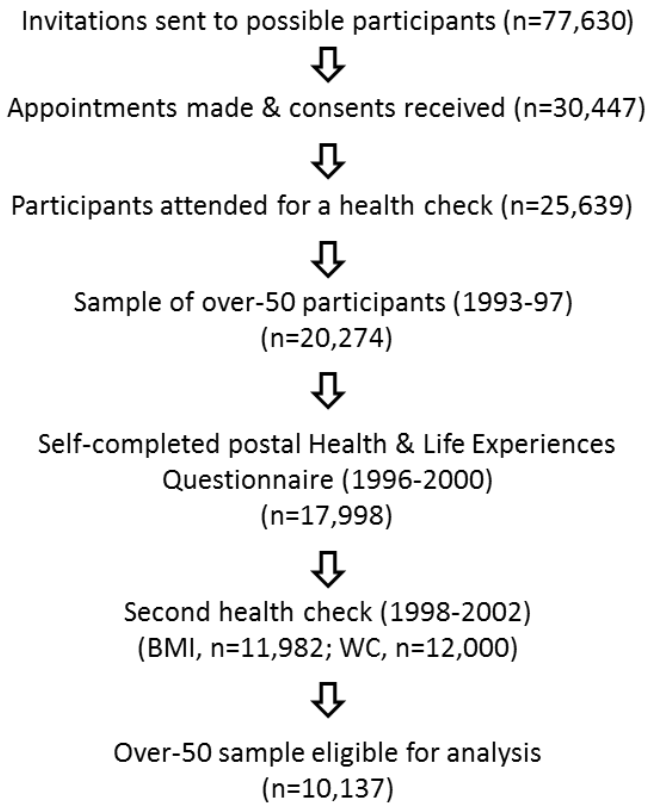



Figure 7–1 Process of sample selection from the EPIC–Norfolk cohort

### 7.3.2 Measures

*Economic exposures*

This study used education, occupational social class, home-ownership (a wealth proxy) as standard indicators of SES. Three FH measures concerned money for needs, frequency of insufficient money for food/clothing and difficulty paying bills. As in Chapter 3, FH responses 'often' and 'always', or 'great' and 'very great', were combined for analysis.

*Obesity outcomes*

Trained nurses in EPIC-Norfolk used standardised protocols to measure weight, height, and waist circumference (WC) of all participants attending the second clinic assessment, as reported elsewhere.[218 392] BMI was calculated as weight in kilograms divided by the square of height in metres. Participants who had a BMI ≥30 kg/m$^2$ were classified as obese overall. Central obesity was calculated using gender-specific threshold criteria: women with WC ≥88 cm and men with WC ≥102 cm were classified as centrally obese.

*Socio-demographic variables*

Socio-demographic characteristics studied included concurrent self-reported smoking status (categorical), marital status (categorical), and self-rated general health status (categorical), regular car use (binary), age and gender.

### 7.3.3 Data analysis

Descriptive statistics summarised socio-demographic characteristics, and general and central obesity, across FH levels. The inter-relationships among the FH indicators were examined using a correlation matrix after recoding two FH indicators into three levels: frequency of insufficient money for food/clothing (never; sometimes/seldom; often/always), and difficulty paying bills (none; very little/slight; some/great/very great).

Odds ratios of prevalent obesity for the six economic variables were examined in base logistic regression models that were *a priori* gender-stratified and adjusted for three known confounders (concurrent age, smoking status and marital status)—each is associated with the exposures and independently with the outcomes.[393-396] For each categorical measure of FH, sequential logistic regression models were fitted to gender-stratified covariate-adjusted base models; first by education, followed by occupational social class, and then by home-ownership. The final model for each FH indicator mutually adjusted for conventional SES and known confounders, and hence the remaining gender-specific odds ratios for general

and central obesity were interpreted as independent associations of the FH variable in question. Results are presented as odds ratios (ORs) and CI95.

In secondary analyses, further adjustment was conducted for concurrent lifestyle variables: total energy intake (kcal/d), total alcohol consumption (units/week), and a physical activity and energy expenditure (PAEE) score. Self-reported total energy and alcohol intake were assessed by FFQ;[226] and PAEE by the EPAQ2 questionnaire that was previously validated against individually calibrated heart rate against energy expenditure.[397] For women, menopause and hormone replacement therapy (HRT) statuses were also added to secondary models.

## 7.4 Results

The mean age of participants was 62.5 years (SD 7.5) with 54% of the sample made up of women. A majority (81%) reported being in good or excellent general health, and 51% were ever smokers. For the whole sample, 11% were educated to degree-level; 14% of men and 9% of women were educated to this level. Professional (class I), and managerial and technical (class II), occupations comprised 42% of the sample; few women (4%) and men (3%) had unskilled occupations. Mean BMI in men was 27 kg/m$^2$ (SD 3.3), and 26.8 kg/m$^2$ (SD 4.4) in women; 16% of men and 20% of women were classified as obese overall. Women's average WC was 82.9 cm (SD 10.6) and men's was 96.7 cm (SD 9.6); 29% of women and 27% of men were classified as being centrally obese.

Table 7–1 below indicates the close inter-relationship between the three measures of self-reported FH and other socio-demographic measures. The three FH measures were moderately related to each other. The indicator having enough money for needs shared 23% and 26% of its variability with the indicators frequency of insufficient money for food/clothing (r=0.48) and difficulty paying bills (r=0.51), respectively. Frequency of insufficient money for food/clothing shared 38% of its variability with difficulty paying bills (r=0.62).

Table 7-1 Characteristics of over-50s in the EPIC-Norfolk study across levels of self-reported financial hardship

| | Women | Not married | Lower education[a] | Lower social class[b] | Renter[c] | Poor/ moderate health | Ever smoker | Irregular car use[d] | General obesity | Central obesity |
|---|---|---|---|---|---|---|---|---|---|---|
| Having enough money for needs (n=10,113) | | | | | | | | | | |
| More than enough (n=1,934) | 53% | 16% | 29% | 7% | 1% | 10% | 47% | 82% | 13% | 21% |
| Just enough (n=7,220) | 55% | 20% | 49% | 17% | 8% | 17% | 52% | 78% | 18% | 28% |
| Less than enough (n=999) | 52% | 32% | 53% | 23% | 23% | 28% | 62% | 73% | 26% | 36% |
| Frequency of insufficient money (n=10,126) | | | | | | | | | | |
| Never (n=6,186) | 53% | 18% | 42% | 12% | 5% | 14% | 50% | 80% | 15% | 25% |
| Seldom (n=2,256) | 56% | 21% | 48% | 18% | 8% | 18% | 53% | 76% | 20% | 30% |
| Sometimes (n=1,223) | 59% | 24% | 53% | 24% | 16% | 22% | 53% | 74% | 21% | 32% |
| Often/ Always (n=461) | 57% | 35% | 56% | 26% | 28% | 31% | 59% | 72% | 25% | 35% |
| Difficulty paying bills (n=10,137) | | | | | | | | | | |
| None (n=6,118) | 55% | 18% | 44% | 13% | 5% | 14% | 51% | 79% | 16% | 25% |
| Very little (n=2,401) | 53% | 21% | 45% | 17% | 8% | 18% | 52% | 79% | 18% | 29% |
| Slight (n=741) | 56% | 22% | 46% | 21% | 14% | 22% | 55% | 76% | 22% | 32% |
| Some (n=731) | 59% | 33% | 52% | 26% | 23% | 29% | 54% | 74% | 25% | 34% |
| Great/ Very great (n=146) | 58% | 36% | 53% | 24% | 29% | 38% | 67% | 76% | 32% | 40% |

Measurement time-points were: gender, education, and occupational class (1993-1997); home-ownership, regular car use and all FH measures (1996-2000); self-rated general health, smoking status, marital status, and anthropometry (1998-2002). [a]No qualification or O-level; [b]Partly skilled (class IV), or unskilled (class V) occupations; [c]Accommodation type: council housing; private and furnished; private and unfurnished; [d]Self-reported travel by car most or all of the time (yes/no).

### 7.4.1 Conventional SES indicators and odds of obesity

There was a clear pattern of inverse association between social class, education, or home-ownership, and general and central obesity in gender-specific models adjusted for covariates (Table 7–2). The lowest social class (V) was significantly associated with greater odds of general obesity in women (2.10 [1.41, 3.13]) and men (2.36 [1.44, 3.87]) aged 50 and over. Similar gender-specific associations were observed between social class and central obesity, but reached significance only in women. Women and men who reported having no educational qualification were more likely to be obese centrally and overall, although odds ratios were larger in men for both outcomes. Similarly, obesity was more likely in women and men who reported renting public or private accommodation (compared with owning); magnitudes were largest for general obesity in men who rented public accommodation.

Further adjustment for total energy intake, physical activity and alcohol intake attenuated or made little difference to most of the associations between conventional SES indicators and obesity (Appendix E, Table E–1). Addition of menopause and HRT status made no difference to overall magnitude or direction of findings for women.

Table 7–2 Odds ratios of general and central obesity across levels of SES in women and men (≥50 years) in the EPIC–Norfolk study

| | General obesity | | Central obesity | |
|---|---|---|---|---|
| | Women | Men | Women | Men |
| Social Class | *(n=6,320)* | *(n=5,277)* | *(n=6,327)* | *(n=5,286)* |
| Professional | 1.00 | 1.00 | 1.00 | 1.00 |
| Managerial and Technical | 1.29 (0.96, 1.72) | 1.33 (0.96, 1.84) | 1.11 (0.88, 1.41) | 1.08 (0.85, 1.37) |
| Skilled non-manual | 1.23 (0.90, 1.66) | 1.57 (1.09, 2.26) | 0.99 (0.77, 1.28) | 1.13 (0.86, 1.49) |
| Skilled manual | 1.49 (1.10, 2.02) | 1.53 (1.09, 2.14) | 1.10 (0.85, 1.41) | 1.03 (0.80, 1.34) |
| Partly skilled | 2.10 (1.53, 2.86) | 1.36 (0.94, 1.96) | 1.41 (1.08, 1.84) | 1.10 (0.83, 1.45) |
| Unskilled | 2.10 (1.41, 3.13) | 2.36 (1.44, 3.87) | 1.57 (1.11, 2.22) | 1.47 (0.97, 2.24) |
| Education | *(n=6,464)* | *(n=5,353)* | *(n=9,531)* | *(n=6,327)* |
| Degree | 1.00 | 1.00 | 1.00 | 1.00 |
| A-level | 1.16 (0.92, 1.46) | 1.48 (1.28, 2.15) | 1.12 (0.92, 1.36) | 1.17 (0.97, 1.42) |
| O-level | 1.33 (1.01, 1.74) | 1.27 (0.90, 1.78) | 1.07 (0.84, 1.36) | 1.27 (0.98, 1.65) |
| No qualification | 1.59 (1.27, 1.99) | 1.66 (1.28, 2.15) | 1.38 (1.14, 1.67) | 1.42 (1.16, 1.73) |
| Home-ownership | *(n=5,727)* | *(n=4,706)* | *(n=5,734)* | *(n=4,712)* |
| Owner-occupier | 1.00 | 1.00 | 1.00 | 1.00 |
| Renting, private | 1.49 (1.02, 2.17) | 1.85 (1.20, 2.85) | 1.41 (1.00, 1.99) | 1.43 (0.97, 2.11) |
| Renting, public | 1.49 (1.15, 1.92) | 1.70 (1.22, 2.35) | 1.66 (1.32, 2.08) | 1.69 (1.27, 2.24) |

Gender-specific odds ratios (CI95) obtained by multivariable logistic regression analysis adjusting for concurrent age, marital status and smoking status.

### 7.4.2 FH and odds of obesity

In an analysis adjusting for age, smoking status, and marital status, all three measures of FH were strongly associated with obesity in both sexes (Table 7–3, Model A). The magnitude of association was greater than that seen for the more traditional measures of SES. In general, the measures of association were similar in men and women. Adjusting for education, social class, and home-ownership attenuated the associations between FH and odds of general obesity (Model D). The degree of attenuation was greater for women than men.

Table 7–3 Odds ratios of general obesity across levels of FH in women and men (≥50 years) in the EPIC–Norfolk study

| | Women | | | |
|---|---|---|---|---|
| | *Model A* | *Model B: A + education* | *Model C: B + social class* | *Model D: C + home-ownership* |
| Enough money for needs | | | | |
| More than enough | 1.00 | 1.00 | 1.00 | 1.00 |
| Just enough | 1.50 (1.24, 1.81) | 1.39 (1.15, 1.69) | 1.36 (1.12, 1.65) | 1.34 (1.10, 1.64) |
| Less than enough | 2.56 (1.98, 3.33) | 2.32 (1.78, 3.03) | 2.20 (1.68, 2.88) | 2.04 (1.54, 2.69) |
| Frequency of insufficient money for food/clothing | | | | |
| Never | 1.00 | 1.00 | 1.00 | 1.00 |
| Seldom | 1.41 (1.21, 1.66) | 1.38 (1.18, 1.62) | 1.36 (1.16, 1.60) | 1.35 (1.14, 1.59) |
| Sometimes | 1.64 (1.36, 1.98) | 1.57 (1.30, 1.90) | 1.53 (1.26, 1.85) | 1.44 (1.18, 1.76) |
| Often/ Always | 1.68 (1.26, 2.25) | 1.57 (1.18, 2.10) | 1.54 (1.15, 2.06) | 1.40 (1.03, 1.90) |
| Difficulty paying bills | | | | |
| None | 1.00 | 1.00 | 1.00 | 1.00 |
| Very little | 1.38 (1.18, 1.62) | 1.37 (1.16, 1.60) | 1.33 (1.13, 1.56) | 1.32 (1.12, 1.56) |
| Slight | 1.78 (1.41, 2.25) | 1.75 (1.39, 2.21) | 1.76 (1.39, 2.23) | 1.67 (1.32, 2.13) |
| Some | 2.08 (1.66, 2.61) | 1.99 (1.59, 2.50) | 1.92 (1.53, 2.42) | 1.81 (1.43, 2.30) |
| Great/ Very great | 2.52 (1.60, 3.98) | 2.37 (1.50, 3.75) | 2.38 (1.50, 3.78) | 2.20 (1.37, 3.55) |
| | | | Men | |
| Enough money for needs | | | | |
| More than enough | 1.00 | 1.00 | 1.00 | 1.00 |
| Just enough | 1.28 (1.02, 1.59) | 1.22 (0.97, 1.53) | 1.18 (0.94, 1.48) | 1.17 (0.93, 1.47) |
| Less than enough | 2.13 (1.59, 2.85) | 2.00 (1.49, 2.69) | 1.93 (1.43, 2.61) | 1.83 (1.34, 2.49) |
| Frequency of insufficient money for food/clothing | | | | |
| Never | 1.00 | 1.00 | 1.00 | 1.00 |
| Seldom | 1.32 (1.09, 1.60) | 1.30 (1.07, 1.57) | 1.29 (1.06, 1.56) | 1.30 (1.07, 1.59) |
| Sometimes | 1.30 (1.01, 1.66) | 1.26 (0.98, 1.62) | 1.24 (0.97, 1.60) | 1.15 (0.88, 1.49) |
| Often/ Always | 2.04 (1.47, 2.84) | 1.98 (1.42, 2.76) | 1.93 (1.38, 2.71) | 1.81 (1.28, 2.56) |
| Difficulty paying bills | | | | |
| None | 1.00 | 1.00 | 1.00 | 1.00 |
| Very little | 1.05 (0.87, 1.28) | 1.04 (0.86, 1.27) | 1.04 (0.85, 1.26) | 1.02 (0.84, 1.24) |
| Slight | 1.18 (0.87, 1.60) | 1.17 (0.86, 1.59) | 1.17 (0.86, 1.58) | 1.13 (0.83, 1.55) |
| Some | 1.61 (1.21, 2.15) | 1.58 (1.18, 2.11) | 1.54 (1.15, 2.06) | 1.39 (1.02, 1.88) |
| Great/ Very great | 2.48 (1.45, 4.26) | 2.43 (1.42, 4.18) | 2.51 (1.46, 4.34) | 2.40 (1.38, 4.17) |

Gender-specific odds ratios (CI95) obtained by multivariable logistic regression analysis adjusting for concurrent age, marital status and smoking status. Model D numbers of women and men were, respectively: money (5,526; 4,588); frequency of insufficient money (5,536; 4,591); difficulty paying bills (5,542; 4,596).

A somewhat different pattern was observed for associations with central obesity which tended to be stronger in women than men (Table 7–4, Model A). As with general obesity, SES adjustment attenuated the odds of central obesity associated with FH, which was greater for women than men (Model D). Additional adjustment for other lifestyle variables had little effect on the measures of association for either general, or central, obesity (Appendix E, Table E–2 and Table E–3).

Table 7–4 Odds ratios of central obesity across levels of FH in women and men (≥50 years) in the EPIC–Norfolk study

| | Women | | | |
|---|---|---|---|---|
| | *Model A* | *Model B: A + education* | *Model C: B + social class* | *Model D: C + home-ownership* |
| Enough money for needs | | | | |
| More than enough | 1.00 | 1.00 | 1.00 | 1.00 |
| Just enough | 1.55 (1.31, 1.83) | 1.48 (1.25, 1.75) | 1.50 (1.26, 1.78) | 1.50 (1.26, 1.78) |
| Less than enough | 2.51 (1.99, 3.18) | 2.37 (1.86, 3.00) | 2.32 (1.82, 2.97) | 2.16 (1.68, 2.78) |
| Frequency of insufficient money for food/clothing | | | | |
| Never | 1.00 | 1.00 | 1.00 | 1.00 |
| Seldom | 1.33 (1.15, 1.53) | 1.30 (1.13, 1.50) | 1.29 (1.12, 1.49) | 1.29 (1.11, 1.49) |
| Sometimes | 1.49 (1.26, 1.77) | 1.45 (1.22, 1.72) | 1.44 (1.21, 1.71) | 1.38 (1.15, 1.65) |
| Often/ Always | 1.76 (1.36, 2.29) | 1.69 (1.30, 2.19) | 1.65 (1.26, 2.15) | 1.51 (1.15, 1.99) |
| Difficulty paying bills | | | | |
| None | 1.00 | 1.00 | 1.00 | 1.00 |
| Very little | 1.39 (1.21, 1.60) | 1.38 (1.20, 1.59) | 1.36 (1.18, 1.56) | 1.36 (1.17, 1.57) |
| Slight | 1.57 (1.26, 1.94) | 1.55 (1.25, 1.92) | 1.57 (1.26, 1.95) | 1.50 (1.20, 1.87) |
| Some | 1.74 (1.41, 2.15) | 1.69 (1.37, 2.09) | 1.68 (1.36, 2.08) | 1.59 (1.28, 1.99) |
| Great/ Very great | 2.66 (1.73, 4.08) | 2.55 (1.66, 3.92) | 2.46 (1.59, 3.82) | 2.34 (1.49, 3.67) |

Table 7–4 (continued)

| | Men | | | |
|---|---|---|---|---|
| | *Model A* | *Model B: A + education* | *Model C: B + social class* | *Model D: C + home-ownership* |
| Enough money for needs | | | | |
| More than enough | 1.00 | 1.00 | 1.00 | 1.00 |
| Just enough | 1.19 (1.00, 1.42) | 1.14 (0.96, 1.36) | 1.16 (0.97, 1.39) | 1.14 (0.95, 1.37) |
| Less than enough | 1.76 (1.38, 2.25) | 1.66 (1.30, 2.13) | 1.69 (1.31, 2.17) | 1.64 (1.26, 2.12) |
| Frequency of insufficient money for food/clothing | | | | |
| Never | 1.00 | 1.00 | 1.00 | 1.00 |
| Seldom | 1.32 (1.13, 1.55) | 1.30 (1.11, 1.52) | 1.30 (1.11, 1.53) | 1.30 (1.11, 1.53) |
| Sometimes | 1.33 (1.08, 1.63) | 1.29 (1.05, 1.58) | 1.30 (1.06, 1.60) | 1.26 (1.01, 1.56) |
| Often/ Always | 1.62 (1.20, 2.19) | 1.58 (1.17, 2.13) | 1.57 (1.16, 2.13) | 1.51 (1.11, 2.07) |
| Difficulty paying bills | | | | |
| None | 1.00 | 1.00 | 1.00 | 1.00 |
| Very little | 1.14 (0.98, 1.33) | 1.13 (0.97, 1.32) | 1.14 (0.98, 1.34) | 1.13 (0.96, 1.32) |
| Slight | 1.25 (0.97, 1.61) | 1.24 (0.97, 1.60) | 1.25 (0.97, 1.61) | 1.24 (0.96, 1.61) |
| Some | 1.53 (1.19, 1.96) | 1.50 (1.17, 1.93) | 1.47 (1.14, 1.90) | 1.35 (1.04, 1.77) |
| Great/ Very great | 1.48 (0.88, 2.49) | 1.45 (0.86, 2.44) | 1.53 (0.90, 2.59) | 1.49 (0.87, 2.54) |

Gender-specific odds ratios (CI95) obtained by multivariable logistic regression analysis adjusting for concurrent age, marital status and smoking status. Model D numbers of women and men were, respectively: money (5,533; 4,594); frequency of insufficient money (5,543; 4,597); difficulty paying bills (5,549; 4,602).

## 7.5 Discussion

### 7.5.1 Synopsis of results

This cross-sectional, population-based study of UK over-50s showed social class, education, and wealth (measured by home-ownership) gradients in obesity. It further demonstrated strong associations with obesity for three types of FH that were independent of the three conventional indicators of SES examined. Independent associations were particularly strong for central obesity in women.

### 7.5.2 Methodological considerations

The FH variables were self-reported and like all such variables may be subject to different forms of bias. Interpretation of the meaning of FH can also vary widely across the population; equivalent levels of financial strain can be perceived and experienced as a normative status of daily living for some groups but as deprivation for others.[282] Precedent exists, however, for the measures used here as findings of independent associations are

consistent with other studies of self-reported and objective health outcomes in similarly-aged groups.[282-284] Although FH was assessed before anthropometry measurement (averaging 18 months), the duration of, or transition in, hardship could not be ascertained in relation to obesity as the survey was administered once. Thus, there may have been misclassification of exposures stemming from changes to participants' hardship levels in the interval between assessment of financial circumstances and anthropometric measurement. Such misclassification would be non-differential since it was unlikely to have been related to our outcomes and hence would have biased results towards the null.

This study may also be subject to residual confounding in two ways. First, income was not collected in The EPIC-Norfolk study and thus there was no accounting for income-based differences. However, income is not consistently shown to have an impact on weight in older adults or for both genders,[398 399] and may not sufficiently reflect structural resources in this sample of older adults since they likely also use savings to fund their expenses.[281] This study nevertheless examined multiple economic factors separately and also included education, social class and home-ownership in analyses of specific forms of FH. Second, parity was not analysed but may have confounded or mediated associations between some of the economic exposures and obesity.[400 401]

Notwithstanding some limitations, the study's strengths include a large sample size, gender-specific analyses, adjustment for several known confounders and lifestyle variables, and two objective obesity measures. Finally, this cohort had similar characteristics to the general UK population apart from fewer smokers and lack of ethnic diversity,[212 392] and so findings could be generalised to other white European-origin older adults.

### 7.5.3 Relationship to previous work

This work is novel in at least three ways. First, it examined three separate FH exposure measures and thus provides unique information on how different types of the FH domain might be associated with higher prevalence of obesity.[288] It therefore adds depth to previous studies[115 208 241 283 301 302 384 385 387] in which responses to hardship questions are combined into one summary indicator that then limits the opportunity to reveal potential targets for intervention. Second, the focus on over-50s fills a gap in the literature as no studies of economic strain and health in older populations have assessed obesity.[209 282] Third and most notably, the study is clinically relevant. It used two objective measures of obesity recommended as separate predictors of health risk, particularly central adiposity,[402] rather

than self-reported weight which is prone to bias from inaccuracy of height and underreporting and misclassification for obese categories.[403 404]

The finding that FH showed independent associations with BMI is consistent with current evidence which notably comes from occupational cohorts.[283 301] The Helsinki Health Study of middle-aged employees, mostly women, reported increased odds of self-reported BMI for frequent FH independent of conventional SES and early life factors,[301] but this study's estimates were slightly larger. Unlike this work, that study of self-reported BMI included only age and no other BMI-related covariates associated with standard SES and obesity.[405] Another study of the same occupational cohort found higher odds of weight gain (≥5 kg) with increasing frequency of FH after conventional SES adjustment, but again without accounting for smoking status, living arrangement or other health behaviours.[302] The Whitehall II study of FH and coronary events in middle-aged men also found that a higher FH score was associated with a higher BMI and waist-hip ratio measured objectively, but the age-adjusted association did not account for conventional SES.[283] To my knowledge, no other studies of FH have reported on central obesity for us to compare our findings.

Existing evidence supports the notion that social inequalities in obesity differ by gender with SES differences being associated more strongly and consistently with BMI in women.[101 176 178 406] Gender differences are also reported among the few studies examining FH and obesity, suggesting independent associations are stronger in men.[301 302] Notably, those results were reported in a younger population comprised of civil servants. The present study of a population-based sample of older British adults revealed contrasting results. Conventional SES proxies tended to be more strongly and consistently associated with men's higher odds of obesity which does not have a clear explanation. By contrast, the main associations between FH and obesity were larger than those of SES and also stronger in women. However, after adjusting for conventional SES, gender differences observed in the magnitude of associations depended on the type of hardship and obesity measure. This observed reversal between the genders in the strength of economic disparities in obesity might point to gender-based differences in the experience of FH. For example, men and women have differential vulnerabilities to FH as women report insufficient money for food twice more often than men,[127 206] and they also have differential power in intra-household economics and division of labour.[407 408]

Several potential pathways might link FH with obesity. FH is a powerful stressor and sociologists have shown that coping and social support can explain how the effects of FH vary across socially and economically demarcated groups.[208 225] Coping behaviours involving the manipulation of goals and values were found to be effective for household financial strain, and to be used to a greater extent by socially advantaged groups, namely men, the educated, and the affluent.[225] Other potential mediators include psychological resources such as self-esteem and sense of mastery.[209] Structural factors range from consumer prices of goods and services (e.g. food, transportation)[115] and neighbourhood access to healthy foods and safe spaces for physical activity,[99] to employment[409 410] and cultural norms and social meanings reinforced through media and advertising.[116 117] Since FH was a stronger correlate of obesity than conventional SES, excess weight and abdominal fat may be more directly influenced by mechanisms related to spending power and material resources, including lack of sleep from financial worries and physiological responses to hardship-related stress, than by non-material factors such as social roles, cultural norms, and knowledge. Both chronic stress and insufficient sleep have independent associations with obesity.[411-413]

Although people of all ages may encounter FH, adults in older age groups are at greater risk of increased FH which commonly results from events they are more likely to experience such as divorce, death of spouse, or involuntary job loss.[208 209] The results suggest that monetary and coping interventions may be useful in efforts to reduce obesity among over-50s. Formal mediation analyses of stress-related indicators are warranted to examine physiological mechanisms of influence between FH and obesity in older women and men. Future research should also explore how both social and economic aspects of an individual's life circumstances interact to produce combined effects on obesity as called for in the public health research and policy literature.[13 20] Nevertheless, prevention of obesity in over-50s would benefit more from an increased focus on their experience of FH in addition to their education or income levels.

## 7.6 Conclusions

British over-50s reporting greater levels of FH were more likely to have excess weight and abdominal fat. Likelihood of obesity was more strongly correlated with FH than conventional markers of SES. Thus, FH indicators provided additional explanatory power beyond education, social class or home-ownership for understanding variation in prevalence

of obesity in over-50 women and men. The findings confirm that it is not sufficient to solely consider education, social class or home-ownership when examining the complex role of economic determinants in the prevention of obesity or in weight support among older adults. Rather, public health policies and strategies need to support older people in terms of their more contemporaneous economic concerns. Interventions and practice standards to reduce or prevent obesity might include coping and monetary strategies and a focus on meeting bill payments might be a suitable target for approaches to address obesity.

# CHAPTER 8 Cumulative financial hardship, excess weight gain and potential mediators

This work is submitted as: Conklin AI, Forouhi NG, Brunner E, Monsivais P. Persistent financial hardship and 11-year weight gain in the Whitehall II study: what is the role of change in lifestyle, depression or marital status? (*Obesity,* submitted).

## 8.1 Abstract

**Background:** SES is strongly associated with obesity and weight gain, but current economic circumstances might also independently impact adiposity outcomes in adults. This study aimed to ascertain prospectively the independent relationship between types and amounts of FH and weight gain, and examine the contribution of multiple potential mechanisms.

**Methods:** Data came from 3,701 adults in a prospective occupational cohort of British civil servants (Whitehall II study). Self-reported FHs (having difficulty paying bills and insufficient money to afford adequate for food/clothing) were assessed four times (1985-88; 1989-90; 1991-93; 1997-99), and weight measured twice (1985-88; 1997-99). Mediation analyses examined four lifestyle factors, marital status and depression.

**Results:** Persistent FH of both types was associated with adjusted mean weight change in women over 10.9 years, but no consistent pattern was seen in men. During follow-up, 46% of women gained ≥5 kg. Women reporting persistently insufficient money for food/clothing had a significantly greater odds of excess weight gain (≥5 kg) (1.42 [1.05, 1.92]) compared to no hardship history, which remained after SES adjustment (1.45 [1.05, 2.01]). The association between persistent difficulty paying bills and odds of excess weight gain was also significant (1.42 [1.03, 1.97]) but attenuated after considering SES (1.39 [0.98, 1.97]). Two factors (change in smoking status and marital status) fulfilled criteria for potential mediators, but did not attenuate associations.

**Conclusion:** Persistently insufficient money for food/clothing over 11 years was independently associated with subsequent weight gain in female British employees, but was not mediated by lifestyle factors, marital status or depression. Results suggested strategies to tackle obesity must address employed women's everyday financial troubles which may influence weight through more biological pathways than classical correlates of economic disadvantage and weight.

## 8.2 Introduction

Cumulative economic hardship is more harmful for health than single exposure,[198 276 282 352 381 389] and a person's financial situation may relate more strongly to health than economic disadvantage based on conventional measures of SES.[115 241 276 301 302 304 354 382-385 387 388] However, current evidence on how everyday financial troubles impact health limits the opportunity to reveal potential targets for intervention because overall FH is assessed by a summary measure, with limited exceptions of item-specific measures.[303 304 381 383] Furthermore, evidence for an independent link between cumulative FH and obesity in adulthood is scarce, with only two prospective studies.[302 381] All existing studies in this area are limited by self-reported measures;[301-303 381] except one cross-sectional study.[304] Great scope exists for more work to unmask the differential impact on measured weight from different types of FH since hardships can arise for various reasons,[303] particularly in older adults,[208 209 282] and have gender differences in vulnerability or strength of impact.[127 206 297]

In addition, there is a need to understand the pathways by which SES, or FH, might influence adiposity. Research on potential mediators between SES and adiposity has focused on lifestyle factors.[177 183 185] The role of potential mediators is absent from current literature on FH and adiposity, although a range of mechanisms are likely to contribute and vary by gender.[181] For example, smoking was associated with low SES, lower BMI and lower rates of weight gain.[386 414 415] While smoking and other lifestyle factors were further patterned by gender,[180] few investigations have explicitly conducted gender-specific mediation.[177] Those studies suggested gender differences existed in the mediating lifestyle factors and that mediators only partly explained the SES-obesity association.[182 183 185 366 380] Beyond lifestyle, other social and psychological factors, such as marital status and depression, were also strongly correlated with both SES and obesity,[181 416-418] but these remain unexamined as potential mediators of economic determinants of adiposity.[73 75 177]

This study examined prospectively overall associations between two types, and amounts, of FH and measured weight gain in employed middle-aged women and men in Britain, while considering conventional SES measures. As individuals can experience transitions in factors that may participate in the pathway linking cumulative FH and excess weight gain, the study also investigated whether change in lifestyle factors, marital status or depression, was a putative mediator and, if so, whether change would partially attenuate associations.

## 8.3 Methods

### 8.3.1 Study population

This study used data from the Whitehall II study—a cohort of London-based civil servants aged 35-55 (n=10,308) working in 20 departments.[216] Repeated postal questionnaires provided exposure data on cumulative FH (1985-88; 1989-90; 1991-93; 1997-99). Cohort participants who responded to hardship questions once or more over the study period (n=6,221) showed a similar socio-demographic profile to participants responding at baseline (n=6,429) (Appendix F, Table F–1). Two clinical examinations (1985-88; 1997-99) provided adiposity outcome data (n=5,704). The available sample included participants who had data on FH, covariates and anthropometry (range: 3,671—3,701). All volunteers gave written informed consent and the study was approved by the University College London ethics committee.

### 8.3.2 Measures

*Cumulative FH exposures*

Each of the four postal questionnaires used in this study included two questions on FH: (1) frequency of insufficient money to afford adequate food or clothing, and (2) difficulty paying bills (see Table 1–2). Responses 'always', 'often', and 'sometimes, or 'very great', 'great', and 'some', were combined to construct a binary variable to indicate exposure to FH at each time-point. Dichotomised variables contributed to a 3-level cumulative FH variable, comprising a reference group (not exposed at any time-point), occasional hardship (exposed at one time-point) and persistent hardship (exposed at ≥2 time-points).

*Adiposity outcomes*

Weight (kg) was measured using standardised protocols in clinical examinations.[419] Baseline weight was subtracted from follow-up weight to calculate weight change for each participant. Since weight change encompasses gain, loss and no change, excess weight gain

was also assessed, using WHO's threshold of ≥5 kg during adulthood for increased risk in chronic conditions.[27] Hence individuals were classified as either gaining ≥5 kg, or not, over follow-up.

*Covariates*

Covariates included baseline weight, follow-up duration (years), ethnicity (binary), and, for overall associations, mid-point age (continuous), current smoker (binary) and married/cohabiting (binary). While commonly not considered in studies of weight-related outcomes, marital status is a potential confounder in addition to age and smoking status given that all three factors show associations with both economic determinants and obesity.[393-396 416] Conditioning on SES considered three conventional measures: baseline education, and mid-point employment grade (occupational social class) and home-ownership (all categorical).

### 8.3.3 Data analysis

*Overall association between cumulative FH and weight-related outcomes*

Descriptive statistics summarised socio-demographic characteristics and adiposity outcomes across levels of cumulative FH. A correlation coefficient matrix assessed the inter-relationship of the two FH measures. The *a priori* strategy for main analyses was to examine gender-specific associations of both types of cumulative FH in relation to subsequent weight change or excess weight gain, independent of SES. Thus, each cumulative FH variable was examined separately in linear or logistic regression models using a sex interaction term with significant gender difference set at $p<0.05$. Resulting coefficients of linear regressions were then used for post-estimation of gender-specific adjusted means and CI95. Analyses conditioned on baseline weight, follow-up years, ethnicity, age, current smoking and being married (Model A). Model A also included all three conventional SES indicators (Model B). For women only, menopause age was added separately to Model A. Results are presented as adjusted means, or odds ratios, and CI95.

Sensitivity analyses of independent associations between cumulative FH and adiposity excluded baseline weight, or included additional confounders; information from mid-point questionnaires on other confounders included: self-rated general health status, depression, anxiety, moderate and vigorous physical activity (MVPA) (all categorical), and total energy and alcohol intake (both continuous). Robust variance estimates were computed to test for potential clustering by civil service department. Independent associations with excess

weight gain were also re-examined with inclusion of baseline height. Secondary analyses of odds of excess weight gain re-examined Model A using a four-level dose variable (no FH at all time-points; FH at any time-point; FH at 2 time-points; FH at ≥3 time-points) and, separately, a revised three-level dose variable based on a more stringent threshold for dichotomising FH ('often' and 'always', or 'great' and 'very great').

*Investigating the potential mediating role of change in lifestyle factors, marital status and depression*

Over time, individuals can experience transitions in lifestyle and other social and psychological factors that are strongly correlated with both SES and obesity. This study therefore also assessed whether change in lifestyle factors, marital status or depression, might constitute a mediator and whether putative mediators then attenuated associations between cumulative FH and excess weight gain. Thus, two categorical indicators of cumulative FH were used as the exposure (reference was no history), odds of weight gain as the outcome and six change variables as potential mediators. A series of multiple regression models were used to identify the potential for a mediating role for six change variables, following a 3-step framework[420] as shown in Figure 8–1.

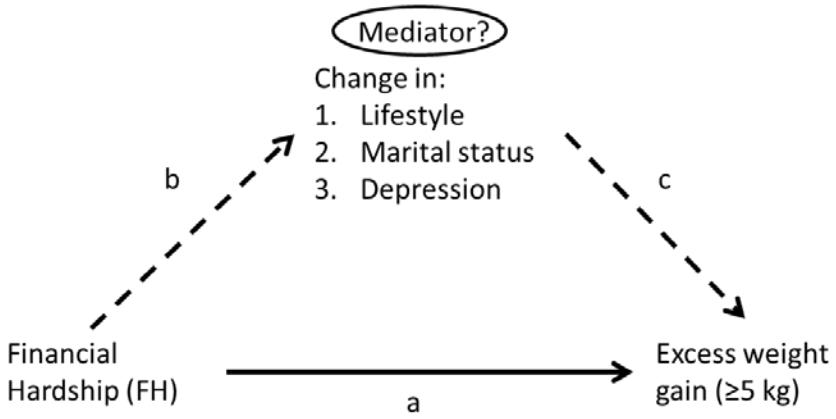



Figure 8–1 Model for investigation of potential mediators of the association between cumulative FH and weight gain.

(a) Financial hardship (FH) would be a significant predictor of excess weight gain; (b) FH is a significant predictor of change in lifestyle, marital status or depression, as putative mediators; and, (c) putative mediating factor(s) would significantly predict excess weight gain, while conditioning on FH.

A change variable was calculated for total intake of energy (kcal/d) and alcohol (units/week) available from mid-point and follow-up questionnaires. Baseline and midpoint data on MVPA (≥1h/week) were combined to derive a binary indicator at each time-point;[283] this was then used to construct a change variable with four possible categories (persistent/never/initiating/stopping physically active. Binary variables were derived from

baseline and follow-up data on smoking, marital status and depression. Depression scores from the General Health Questionnaire (range 0-12) were dichotomised using a ≥4 cut-point following other studies.[417] Change variables for smoking behaviour, marital status and depression were constructed from dichotomised indicators by defining four categories, for example, persistent/never/initiating/stopping smokers.

In Step 1, the overall association of cumulative FH exposure with excess weight gain outcome (**path a**) was determined for each gender using multivariable logistic regression. Step 2 assessed the associations between each FH and each change variable (**path b**) using different regression approaches. For each change variable that was significantly related to the exposure, Step 3 examined the independent relationship with weight gain (**path c**) using multivariable logistic regression conditioning on the exposure (separate models used for each FH indicator). All models were adjusted for baseline weight, follow-up years, age, ethnicity, education, occupational status, home-ownership, and, in Steps 2 and 3, gender.

Analyses of **path b** used three regression approaches according to the type of dependent change variable. As change in total intake of alcohol (units/week) and energy (kcal/d) were continuous dependent variables, multivariable linear regression was used. Change in marital status was retained as a multiple unordered categorical dependent variable, therefore multinomial logistic regression was employed with base outcome of persistent married (married at baseline and follow-up) for comparison.[421] Change variables for smoking status and depression were also examined with this approach, but results were similar when the putative mediators were simplified as binary dependent variables and thus multivariable logistic regression was used to determine FH associations with odds of persistent/initiating smoker and depressed (smoker or depressed at both time-points (persistent); never-smoker or never-depressed at baseline and smoker or depressed at follow-up (initiating)).

A change variable that showed significant associations in both **path b** and **path c** was considered as a potential mediator, and was then included in a multivariable logistic regression that re-examined each cumulative FH measure in relation to excess weight gain. Subsequent attenuation of association in **path a** suggested the included change variable had a mediating role and would be further analysed for its mediation effects and contributing proportions.

## 8.4 Results

Study follow-up averaged 10.9 years (SD 0.6), with participants averaging 44 years (SD 6) at baseline. The sample comprised nearly 30% women (n=1,042), 8% non-white, and 31% educated up to age 16. Lowest education level differed by gender (27% of men vs. 41% of women). The lowest occupational status comprised 17% of the sample; again, more of the women (42%) were in this group than men (6%). By mid-point, they were generally in good-to-excellent general health (90%), not depressed (87%), married/cohabiting (78%), and not current smokers (87%). Over the follow-up period, average weight change was 4.3 kg (SD 5.7) in men and 5.0 kg (SD 7.0) in women. Excess weight gain (≥5 kg) occurred in 42% of men and 46% of women. The two FH measures were moderately related: frequency of insufficient money for food/ clothing shared 31% of its variability with difficulty paying bills (r=0.69).

Nearly one fifth of respondents reported persistently insufficient money for food/clothing (16%) or persistent difficulty paying bills (18%). Table 8–1 below shows that each self-reported FH measure was closely related to several socio-demographic measures. Excess weight gain was more prevalent among participants reporting persistent hardships compared to those reporting no history.

Table 8-1 Characteristics of participants in the Whitehall II study across levels of cumulative financial hardship

| | Mean (SD) age | Women | Non-white | Not married | Lowest education[a] | Lowest occupational status[b] | Renter[c] | Poor/ fair health[d] | Ever smoker | Depressed[e] | Mean (SD) weight change (kg) | Gain of **≥5kg** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| History of insufficient money for food/clothing (n=3,701) | | | | | | | | | | | | |
| None *(n=2,361)* | 50 (6) | 28% | 5% | 21% | 29% | 11% | 5% | 7% | 47% | 10% | 4.3 (6) | 41% |
| Occasional *(n=659)* | 49 (6) | 27% | 10% | 22% | 34% | 15% | 7% | 13% | 59% | 14% | 4.5 (6) | 44% |
| Persistent *(n=681)* | 48 (6) | 32% | 17% | 24% | 36% | 27% | 11% | 16% | 55% | 20% | 5.2 (7) | 49% |
| History of difficulty paying bills (n=3,671) | | | | | | | | | | | | |
| None *(n=2,509)* | 50 (6) | 29% | 6% | 22% | 30% | 12% | 5% | 7% | 47% | 10% | 4.3 (6) | 41% |
| Occasional *(n=586)* | 49 (6) | 26% | 9% | 21% | 33% | 13% | 6% | 13% | 58% | 15% | 5.1 (6) | 47% |
| Persistent *(n=576)* | 49 (6) | 30% | 14% | 24% | 31% | 25% | 12% | 16% | 59% | 22% | 4.8 (7) | 48% |

Measurement time-points were: gender, education, ethnicity (1985-88); age, marital status, smoking status, moderate and vigorous physical activity (MVPA), energy intake, self-rated general health, self-reported depression, occupational status, home-ownership (1991-93); and adiposity (1985-1999). [a]Up to age 16. [b]Clerical/support occupational category. [c]Rented accommodation (councils, private and furnished, or private and unfurnished). [d]Self-rated general health reported on 5-point scale in the General Health Questionnaire (GHQ). [e]Depression score of ≥4, assessed by the GHQ (range 0—12). [f]Change calculated by subtracting energy intake (kcal/d) available at mid-point from energy intake (kcal/d) at follow-up assessed by FFQ. [g]Baseline and midpoint questionnaire data on MVPA (≥1h/week) were combined to derive a binary indicator at each time-point which was then used to construct a change variable with four possible categories (persistent/never/initiating/stopping physically active)

Table 8–1 (ctd)

| | Mean (SD) energy intake | Mean (SD) change in energy intake[f] | Physically active | Remained physically active[g] |
|---|---|---|---|---|
| History of insufficient money for food/clothing (n=3,701) | | | | |
| None *(n=2,361)* | 2124 (601) | 110 (580) | 21% | 11% |
| Occasional *(n=659)* | 2097 (717) | 141 (664) | 21% | 10% |
| Persistent *(n=681)* | 2063 (673) | 81 (680) | 18% | 8% |
| History of difficulty paying bills (n=3,671) | | | | |
| None *(n=2,509)* | 2105 (625) | 128 (584) | 21% | 11% |
| Occasional *(n=586)* | 2126 (637) | 60 (654) | 21% | 12% |
| Persistent *(n=576)* | 2119 (690) | 99 (683) | 20% | 10% |

Measurement time-points were: gender, education, ethnicity (1985-88); age, marital status, smoking status, moderate and vigorous physical activity (MVPA), energy intake, self-rated general health, self-reported depression, occupational status, home-ownership (1991-93); and adiposity (1985-1999). [a]Up to age 16. [b]Clerical/support occupational category. [c]Rented accommodation (councils, private and furnished, or private and unfurnished). [d]Self-rated general health reported on 5-point scale in the General Health Questionnaire (GHQ). [e]Depression score of ≥4, assessed by the GHQ (range 0—12). [f]Change calculated by subtracting energy intake (kcal/d) available at mid-point from energy intake (kcal/d) at follow-up assessed by FFQ. [g]Baseline and midpoint questionnaire data on MVPA (≥1h/week) were combined to derive a binary indicator at each time-point which was then used to construct a change variable with four possible categories (persistent/never/initiating/stopping physically active).

### 8.4.1 Cumulative FH and mean weight change

Prospective analyses showed a significant association between persistent FH of both types and 11-year weight change in women only (Table 8–2, Model A). Compared to women reporting no history of insufficient money for food/clothing for whom weight changed to +4.67 kg (4.22—5.12), adjusted mean weight change in women reporting persistently insufficient money for food/clothing was significantly greater (+5.85 kg [5.13, 6.57]). SES adjustment strengthened this association to +6.17 kg (5.37, 6.96) (Table 8–2, Model B), and revealed a significant linear trend (p=0.025) and difference from men (p=0.048). Adjusted mean weight also changed in women reporting persistent difficulty paying bills (+5.81 kg [4.98, 6.64]), even after SES adjustment (+5.79 kg [4.89, 6.68]) (Table 8–2).

Sensitivity analyses excluding baseline weight or including physical and mental health and lifestyle variables did not alter the results (Appendix F, Table F–2), and tended to amplify adjusted 11-year mean weight change associated with persistent FH. Significant associations remained after computing robust variance estimates (Appendix F, Table F–3). Women's menopause age minimally reduced mean weight change across FH levels (range: 0.34—0.95 kg), but increased differences between the extremes by 0.30 kg.

Table 8–2 Adjusted mean weight change in women and men and cumulative FH in the Whitehall II study

| | Women | |
|---|---|---|
| | *Model A* | *Model B: A + SES* |
| History of insufficient money for food/clothing | | |
| None | 4.67 (4.22, 5.12) | 4.58 (4.13, 5.03) |
| Occasional | 5.12 (4.35, 5.89) | 5.07 (4.21, 5.93) |
| Persistent | 5.85 (5.13, 6.57) | 6.17 (5.37, 6.96) |
| History of great difficulty paying bills | | |
| None | 4.71 (4.28, 5.14) | 4.65 (4.22, 5.08) |
| Occasional | 5.20 (4.39, 6.00) | 5.64 (4.70, 6.57) |
| Persistent | 5.81 (4.98, 6.64) | 5.79 (4.89, 6.68) |
| | Men | |
| History of insufficient money for food/clothing | | |
| None | 4.33 (4.05, 4.62) | 4.21 (3.93, 4.50) |
| Occasional | 4.25 (3.78, 4.73) | 4.15 (3.62, 4.68) |
| Persistent | 4.69 (4.19, 5.19) | 4.59 (4.04, 5.14) |
| History of great difficulty paying bills | | |
| None | 4.27 (3.99, 4.55) | 4.20 (3.92, 4.47) |
| Occasional | 4.60 (4.09, 5.11) | 4.68 (4.12, 5.23) |
| Persistent | 4.33 (3.79, 4.88) | 4.23 (3.64, 4.81) |

Gender-specific mean (CI95) weight change (kg) obtained by multivariable linear regression analysis adjusting for baseline weight, follow-up years, ethnicity, and midpoint age, current smoker and married (Model A), and then also for SES (Model B).. Numbers were: insufficient money for food/clothing (Model A: 4,025; Model B: 3,701); difficulty paying bills (Model A: 3,923; Model B: 3,671).

### 8.4.2 Cumulative FH and excess weight gain

Compared with no history, women reporting persistently insufficient money for food/clothing over 11 years had greater odds of gaining ≥5 kg (1.42 [1.05, 1.92]) (Table 8–3, Model A). The statistically significant association was similar after SES adjustment (1.45 [1.05, 2.01]) (Table 8–3, Model B). Persistent difficulty paying bills (reference: no history) also increased women's likelihood of excess weight gain by 42% (1.03, 1.97), but was attenuated after SES adjustment (1.39 [0.98, 1.97]).

Results of sensitivity analyses for excess weight gain showed little change to observed associations (Appendix F, Table F–4 through Table F–6). In secondary analyses of four levels of cumulative FH, the odds of excess weight gain was significant in women (1.68 [1.07, 2.64]) and men (1.59 [1.18, 2.16]) reporting ≥3 occurrences of FH over follow-up (Appendix F, Table F–7). Furthermore, secondary analyses of the use of a more stringent FH threshold revealed

that women and men differed (p=0.048) in the relationship between occasional history of insufficient money for food/clothing, and excess weight gain (Appendix F, Table F–8).

Table 8–3 Odds ratios for 11–year excess weight gain (≥5 kg) and cumulative financial hardship in the Whitehall II study

| | Women | |
|---|---|---|
| | *Model A* | *Model B: A + SES* |
| History of insufficient money for food/clothing | | |
| None | 1.00 | 1.00 |
| Occasional | 0.95 (0.70, 1.30) | 1.01 (0.72, 1.42) |
| Persistent | 1.42 (1.05, 1.92) | 1.45 (1.05, 2.01) |
| History of great difficulty paying bills | | |
| None | 1.00 | 1.00 |
| Occasional | 1.12 (0.81, 1.54) | 1.26 (0.88, 1.81) |
| Persistent | 1.42 (1.03, 1.97) | 1.39 (0.98, 1.97) |
| | Men | |
| History of insufficient money for food/clothing | | |
| None | 1.00 | 1.00 |
| Occasional | 1.06 (0.87, 1.29) | 1.03 (0.83, 1.28) |
| Persistent | 1.15 (0.94, 1.41) | 1.13 (0.91, 1.41) |
| History of great difficulty paying bills | | |
| None | 1.00 | 1.00 |
| Occasional | 1.06 (0.86, 1.30) | 1.09 (0.88, 1.36) |
| Persistent | 1.11 (0.90, 1.38) | 1.08 (0.86, 1.36) |

Gender-specific odds ratios (CI95) of gaining ≥5kg obtained by multivariable logistic regression analysis adjusting for baseline weight, follow-up years, ethnicity, and mid-point age, current smoker and married (Model A), and then also for SES (Model B). Numbers were: insufficient money for food/clothing (Model A: 4,025; Model B: 3,701); difficulty paying bills (Model A: 3,923; Model B: 3,671).

### 8.4.3 Investigation of potential mechanisms

Significant overall associations were found for persistent FH with higher odds of excess weight gain (**path a**), conditioned on SES and key covariates (Table 8–4, Model 1). Table 8–5 shows the association between each cumulative FH measure and the six factors as change variables that may be potential mechanisms (**path b**). As can be seen, cumulative FH was significantly associated with only three potential mediators. Positive associations were observed for a person's history of both types of FH and their odds of being a persistent or initiating smoker or depressed. Similarly, persistent FH was consistently associated with stopping being married. Of the three potential mediators, excess weight gain was significantly associated with change in smoking and marital status, but not depression,

independent of FH (**path c**) (Table 8–6). Specifically, both initiating and stopping smoking were significantly independently associated with, respectively, lower and higher odds of excess weight gain. For change in marital status, only the never-married category significantly increased the likelihood of excess weight gain when conditioning on history of difficulty paying bills.

Although the two potential mediators were significantly associated with exposure and with outcome variables, they did not attenuate the independent associations between cumulative FH and excess weight (Table 8–4, Models 2 to 4). Rather, as Model 3 shows, change in marital status strengthened associations of both types of persistent FH, and revealed a significant association between persistent difficulty paying bills and higher odds of gaining ≥5 kg (1.44 [1.01, 2.06]).

Table 8–4 Potential mechanisms of the independent FH–weight gain relationship among women in the Whitehall II study

| | Model 1 (path a) | Model 2: 1 + change in being a current smoker | Model 3: 1 + change in being married | Model 4: 1 + change in both factors |
|---|---|---|---|---|
| History of insufficient money for food/clothing | | | | |
| None | 1.00 | 1.00 | 1.00 | 1.00 |
| Occasional | 1.01 (0.72, 1.42) | 1.03 (0.73, 1.45) | 0.98 (0.69, 1.39) | 0.99 (0.70, 1.41) |
| Persistent | 1.43 (1.04, 1.96) | 1.45 (1.05, 2.00) | 1.54 (1.11, 2.14) | 1.58 (1.13, 2.20) |
| History of difficulty paying bills | | | | |
| None | 1.00 | 1.00 | 1.00 | 1.00 |
| Occasional | 1.26 (0.89, 1.78) | 1.25 (0.88, 1.79) | 1.30 (0.90, 1.87) | 1.31 (0.90, 1.90) |
| Persistent | 1.37 (0.97, 1.93) | 1.40 (0.99, 1.99) | 1.44 (1.01, 2.06) | 1.49 (1.03, 2.14) |

Gender-specific odds ratios (CI95) of gaining ≥5kg obtained by multivariable logistic regression analysis adjusting for baseline weight, follow-up, ethnicity, and mid-point age, education, occupational status and home-ownership (Model 1). Numbers were: insufficient money for food/clothing (Model 1: 3,778; Model 2: 3,735; Model 3: 3,604; Model 4: 3,577); difficulty paying bills (Model 1: 3,735; Model 2: 3,694; Model 3: 3,568; Model 4: 3,539).

Table 8–5 Multivariable regression with potential mediators as dependent variables and cumulative FH as independent variable (path b)

| | History of frequently insufficient money for food/clothing[a] | | History of difficulty paying bills[a] | |
|---|---|---|---|---|
| | *Occasional* | *Persistent* | *Occasional* | *Persistent* |
| POTENTIAL MEDIATORS | | | | |
| Change in lifestyle | | | | |
| *Odds of persistent/ initiating smoker* | 1.46 (p=0.002) | 1.45 (p=0.003) | 1.59 (p<0.001) | 1.76 (p<0.001) |
| Change in lifestyle | | | | |
| *Odds of persistent/ initiating MVPA[b]* | 1.02 (p=0.827) | 0.99 (p=0.957) | 1.00 (p=0.986) | 0.97 (p=0.804) |
| Change in lifestyle | | | | |
| *Difference in alcohol intake[c]* | -0.33 (p=0.471) | -0.25 (p=0.607) | 0.32 (p=0.504) | 0.35 (p=0.497) |
| Change in lifestyle | | | | |
| *Difference in energy intake[c]* | 28.75 (p=0.262) | -15.69 (p=0.558) | -23.85 (p=0.370) | -17.04 (p=0.546) |
| Change in marital status | | | | |
| *Persistent married* | (base outcome) | (base outcome) | (base outcome) | (base outcome) |
| *Never-married* | 0.01 (p=0.951) | -0.19 (p=0.12) | -0.14 (p=0.28) | -0.22 (p=0.085) |
| *Initiating married* | 0.26 (p=0.142) | -0.07 (p=0.97) | 0.22 (p=0.217) | -0.24 (p=0.258) |
| *Stopping married* | 0.47 (p=0.008) | 0.66 (p<0.001) | 0.28 (p=0.14) | 0.46 (p=0.009) |
| Change in depression | | | | |
| *Odds of persistent/ initiating depressed* | 1.35 (p=0.014) | 2.45 (p<0.001) | 1.53 (p<0.001) | 2.20 (p<0.001) |

Multivariable logistic regression assessed associations between FH and change in smoking status or depressed as binary dependent variables (reported coefficients are exponentiated). Multivariable linear regression assessed associations between FH and difference in total intake of alcohol (units/week) or energy (kcal/d) as continuous dependent variables (reported as β-coefficients). Multinomial logistic regression assessed association between FH and change in marital status as a multiple unordered categorical dependent variable (reported β-coefficients are unexponentiated). All models adjusted for gender, baseline weight, follow-up years, age, ethnicity, and SES (education, occupational status and home-ownership). [a]Reference category was no FH reported at any of four time-points over 11 years. [b]MVPA, moderate and vigorous physical activity (≥1h/week leisure exercise). [c]Difference between study midpoint and follow-up also adjusted for midpoint intake. Bold values represent significant association.

Table 8–6 Multivariable logistic regression with excess weight gain as dependent variables and potential mediators as independent variables, conditioning on cumulative FH exposure (path c)

| | **Odds of excess weight gain (≥5kg)** | |
|---|---|---|
| | *Controlling for history of frequently insufficient money for food/clothing* | *Controlling for history of difficulty paying bills* |
| POTENTIAL MEDIATORS | | |
| Change in smoking | *n=3,735* | *n=3,694* |
| *Never-smoker* | 1.00 | 1.00 |
| *Persistent smoker* | 0.90 (p=0.404) | 0.92 (p=0.485) |
| *Initiating smoker* | **0.48 (p=0.015)** | **0.50 (p=0.021)** |
| *Stopping smoker* | **2.13 (p<0.001)** | **2.09 (p<0.001)** |
| Change in marital status | *n=3,604* | *n=3,568* |
| *Persistent married* | 1.00 | 1.00 |
| *Never-married* | 1.22 (p=0.055) | **1.27 (p=0.020)** |
| *Initiating married* | 0.90 (p=0.533) | 0.90 (p=0.523) |
| *Stopping married* | 0.87 (p=0.409) | 0.85 (p=0.337) |
| Change in depression | *n=3,672* | *n=3,634* |
| *Never-depressed* | 1.00 | 1.00 |
| *Persistent depressed* | 1.03 (p=0.862) | 1.07 (p=0.679) |
| *Initiating depressed* | 0.86 (p=0.251) | 0.83 (p=0.164) |
| *Stopping depressed* | 1.12 (p=0.415) | 1.15 (p=0.292) |

Multivariable logistic regression models adjusted for gender, baseline weight, follow-up years, age, ethnicity, and SES (education, occupational status and home-ownership). Bold values represent significant associations.

## 8.5 Discussion

### 8.5.1 Synopsis of results

This prospective study found gender differences in the vulnerability to long-term weight change from cumulative experience of FH. Associations were significant in women, independent of conventional SES indicators. Specifically, women reporting persistently insufficient money for food/clothing gained 1.59 kg more than women with no history of this hardship, over approximately 11 years. Similarly, women experiencing persistent difficulty paying bills gained 1.14 kg more than those reporting no such hardship. Moreover, women reporting persistently insufficient money for food/clothing had a 45% greater likelihood of excess weight gain compared to those without hardship, independent of education, occupational status and home-ownership. Persistent difficulty paying bills also increased the

odds of long-term excess weight gain for women. Mediation analyses of six variables showed change in smoking and marital status were potential mechanisms, yet the independent associations of cumulative FH with excess weight gain were not attenuated.

### 8.5.2 Methodological considerations

The FH variables were self-reported and thus may be subject to reporting bias. Interpretation of the meaning of FH can also vary widely across the population; equivalent levels of financial strain can be perceived and experienced as a normative status of daily living for some groups but as deprivation for others.[282] Precedent exists, however, for the measures used here as findings of independent associations are consistent with studies of other outcomes in this cohort.[283 284 387] Misclassification of exposures from reporting bias would be non-differential since it was unlikely related to measured weight and hence would have biased results towards the null. Another source of bias is non-response from those in lower occupational class who are more likely to experience FH and have excess weight.

Furthermore, this cohort is largely comprised of employed adults in the British civil service which potentially limits generalisability of findings, although similar associations are observed in a population-based UK cohort.[304] Findings may also be subject to residual confounding from income, which was collected after our study period. However, income is inconsistently associated with either weight gain[177] or weight status among adults.[398] Moreover, participants covered multiple employment grades (which had wide-ranging salary bands),[216] and these grades were included with education and home-ownership to account for different forms of a person's economic conditions. Finally, imprecise measurement of self-reported potential mechanisms may have introduced bias that would either attenuate or inflate observed associations,[283 422] and thus might partly explain the amplified odds of excess weight gain from including potential mediators.

There are many strengths of this study: namely, longitudinal design with a sufficient interval to assess change, gender-specific analyses, measured weight, and adjustment for multiple SES indicators and other known confounders of adiposity.[405] In addition, this work is novel in three important ways. First, it examined separate FH measures which provided unique information on how different types of this economic domain might be associated with adiposity,[288] thus pointing to targets for intervention. Since different types of FH can arise for diverse reasons with differential impact on body weight, the study clearly added depth to previous studies which combine hardship questions into a single indicator.[115 208 283 301 302 354]

[381 387 388] Second, this prospective study is the first to bring a gender perspective which is critically lacking from work in this area. It is necessary to uncover whether and how women and men might differ in which types of cumulative FH are associated with different adiposity outcomes, given women's greater exposure to, and strength of impact from, economic disadvantages.[127 206 297 350] And third, it is also the first explore potential mechanisms underlying independent gender-specific associations of hardship and weight gain, including social and psychological factors that were previously identified as needing further investigation.[73 75 177]

### 8.5.3 Relationship to previous work

That FH showed independent associations with weight-related outcomes is consistent with previous work that is predominantly cross-sectional.[241 283 301-304 381] Independent associations between current economic difficulties and odds of gaining ≥5 kg in self-reported weight were observed in middle-aged female employees in Finland (OR range 1.50—1.70), but cumulative exposure was not measured, and living arrangement and key lifestyle factors related to adiposity not considered.[302] Prolonged FH over 1 year was examined in the Australian population and found to increase the risk of subsequent measured obesity by 20%, independent of income or education, and to be stronger than the relationship between income and obesity.[381] More broadly, cumulative exposure to financial stress had a dose-response effect on several health outcomes in Swedish women, but was less consistently related to men's outcomes.[352] Similarly, more years in poverty (a ratio of income-to-theoretical needs) monotonically reduced self-rated health in US adults,[198] and income-based measures of sustained hardship had a strong graded effect on depression and some other outcomes in older Americans women and men.[389]

Some previous work suggests independent associations of FH with weight are stronger in men,[301 302] but this study found greater associations in women for both hardship types, particularly persistent insufficient money to afford adequate food/clothing. These gender-specific findings are consistent with a wider body of evidence: difficulty paying bills was associated with obesity in female but not male youth;[303] food insecurity increased the odds of 1-year weight gain for women only;[423] and women report higher impact and slower adaptation to adverse life events (e.g. job loss) associated with weight.[74 222] However, the pattern of gender differences in the relationship between FH and obesity among British older adults can depend on which FH type or anthropometric outcomes is studied. In British

older adults, the independent odds of general and central obesity in women, and general obesity in men, was highest for often/always difficulty paying bills; but the independent odds of central obesity in men was highest for having less than enough money for needs.[304] Over-50s in this occupational cohort were also examined in supplementary cross-sectional analyses, with similar close inter-relationships between the two measures of self-reported FH and other socio-demographic measures (Appendix F, Table F–9). Supplementary analyses showed a similar pattern and strength of independent associations between both FH and obesity measures in older civil servants (Appendix F, Table F–10 and Table F–11); except the independent odds of central obesity in men was strongest for greatest difficulty paying bills.

Although mediators of the SES-obesity association were examined in some studies,[183 185 366] the present study is the first to my knowledge to explore potential mechanisms of the FH-adiposity relationship and to go beyond lifestyle factors. The examination of changes in marital status and depression revealed that, although FH was strongly associated with remaining or becoming depressed, change in depression was not associated with odds of excess weight gain. The latter may be explained by the fact that the depression-obesity relationship is known to be bidirectional.[418] Other prospective work also showed depressive symptoms were associated with subsequent unemployment,[424] and material hardship such as difficulty paying bills was strongly associated with depression, more so than income.[276 383] It is therefore unsurprising to find significant associations between cumulative FH and odds of remaining or becoming depressed (path b).

Among the six factors analysed, only change in smoking and marital status met all mediation criteria, and yet neither showed the expected attenuation of the relationship between cumulative FH and excess weight gain. Lack of attenuation from including change in smoking status may be because of the long follow-up period during which an individual may have undergone several changes in smoking status that the change variable would likely have missed. Change in marital status notably strengthened associations and there are several possible reasons for this finding. First, the exposure-mediator relationship was weak and showed inverse associations except for one category (leaving marriage) which was strongly and positively associated with increasing history of FH. Second, like depression, it is conceptually possible that change in marital status has a bidirectional association with FH, with change in marital status potentially preceding FH. FH may be a consequence of remaining or becoming non-married since being married provides practical economic

resources and also confers social resources through the strong socio-political value attributed to married status. Finally, the mediator was not constructed to capture multiple transitions of marital status that might occur over ten years.

Since lifestyle, social or psychological factors did not appear to explain the relationship between cumulative FH and excess weight gain, it may be that prolonged financial worries led to unhealthy adiposity through biological mechanisms related to stress and inadequate sleep. Both chronic stress and insufficient sleep have independent associations with obesity.[72 411-413] Objective indicators of stress and sleep patterns should be accounted for in future studies so as to examine physiological mechanisms of influence between FH and long-term weight gain. Meanwhile, prevention of excess weight gain would benefit from greater attention to employed women's experiences of different types and amounts of FH, separate from their education, occupational status and wealth. Strategies might focus on helping their management of money and budgets,[381] and on improving reach of existing financial assistance programs.[309]

## 8.6 Conclusion

To conclude, employed British women reporting persistently insufficient money for food or clothing were more likely to gain ≥5 kg over 11 years, independent of SES. Lifestyle factors, social and psychological factors did not appear to explain the independent relationship of cumulative FH and excess weight gain. Results suggested that public health policy and practice standards in obesity prevention or management need to consider more than SES and address in particular women's greater experiences of, and sensitivity to, prolonged financial concerns.

# CHAPTER 9 Summary, interpretation and future directions

This dissertation presented a series of studies that examined multiple factors describing an individual's economic and social conditions in relation to diet quality and weight-related outcomes, with a particular focus on older adults and differences between women and men. It had the key aim of better understanding how the complex reality of a person's life circumstances influences key risk factors for chronic diseases. It also sought to address the identified need for unpacking the relative importance and inter-relations of diverse drivers of diet quality or obesity that underpin variation between people who occupy uniquely differentiated social categories. It gave specific attention to indicators representing more everyday economic strains and material conditions and thus analysed at least two separate types of FH in the studies of potentially relevant economic determinants. The main findings of the different studies in this dissertation are summarised below (section 9.1), as are key methodological concerns (9.2). Results are then interpreted against my conceptual framework (9.3), and their implications for future work in public health research practice are considered in turn (9.4).

## 9.1 Main findings and key conclusions

Moderate to large gradients by multiple economic conditions were observed for older British women and men in two prominent risk factors for chronic conditions. Those with lower SES or greater FH reported lower FV variety (i.e. they ate fewer different fruit and/or vegetable items), and were more likely to be centrally and generally obese. Magnitudes of association between SES and diet quality were stronger than between FH and diet quality, however the reverse was observed in relation to obesity in cross-sectional studies. Investigation of three different types of FH revealed that each played a significant role in diet quality and obesity, independent of SES (education, occupational social class and home-ownership). The role of

six factors describing a person's economic conditions, moreover, differed significantly between women and men, with gender-specific patterns and strengths of associations depending on the specific exposures and outcomes investigated. Gender differences were also evident in the independent association between cumulative FH and long-term excess weight gain that was significant only in women civil servants.

In addition, different structural aspects of older people's social conditions showed gender-specific associations with fruit variety or vegetable variety, with men generally faring worse than women in the relationship of marital status, living arrangement or social isolation with variety. Inter-relations between different social relationships showed clear synergy of action on diet quality, as measured by FV variety. When multiple economic disadvantages were examined in combination with disadvantage in different social relationships, much lower variety scores were observed than were seen when only economic or social disadvantage was examined; again, dual disadvantages indicated that men fared worse than women. Many differences between women and men in the variety of FV intake were significant for associations of different economic conditions, social relationships, or their combinations. Notably, the double burden of economic and social disadvantages was more strongly associated with lower FV variety than the combinations of two social ties.

An overview of each study's objectives, main findings and key conclusions is provided at the end of this section in Table 9–1.

### 9.1.1 Specificity in indicators for common exposures and outcomes

Among the multiple economic exposures studied in Chapter 3, Chapter 5 and Chapter 7, results suggested that the magnitude of associations and strength of gradients, of SES or FH differed between various indicators, and also between genders. For fruit variety, economic differences were largest for difficulty paying bills in older women and for occupational social class in older men. For vegetable variety, larger differences in social class were observed for both genders compared to five other economic exposures. For general obesity, economic differences were largest for having enough money for needs in older women and for difficulty paying bills in older men; for central obesity, both factors showed the largest differences but reversed between the genders, compared to all other economic factors (Figure 9–1).

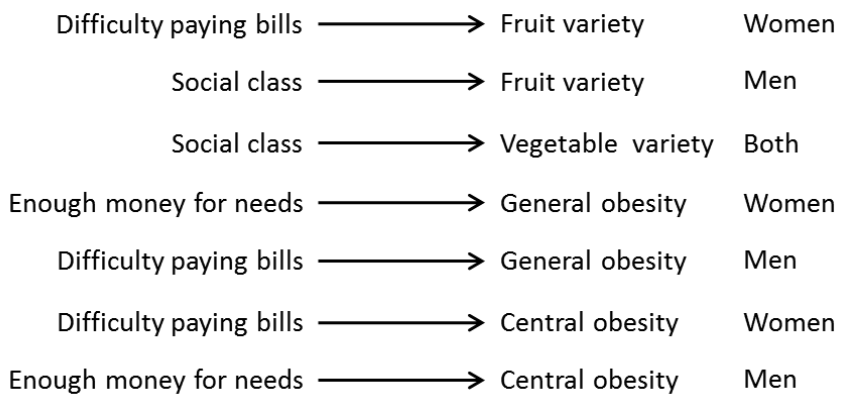



Figure 9-1 Illustration of specific economic exposures most strongly graded in specific outcomes in older women and men in the EPIC-Norfolk study

With regard to different social relationships examined in Chapter 4, again magnitudes of associations were stronger for different outcomes depending on the measures used. Thus, in both older women and men, unit differences in fruit variety were greatest for the most infrequent friend contact, but in vegetable variety for single status (Figure 9–2).

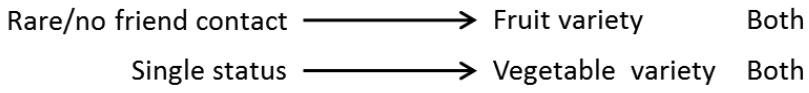



Figure 9-2 Illustration of specific social exposures most strongly associated with specific outcomes in older women and men in the EPIC-Norfolk study

As revealed in Chapter 5, when economic and social disadvantages were considered together, a different set of factors were most strongly associated with fruit variety and vegetable variety. Fruit variety in older women was lowest for the combination of renting and infrequent friend contact; whereas in older men, differences in fruit variety were largest for the dual disadvantage of low social class and non-married. By contrast, larger differences in vegetable variety in women were found for insufficiency of money to afford food/clothing combined with non-married status; but again in men, differences in vegetable variety were greatest for the combination of low social class and non-married (Figure 9–3).

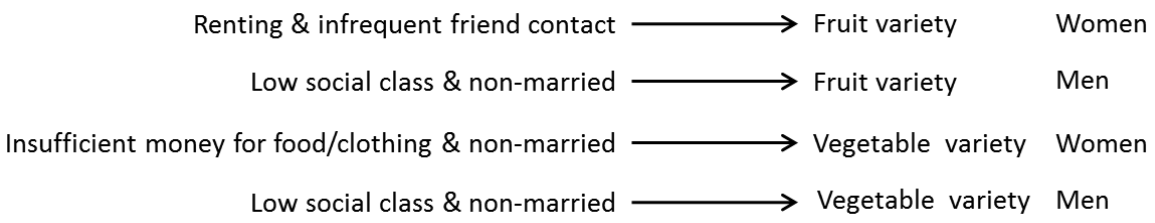



Figure 9-3 Illustration of specific combinations of economic and social disadvantages most strongly associated with specific outcomes in older women and men in the EPIC-Norfolk study

In conclusion, everyday financial troubles constituted a unique economic influence on diet quality and obesity in older adults, and the influence of a given economic or social factor on diet quality was modified when another social factor was also considered. Different aspects of economic or social circumstances, and their unique combinations, must be considered explicitly in future public health research and practice as each reflected a distinct process of social differentiation and hence added to our understanding of contextual influences on chronic disease risk factors.

Table 9-1 Overview of chapter objectives, main findings and key conclusions

| Chapter objective | Main findings | Key conclusions |
|---|---|---|
| To review evidence on economic determinants of diet in older adults (Chapter 2) | Nine prospective studies were included as eligible and generally had moderate study quality. The majority focused on retirement from work with mixed impact on food spending and/or food intake. Some observed subgroup differences, especially between women and men. | Evidence on economic determinants is still scarce and limited to studies of retirement from employment as the determinant of interest. Studies which suggest divergent effects in older people. Robust high-quality longitudinal studies to decipher economic drivers of diet are needed before firm conclusions can be made. |
| To examine associations of multiple economic factors with variety and quantity of fruit and/or vegetable intake in older British adults (Chapter 3) | Differences by SES or novel FH measures were not consistently observed for quantity of fruits and/or vegetables consumed. However, lower variety was significantly associated with lower education, social class or wealth. Gradients by SES indicators were stronger in men: mean vegetable variety differed between top and bottom social classes by 2.9 items/m for men but 2.5 for women. Gradients by FH were also seen for variety and were stronger in women for fruits and in men for vegetables. Women reporting greatest difficulty paying bills ate 1.2 fewer different fruits a month than those able to pay bills (the difference in men was 0.5 fruits/m); while men reporting greatest difficulty paying bills ate 2.0 fewer different vegetables a month compared to those without difficulty (the difference in women was 1.1 items/m). Inverse associations of FH with variety remained significant after conditioning on SES, and vice versa. | British over-50s who reported greater economic disadvantage, including everyday financial troubles, consistently consumed fewer different fruits and/or vegetables, but not lower amounts. Further nutritional understanding of variety's protective effects and underlying mechanisms is needed to address social inequalities and gender differences between fruit and vegetable variety. Dietary guidance should separately emphasise variety, and interventions should also address financial barriers to older adults' consumption of diverse FV. |
| To assess which structural aspects of social relationships most affect FV variety and social relationships interact to produce a combined effect on healthful eating behaviours in older women and men (Chapter 4) | Negative associations of non-partnered or lone-living persons and fruit variety were stronger in men than women, compared to partnered or in shared-living. Women and men differed in the negative association of widowhood with vegetable variety (women: Beta= −0.79, p<0.001; men: Beta= −2.17, p<0.001), similarly regarding lone-living and vegetable variety (women: Beta= −0.66, p<0.001; men: Beta= −1.46, p<0.001). Decreasing friend contact was negatively associated with variety of fruits and vegetables in a graded trend for women but was stronger in men. Family contact appeared to have no association with vegetable variety in men while variety scores in women were initially positive but then lower as contact decreased. Interaction models including both genders revealed the most striking results. For example, the negative association of lone-living with vegetable variety was significantly different (p=0.007) between infrequent friend contact (Beta= −1.62; P<0.001) and frequent contact (Beta= −0.80; P<0.001). | Marital status, living arrangement or friend contact influence variety scores more for men than women. Different social ties interacted to produce unique synergistic effects on healthful dietary behaviours. Results highlight the importance of considering living arrangement and frequency of social contact when assessing whether widowed or single older adults are most at risk of lower fruit and vegetable variety. |
| To examine the inter-relations of economic and social disadvantages on fruit variety and vegetable variety in older British adults (Chapter 5) | Inverse associations between each of three SES indicators and variety were seen, independent of social relationships. Independent associations for three FH measures were consistently observed for fruit variety in women only. Independent of six economic factors, all social relationships were inversely associated with both variety outcomes in men and vegetable variety in women; only friend contact was significant for women's fruit variety. All combinations of economic and social disadvantages aggravated negative associations with variety. Greatest amplification of unit differences were seen for vegetable variety in non-married men of low social class (β -4.11, [-4.83, -3.38]), and non-married women reporting insufficient money for food/clothing (β -2.83, [-3.83, -1.84]). | Older British adults experiencing economic disadvantage ate fewer different fruits or vegetables. Older women and men without social relationships also ate fewer different vegetables, but the role of various social relationships in fruit variety differed by gender. More importantly, the double burden of economic and social disadvantages suggests they are potentially joint determinants of low variety in older British adults. Healthy ageing strategies to promote healthful eating require simultaneous improvements in the economic and social |

| Chapter objective | Main findings | Key conclusions |
|---|---|---|
| | Strong gender differences were seen for many independent, and interaction, associations. | conditions of older adults who are most vulnerable to less FV variety. |
| To briefly summarise literature on known economic determinants of obesity and weight gain, particularly in older adults (Chapter 6) | Several literature reviews indicate a range of diverse factors describing economic conditions are strongly associated cross-sectionally with obesity and prospectively with weight gain. As an important risk factor for chronic conditions, the majority of weight-related studies examine economic differences using conventional measures of SES, and some also show how gradients by SES differ between women and men. Literature on other forms of economic disadvantage as potential determinants of obesity, including everyday financial troubles, is more limited and rarely focuses on older populations, or explicitly considers gender. | To date, examination of separate hardships is still rare in studies of obesity, with scarce focus on older adults. Consequently, evidence remains limited regarding the role of different FH types in obesity as unique economic determinants among older adults who comprise a growing population. And, more critically, knowledge is limited as to whether, and to what extent, women and men differ in which types of FH are more strongly associated with obesity both in cross-section and over time. |
| To examine three types of financial hardship (FH) in relation to measured general and central obesity in a general population of older adults, while considering conventional socioeconomic indicators (Chapter 7) | Obesity prevalence was consistently patterned by standard SES indicators, with over-50s in the lowest social class being twice as likely to be obese than those in the highest class (women: 2.10 [CI95: 1.41—3.13]; men: 2.36 [1.44—3.87]). After SES adjustment, reporting having less than enough money for one's needs (compared to more than enough) was associated with obesity in women (2.04 [1.54—2.69]) and men (1.83 [1.34—2.49]). Similar associations were demonstrated between obesity and always or often insufficient money for food/clothing (women: 1.40 [1.03—1.90]; men: 1.81 [1.28—2.56]), compared to reporting this never occurred. The strongest independent associations were seen for obesity and reported greatest level of difficulty paying bills (women: 2.20 [1.37—3.55]; men: 2.40 [1.38—4.17]), compared to having no difficulties. Findings for central obesity were slightly higher in women and lower in men. | General and central obesity in British over-50s was more likely in those reporting greater levels of FH, even after considering education, social class and home ownership. Public health policies need to consider the hitherto neglected role of FH in older people, especially difficulty paying bills, as part of strategies to prevent or reduce obesity. |
| To ascertain prospectively the independent relationship between types and amounts of FH and weight gain, and assess the role of six factors as potential mechanisms (Chapter 8) | Two types of persistent FH were strongly associated with adjusted mean weight change over 10.9 years in women only. During follow-up, 46% of women gained ≥5 kg. Women reporting persistently insufficient money for food/clothing had a significantly greater odds of gaining excess weight (1.42 [1.05, 1.92]) compared to the reference group, which remained after SES adjustment (1.45 [1.05, 2.01]). The association between persistent difficulty paying bills and odds of excess weight gain was also significant (1.42 [1.03, 1.97]) but attenuated after considering SES (1.39 [0.98, 1.97]). Of six factors, two fulfilled criteria for potential mediators (change in smoking status and marital status), but did not attenuate associations. | Female British employees reporting persistent insufficient money for food/clothing over 11 years had a 45% greater likelihood of excess weight gain compared to those without hardship, independent of three conventional SES indicators. The relationship was not mediated by lifestyle factors, marital status or depression. Results suggested strategies to tackle obesity must address employed women's everyday financial troubles, especially affording food/clothing, which may influence weight through more biological pathways than classical correlates of economic conditions and weight. |

## 9.2 Methodological issues

This section considers a number of methodological issues common to the studies contained in this dissertation: namely, limitations of cross-sectional study design, bias of self-reported measures, and limits of generalisability.

The last two empirical studies in this dissertation used outcomes based on clinically measured anthropometry (weight, height and WC) which was a key strength of those investigations. But, levels of body weight and any changes in older adults present a paradox for health that is controversial in the literature, as noted in the Introduction (1.2.2). The detriment to health from excess weight gain defined by WHO's threshold may depend on the individuals' starting weight. Moreover, initial weight was found to interact with economic stressors to modify their associations with subsequent weight change. [74 425] In the Whitehall II study, differential effects of job stress were found, with overweight or obese gaining weight at 5-year follow-up but lean individual losing weight.[425] Thus, findings of cumulative FH and subsequent excess weight gain in Chapter 8 may apply only to women who already had a higher weight. Although analyses included baseline weight as a covariate, they did not explicitly examine possible effect modification. Another methodological consideration for the study in Chapter 8 is fluctuations in weight over a long period may be more consequential for health than an overall increase of 5 kg in adults at the end of the working life and beyond, but weight fluctuations were not ascertained in analyses of 11-year weight gain.

### 9.2.1 Cross-sectional analyses

The majority of studies in this dissertation were cross-sectional in design which prohibits any conclusions about causal relationships. Although cross-sectional analyses cannot indicate the direction of associations, they are informative nevertheless insofar as they can indicate potentially relevant relationships and generate hypotheses for prospective examination. While reverse causality is possible in the cross-sectional studies, information on economic and/or social exposures was assessed by surveys undertaken before the outcomes measured at the second clinical assessment, averaging at least 18 months. Studies also included a number of relatively time-invariant exposures, particularly education and social class, for which strong gradients were observed in the cross-sectional studies of both diet quality and obesity. Gender as a fundamental principle of social organisation is also likely to be a stable

variable in cross-sectional analyses of differences between women and men in the economic or social exposures studied. Furthermore, the many longitudinal studies of similar exposures, including in the EPIC-Norfolk cohort,[177 302 336 337 366 381 426] provide more support overall for causation rather than selection processes related to the exposures and outcomes studied in this dissertation.

Nevertheless, findings could be affected by residual confounding from income that was unmeasured, as previously discussed in sections 3.5.2, 4.5.2, 5.5.2 and 7.5.2. There may be other possible contextual and personal factors that could be associated with the exposures and outcomes.[85 86 89 92 99 165] For example, personality and cognitive ability may be associated with various economic and social exposures (e.g. eligibility for, and interest in, higher education) and also with maintaining a healthful weight status, or consuming greater variety of FV. Standard health behavioural models emphasise causal relationships of individual cognitive factors of attitude, locus of control and intention, with lifestyle factors such as diet.[92] Such models suggest that greater variety was more likely among individuals who had a positive attitude towards liking new types of food; psychological attributes that were not explored in this dissertation. Culture is a another broad factor encompassing traditional practices as well as norms and values associated with, for example, gender, age, language, and country of origin, that will be related to dietary intake and body weight, and also to economic and social exposures. Culture deserves further investigation as it was an unobserved factor that could alter findings in this dissertation.

### 9.2.2 Reporting bias, potential misclassification and measurement error

All exposures and dietary outcomes used in this dissertation were self-reported in surveys by participants. Although self-reported measures are generally more common in large epidemiological studies as they are easier to obtain than objective assessments, they have known limitations of multiple forms of reporting bias, such as social desirability, same-source, or recall bias. These issues are discussed for the exposures and then for diet.

*Self-reported exposure data*

Social desirability bias may have affected variability in the exposures examined. Social desirability favouring variety, or normal body weight, may be associated with higher SES, less FH, or more social ties, and thus falsely increased variety, or reduced obesity, in more advantaged groups in the sample. Thus, true differences may be less than currently observed. In my longitudinal study of Whitehall II, another source of bias is non-response

from those in lower occupational class who were perhaps more likely to experience FH and also gain excess weight.

Same-source bias could also influence participants' responses to FH questions about their economic conditions, either positive or negative. It is possible that self-reported FH was systematically influenced by an overall view of life, with greater FH reported by lower SES groups who are known to have more pessimism, negative affect and depressed feelings.[99] It is also known that some groups of older adults interpret the meaning of FH as a normative status of daily living while others perceive FH as deprivation.[282] Same-source bias may therefore have resulted in an overestimation of differences by FH in the outcomes.

However, as reviewed in section 6.2 in this dissertation, there is a strong evidence base for the use of self-reported FH measures as numerous studies showed differences by FH in the health of older adults and civil servants that were independent of other economic resources such as education and income.[209 282 283 301 304 384 385 387] Some studies also suggested that a person's subjective report of their financial situation was a stronger predictor of a mixed diet, including fruit variety, than objective levels of economic resources.[126-128 351] Other work has shown that differences by FH occurred even among high-income groups and that variation in FH was constant across income categories.[279 351]

Self-reported FH measures have the methodological advantage of measuring individuals' subjective perceptions of their financial situation as an overall reflection that takes into account their other economic resources.[382] This would therefore suggest that FH questions are closer than conventional SES indicators to each person's internal processes of deliberation over competing interests and negotiation of multiple values. As such, FH measures may be the best information available to use in epidemiological studies of economic determinants of diet or obesity. Furthermore, several different types of FH were examined separately and using as many possible categories, in addition to multiple SES indicators, which is recommended for understanding variation across the full spectrum of uniquely differentiated social groups.[179]

Reporting bias in FH or SES indicators could result in misclassification of exposures. Women's occupational social class may also be misclassified due to the fact that social class of women in the sample was generally assigned based on their husband's occupation rather than their own. This might explain unexpected and contradictory findings that conventional SES indicators, particularly social class, were less strongly associated with women's diets or

BMI than men's in the EPIC-Norfolk study. Nevertheless, a spouse's, and not one's own, social class may be independently associated with diet quality, at least among married women in British civil service.[391] Furthermore, an investigation of social class in women in the EPIC-Norfolk study indicated there was little difference between using personal or partner's occupation for predicting survival.[427]

There may also be misclassification of exposures stemming from changes to participants' level of economic or social resources in the interval between surveys. Despite using measurements of economic and social exposures that preceded those for diet or obesity, the durations of, and transitions in, exposures could not be ascertained in the EPIC-Norfolk study. However, since any errors in misclassification from changes in exposures would be unlikely related to the outcomes, they would be non-differential and hence would have biased results towards the null.

Finally, another important source of bias may stem from errors in measuring the exposure variables and/or the confounders examined in this dissertation. Apart from possible error in the variables of self-reported exposures (and confounders) that, as described above, may be due to participant's inability to accurately recall the factor in question and/or to a tendency to over-/under-estimate the quantity being questioned, some errors could be technical as a result of imperfect measurement instruments and fluctuations over time. Variables for exposures and confounders, however, were reported in questionnaires that followed standard survey design principles.[224] Nevertheless, measurement error in exposures could distort estimates of their relationship with outcomes studied, while error in confounders could result in imperfect adjustment and also lead to biased estimates of the associations.

*Self-reported outcome data*

Another source of potential bias is differential recall of dietary intake. For example, older ages or lack of food preparation involvement may lead to under-reporting of the full range of items consumed. Lower education and social class of widows, or stress from recent bereavement, may affect reported variety. Bias in diet recall, however, was found to be unrelated to age, with errors occurring more in relation to education and income.[334] All dietary analyses in this dissertation adjusted for at least education and social class which would partly account for bias on observed estimates from some SES differences in diet recall.

There are known biases and limitations to the FFQ instrument that create error in dietary measurement. The FFQ poorly measures absolute intakes in a person's diet; is subject to misreporting by weight status; and, is unresponsive to a dynamic and prospective approach to understanding disease outcomes.[230] Unlike 24-hour recall or diet record/diary methods of measurement, the FFQ in EPIC-Norfolk was neither a snapshot in time nor idiosyncratic to an individual as it measured a person's usual diet over a year. Thus, it may be the better assessment method from which to derive FV variety scores since it covers a timeframe sufficient for most people to exhaust their food repertoire.[64] Moreover, questions about the contextual influences on diet require ascertaining a person's usual intake of foods and/or beverages. Diet data assessed by FFQ was arguably most suitable to this dissertation as it aimed to examine the influence of different facets of an older person's life circumstances on healthful eating behaviours. Furthermore, the FFQ instrument is considered the most conceptually intuitive of dietary measurements,[230] and may make the instrument most salient for older people to describe their food intake which was the focus of this dissertation.

Nevertheless, the close-ended nature of the FFQ, with a pre-specified number of fruit and vegetable items, may be a limitation and could under-estimate the variety of FV intake. Study findings could be altered by social changes in the variety of FV products that have become increasingly available through technological advances and globalisation. However, a study of food repertoires and meal structure of the British diet found these were unchanged in the 1990s.[335] More generally, an increased availability of different fruits and vegetables over the relatively short timeframe of my studies would be unlikely to significantly alter the diets measured by the FFQ. This is because, for participants to broaden their habitual variety of intake, they would need to undergo a time-dependent process of decision-making to re-construct heuristics for novel FV.[107 108 164 201 202] It bears noting that the over-50s in EPIC-Norfolk would have been brought up in a food culture of the post-war rationing period in British history (ending in 1954),[428] and hence would have developed food strategies and habits informed by a historical context involving a limited range of food items. In other words, it is expected that the variety scores used as outcomes of interest reasonably quantify the sample's consumption of different fruits and vegetables.

Finally, scores for FV variety may not measure overall diet quality as adequately as a score for diversity of the whole diet, or other published indices.[57 58] It is possible that the FV

variety scores examined in this dissertation are positively correlated but not fully synonymous with overall diet quality,[46 47] and may show a different pattern in the relative importance of similar determinants.[59] Diet quality indices, however, tend to emphasise nutrient adequacy and macronutrient distribution and do not generally include variety as a distinct component.[57 58] Existing indices also rarely address variety *within* food groups such as fruits or vegetables, which was an aspect of diet included in this dissertation. Others have shown that simply measuring the total number of foods consumed may be less appropriate for explaining the relationship between overall food variety and diet quality than assessing both the heterogeneity and the number of foods.[47] The concept of heterogeneity within the fruit and vegetable food groups was reflected in the FV variety scores. In addition, measuring the variety of fruits or vegetables consumed appears to be a suitable proxy for *healthful* eating behaviours as similar scores were used in aetiological studies showing higher FV variety reduced the risk of prominent chronic conditions.[61 62 305]

### 9.2.3 Generalisability to other populations

External validity of findings from observational epidemiological studies is always an important methodological consideration. The population-based EPIC-Norfolk cohort has similar characteristics to the general UK population, apart from fewer smokers and minimal ethnic minorities.[212] The sample of over-50s in EPIC-Norfolk used for my studies differed from the full cohort in greater prevalence of higher education and social class. As a result, findings cannot be generalised to lower SES populations, or to non-white and younger groups in Britain or elsewhere.

Arguably, findings may be more generalisable to other white, European-origin, relatively higher SES groups than to non-European cultures. However, important regional differences in eating behaviours across Europe might limit findings to those of Anglo-Saxon origin, or perhaps only to the UK. There is some evidence that FV intake was more common in Southern and Eastern Europe, and tended to be higher among lower status groups.[99 237] Nevertheless, there may be less regional difference in the relative importance of determinants of diet, particularly for inequalities in FV consumption.[429] In particular, price was commonly perceived by unemployed and retired adults as the most important influence on their food choice in a nationally-representative survey of 15 European member states.[430]

Globally, cultural systems vary widely in their traditional practices such as cuisines and the norms of what is acceptable and preferable for eating and body weight. Cultural differences

in, for example, the amount and combinations of food they choose, could therefore hinder external validity. But, cultural limits to generalisability may be less problematic given some evidence showing health benefits of a culturally-specific diet were transferred to another population.[55] Moreover, the importance of food variety for survival has been demonstrated in older adults from South East Asia, US and Europe.[49 51 53] In addition, reports in Chinese-based food cultures in Australia and Taiwan are consistent with findings in Chapter 3 that greater FH was associated with lower variety in older adults, thus providing some support for generalisability to diverse countries.

Unlike the EPIC-Norfolk study, the Whitehall II study was an occupational cohort largely comprised of employed adults in the British civil service. Participants will therefore differ from other working-age groups in non-public sectors of employment in the UK, and especially from the general population in the UK and elsewhere. Thus, results from Chapter 8 are more limited in external validity than findings from studies in EPIC-Norfolk, but may be more generalisable to other occupational cohorts of publically employed adults of similar age, such as in Finland where similar results were reported.[302] More work is needed in other nationally representative adult samples to determine whether parallel findings in the Australian population,[381] extend to populations in other countries.

On a final note, between-country variation in policies for welfare, healthcare or mandatory retirement might also hinder external validity of my results. Countries will differ in specific social welfare policies affecting the whole population, such as food assistance and feeding programmes, and also in regulations for local/regional services and institutions. Policies and regulations are reported to shape what is available to people by restricting the variety and location of food choices.[367 431] Other policies on public transportation and urban planning might affect, for example, older people's strategies and routines related to food procurement and storage.[121] National differences in, for example, mandatory retirement and social welfare policies raise another consideration about the heterogeneity of over-50s studied in this dissertation. Findings may differ across age subgroups such as some age groups (e.g. 'old old' aged ≥85) may be more vulnerable to poor diet quality or excess body weight from greater FH or poorer social ties. The country context of retirement and social support policies may inform the extent to which vulnerability differs by age subgroups.

How individuals interpret their experiences of greater FH or lower SES, or poor social ties will vary by the broader political context of a given country shaping a person's economic and

social conditions. It is unclear how the direction of associations would be altered between countries with different welfare regimes, such as conservative-corporatist or social-democratic regimes, compared to the liberal welfare regime of the UK.[2] Recent international comparative analyses illustrated how even European countries with relatively universal and generous welfare policies did not necessarily have smaller health inequities.[406] The comparability of findings from high-income countries, such as the UK, to low-income countries is even less clear, as not all countries have shown the same pattern of association between obesity and degrees of social disadvantage.[68] Furthermore, the role of gender in understanding disparities in overweight and obesity may be unique to a development context.[432] Ultimately, despite agreement that multiple factors describing the political environment are important determinants of diet and obesity,[66 89 124 426] questions of external validity critically depend on the much-needed research on policies related to, for example, education, employment or gender discrimination.[174]

## 9.3 Interpretation of findings: revisiting my conceptual framework

Research on the broad determinants of health and related behaviours is acknowledged as being limited in two critical areas: (1) examination of the relative contribution and synergy of action among different elements of social disadvantage; and, (2) development of more complex causal explanations that could inform preventive action about the multi-level interconnected drivers of population health.[13 19 20 199] This dissertation aimed to contribute to filling the gap in evidence on understanding the relative contribution and inter-relationships of multiple (presumed) determinants operating within the contextual-level of influence,[11] particularly regarding older adults' diet quality as a prominent risk factor for chronic conditions.[124] It also sought to bring a gender perspective to this work as there is still disproportionately too little attention given in the literature to differences between women and men.[174 187]

Overall, this dissertation indicated that multiple forms of economic and/or social disadvantage were each important for understanding differences in the diet quality of older adults, but some more so than others and with clear gender differences. In particular, this dissertation indicated the relative importance of conventional SES and novel FH measures differed between diet quality and obesity in British women and men who are not conventionally considered poor. One the one hand, financial hardships played a role in

variety but SES was relatively more important and stronger, and more so in men than women (research question 1). On the other hand, financial hardships appeared relatively more important in associations with obesity than SES, with differences between women and men depending on specific hardships and obesity outcomes (research question 4).

Results from longitudinal analysis of middle-aged civil servants in the UK further suggested that the impact on weight gain from cumulative FH differed by gender, with strong independent associations found in employed women only (research question 5). Additional investigation of change in multiple correlates of economic disadvantage and obesity pointed to the potential role for other biological processes to explain the associations observed in women. The null findings for the potential mechanisms studied were likely due to measurement error and/or limitations of the construction of change variables. Yet, these findings were similar to null results of behavioural factors mediating the association between conventional SES and weight gain in an EPIC-Norfolk study.[366] Evaluation evidence has also pointed to the need to consider other putative mediators since an 18-month trial of food provision and financial incentives for exercise did not result in long-term weight loss in US adults.[433]

Taken together, results implied that mechanisms of influence likely vary between risk factors of interest. Whereas mediating pathways of diet quality may involve for example social roles, cultural norms and knowledge which go beyond material resources, body weight may be more directly influenced by mechanisms related to spending power and material resources, including lack of sleep from financial worries and physiological responses to hardship-related stress. From a gender perspective, the plausible role of biological mechanisms involving sleep and/or stress may be particularly relevant for FH-obesity associations in women. Research in Finland concluded that sleep might explain why strong educational differences in BMI remained in women (but not men) after including mediating lifestyle factors.[185]

Review evidence supports the independent associations of both insufficient sleep and chronic stress, with general and central obesity; although gender differences were not considered.[411-413] Additional work offers an evolutionary and behavioural ecology perspective on how biological factors, such as neuroendrocine pathways, might explain why income insecurity and other economic stressors are associated with body weight. Several studies provide support for a physiological fattening response that is triggered by income

insecurity as preparation for the perceived risk of future famine.[434-436] This dissertation concurs with broader literature suggesting that a conceptual framework linking a person's life circumstances to obesity must include a range of factors beyond only common health behaviours, particularly the two (diet and physical activity) given central focus for energy balance in the Foresight Report.[165]

In returning to my conceptual framework, personal factors of physiology such as stress responses and taste were conceptualised as among the proximate inputs to the cognitive process of food choice decision-making in which trade-offs between sensory perceptions of taste and food preferences, and other competing priorities would result in observed (un)healthful eating behaviours, and then in medium-term health outcomes, including excess body weight. Rather, it would appear that the complexity of contextual and personal inputs to outcomes such as obesity may be translated through automatic processes that are not cognitive. It may be that obesity is the result of a dual process of conscious deliberative processes that reconcile competing priorities of diverse inputs into simple heuristics, and of biological processes to which individuals remain largely unaware. That is to say, obesity is likely to also be the outcome of unconscious processes involving a person's affective system that responds rapidly to inputs without any cognitive deliberation.[203] This 'irrational' pathway has some support from a recent economic analysis of overeating and obesity.[437]

Whether such biological processes act in parallel to, interact with, or override, the cognitive processes envisioned in the Food Choice Process Model central to my conceptual framework is a question for further investigation. But, it would appear that conceptual models to explain complex causes that could inform preventive action will need to be specific to healthful eating behaviours and to obesity, so that a model of obesity avoids the central focus on only diet (energy in) and physical activity (energy out). It is promising that sleeping habits were also included in a recent conceptual framework for the key determinants of excessive weight gain in European youth.[438] Below is an alternative model for mechanisms of influence of economic disadvantage on obesity (Figure 9–4) resulting from Chapter 8, adapted from earlier work by Sobal.[181]

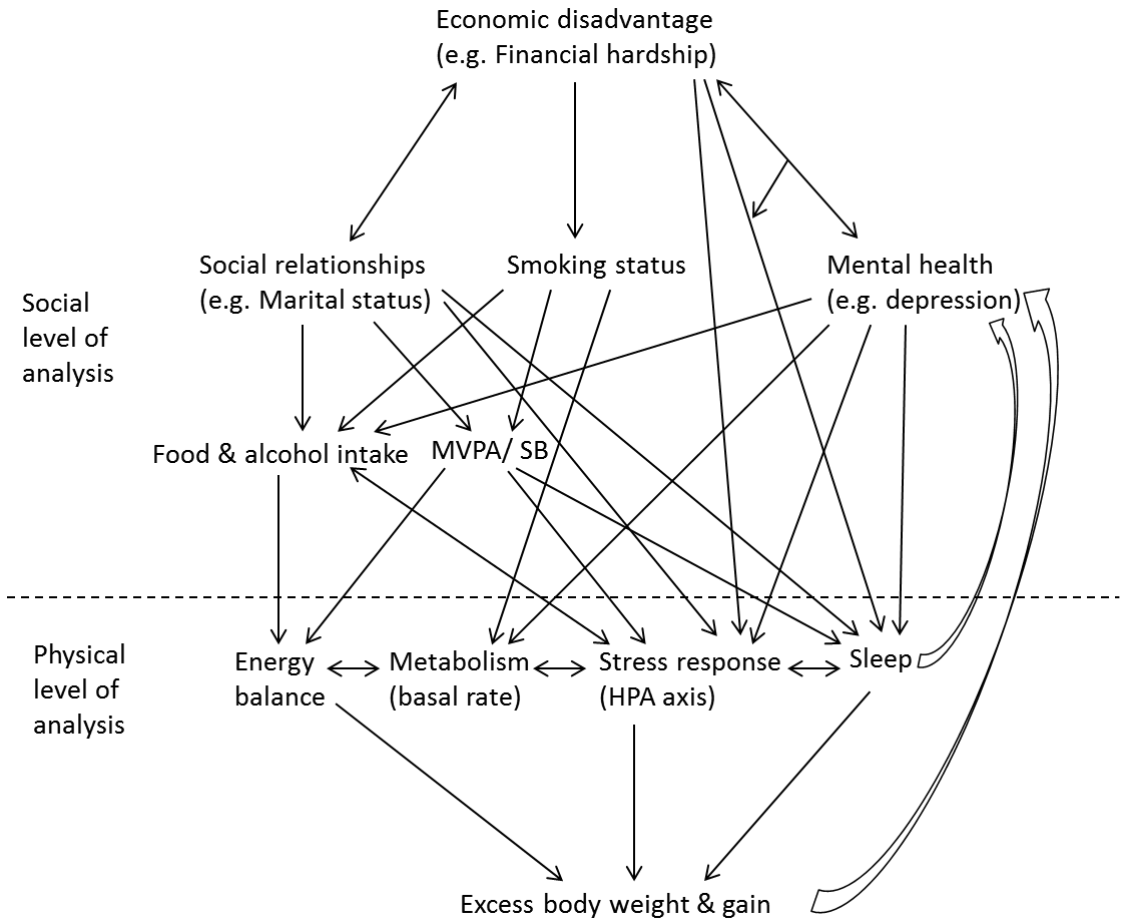



Figure 9–4 Conceptual model of mechanisms for the influence of economic disadvantage upon excess body weight and gain (adapted from Sobal 1991[181])

MVPA, moderate and vigorous physical activity; SB, sedentary behaviours

Within the social environment, specific attention to different types of social relationships showed that marital status played a relatively more important role in diet quality than living arrangement and social isolation, particularly for older men (research question 2). And, new evidence on inter-relationships between different social relationships exposed an important source of heterogeneity in older people's social lives that had unique associations with FV variety (research question 2). For example, it was not solely widowhood but rather the combination of both widowhood and lone-living that put older people most at risk of lower FV variety.

Even more novel was the demonstration that multiple economic influences interlinked with different social ties to reveal highly differentiated categories that were uniquely associated with diet quality and differed by gender (research question 3). Thus, the negative effects of low SES or greater FH on variety was buffered by the presence of a given social relationship; and, more so in older men than women. That is to say, relative to older adults who

experienced strong economic and social conditions, there was a double burden on diet quality of combined disadvantages in diverse economic and social conditions that was worse for men. In addition, women and men differed in which specific economic factor combined with a social relationship to produce the greatest double burden on diet quality. Notably, among older adults with strong economic conditions, women and men differed in the effect of social disadvantage on fruit variety as all social ties were important for men but only friend contact was for women.

Taken together, results from Chapter 3, Chapter 4 and Chapter 5 suggested that there may be some consistency in which specific exposures were most important for older women's and men's diet quality. More consistency was seen for the role of two types of social relationships in the diet quality of women than for a specific economic indicator. Thus, it is likely that, for women, friend contact mattered most for fruit variety, and marital status for vegetable variety. For men, social class and marital status appeared most consistently among the strongest associations observed in relation to both variety outcomes.

The intrapersonal (ego-centric) perspective incorporated into my conceptual framework was useful for interpreting the results of this dissertation as it called out the system of different values people need to negotiate including, but not limited to, monetary considerations and managing relationships.[107 108 164] The role of monetary considerations was also highlighted in economic and consumer behaviour literature as prominent among the competing priorities people trade-off when purchasing and choosing to eat foods and beverages.[94 129 204] Older British adults did appear to place strong priority on other daily living expenses that they may perceive to be of greater importance, or less flexible, than food; each of the three specific FH indicators, especially difficulty paying bills and having enough money for needs, were independently associated with fruit variety and vegetable variety for both genders (see Figure 9–1 and Figure 9–3). It is possible that some of these trade-offs involved competing priorities of 'heating or eating', as shown in poor, older households in the UK and US.[204 439] In the UK, other work showed that unexpected temperature declines was related to increased spending on heating and reduced food spending by about 7% across all major food categories including storable and perishable products.[204] Thus, as others have suggested, the important trade-off that economically disadvantaged groups need to make between food and paying bills indicates that healthful eating is not just a matter of knowledge and choice.[155]

That the social structures of older people's life circumstances had particular primacy for diet quality in this dissertation finds support from the concept of 'relational agency 'in Feminist Critical Theory and Social Constructivist philosophy. These theories posit that human agency is an inherently *relational* phenomenon as individuals are in reality not isolated, free-floating, self-reliant people exercising agency in a vacuum but live and make judgements embedded within social relations that make individuals dependent on others.[16 440 441] Therefore, individual decisions and actions take place because of the person's interactions in a group. In Feminist Critical Theory, moreover, each person's interactions in a given group depend on how that group ascribes specific and different roles and statuses to women and men. Relational agency is therefore also a gendered phenomenon inasmuch as women and men of the same group have different social positionings, powers and interests within it.[442]

As a result, gender will force women and men to make different decisions and prioritise a different set of values according to what their role requires them to consider. For example, women are often given the gendered role of the family's food procurer and/or preparer,[116] but their gender means they also have greater time poverty and limited finances.[371 377] Thus women's roles can require trade-offs that demand convenience to minimise time and cognitive effort but also require relationship management to maintain harmony in the household where others' preferences and needs differ from their own.[107 154 164]

Relational agency might explain not only why specific 'inputs' such as social class or marital status were relatively more important for diet quality in men for example, but also why men showed stronger associations with vegetable variety (compared to fruit variety in women). So, in a socio-cultural context where men are ascribed the gendered role of the family's economic provider, the salience of their social class means men will make judgements about which different fruits or vegetables to eat based less on monetary considerations than on the prestige value. Research has shown that foods enable people to express their personal worth and ability to provide basic needs,[371] and also that vegetables are lowest on the hierarchy of foods and are most associated with women's foods (e.g. salads).[117] Hence, findings here might be explained by the fact that older men were less able to express their personal worth, and ability to provide basic needs, through consumption of different vegetables than they might from eating different fruits which might offer more prestige value particularly if foreign or exotic. The difference in gender roles between women and

men also means that men were much less likely than women to have the food preparation skills required for eating a variety of different vegetables, compared to fruits.[286]

In sum, my empirical results illustrated how diverse economic factors contributed uniquely to either diet quality or obesity in older adults and how unique combinations of different contextual factors contributed to (un)healthful eating behaviours. It further demonstrated that economic factors interlinked with an older person's social context in ways distinct to each gender that revealed an underlying heterogeneity which was otherwise masked by the consideration of only a single condition.[206 207 442] The strong differences observed between women and men in the relative importance of SES, FH, social ties, and their combinations, further highlighted that women and men are *dis*similarly situated within the existing power structures of society at large.[443 444] As a principle of social organisation, gender clearly structures how seemingly similar economic and social conditions differentially shape an individual's resources and opportunities (including education). Hence, this dissertation also reaffirmed gender is a fundamental determinant of two prominent risk factors for chronic conditions.

## 9.4 Implications for future work

This dissertation ends with a general discussion of further work that could be undertaken in future public health research and some recommendations for public health practice. Each topic is addressed in turn below.

### 9.4.1 Future directions for public health research

Given the dominance of cross-sectional analyses in research on dietary determinants, change in the economic environment is of special interest for future research particularly with respect to financial hardships.[445] Despite good evidence that food intake varies by factors such as income, price, or cost of living, there is still very limited longitudinal data examining what happens to variety in food choice when economic conditions change, particularly for older adults at the end of work life and beyond.[112 124 247 426] This knowledge gap remains despite reported concerns in early the 1970s that increasing inflation and the cost of meat, fresh vegetables and fruit might constrain older British people's choices in diet variety.[110] Future work should use longitudinal data to unpack how a change in an older person's economic environment might change their diet and how this change might be altered by other factors, such as social relationships and physiology (i.e. tooth loss). For

example, analyses should seek to assess (a) how a change in a given economic condition influences food variety overall and within subgroups and (b) how economic change interacts with change in other factors to influence food variety. Moreover, different dimensions of both SES and FH will need to be included since each economic domain can vary over time as a result of broader social changes to work relationships, population income, resource distribution, social definition, and meanings of prestige.[166]

Similarly, there is value to public health research to also examine the main role of change in social conditions in relation to either diet or obesity. In particular, marital transitions can change diet quality in opposing directions according to different types of transition (e.g. into marriage versus into widowhood).[336] [337] Gender will continue to be important for understanding the effects of marital transitions on excess weight gain, as suggested by an earlier US study.[416] Furthermore, the experience and effects of change in social relationships should also be studied across levels of SES and FH, given findings in this dissertation that older women and men occupied distinct and highly differentiated combinations of economic and social categories.

As an identified knowledge gap,[124] the interplay between different aspects of older people's economic and social conditions regarding both diet quality and obesity deserves further epidemiological attention in cross-section and over time. Given the dearth of evidence on these linkages, cross-sectional research would support further prospective investigations by indicating potentially relevant relationships of combinations of economic and social factors, with risk factors of chronic disease. For example, a cross-sectional study of older Australian women found that low education, occupation and ability to cope on available income combined to increase the risk of being obese, and that associations with lifestyle factors were no stronger with prestige-based measures of SES than with indicators reflecting material or psychosocial resources.[166] There is scope to continue similar work on older adults following recommendations for the use of as many potentially relevant measures of economic conditions to (1) better understand how different aspects of their economic conditions relate to key risk factors for chronic disease, and (2) avoid any assumptions of economic comparability of individuals who are similar on a single economic factor.[179] Equally, inter-relationships between factors describing older people's social conditions should be pursued in future studies. The potential linkages between economic and social

drivers of obesity and weight change is also important to investigate in younger age and/or employed populations given the scant literature in this area.

In addition to factors describing the economic or social conditions of older adults, influences of the physical environment also deserve attention in terms of the trade-offs that older adults might make in deciding to consume a variety of fruits, vegetables or other foods. For example, factors related to location and transportation should be investigated as they might hint at other priorities regarding convenience that could be particularly salient for rural older adults.

Many note the need to reconcile the combination of economic, psychological and biological factors to understand (un)healthful eating behaviours and body weight.[434-437] With regard to obesity and adiposity outcomes, this dissertation pointed to the need for including work on potential biological mechanisms that may link economic disadvantages to weight change, and which might have greater relevance for women. Large epidemiological datasets that include a diversity of economic variables, anthropometrics as well as biomarkers of life stress (e.g. variability in heart rate or cortisol levels in saliva or hair), offer promise for future research. In the absence of clinical measures of sleeping habits, moreover, sleep-related questions could be an opportunity for future longitudinal studies to ascertain whether different aspects of sleep problems related to worrying might explain, for example, hardship differences in subsequent excess weight gain.

Future mediation analyses would need to be performed separately for women and men and possibly for individuals starting with normal weight and overweight/obese. Of particular interest for future research is an assessment of the relative contribution of different mechanisms linking the chronic life strains of FH with adiposity, similar to a recent prospective study in the Netherlands.[74] Three proposed pathways that deserve further investigation, potentially in the EPIC cohort, include: health-compromising behaviours (e.g. alcohol consumption; intakes of high sugar and/or high fat foods; sedentary behaviours); physiological changes (e.g. immune suppression; cardio-endocrine reactivity); and psychological traits (e.g. rumination; depressed mood; negative affect; sense of mastery; working memory).

A number of psychological mechanisms theorised in the psychology and behavioural economics literature on decision-making could be explored in the relationship between FH, both dynamic and chronic, and (un)healthful behaviours or body weight. Recent work

showed how the evocation of financial concerns blocked executive function among poor individuals because more mental resources were consumed, with the cognitive impact comparable to losing a full night of sleep.[446] The constraint or lack of cognitive resources from preoccupations with, for example, pressing budgetary concerns was likely to cause individuals to make decisions based on affective reactions of their experiential system (i.e. sensory-motor processes) instead of their rational system of schematic and cognitive processing.[203] An economic behavioural study of experimental and survey data indicated a link between economic decision-making and depleted behavioural control among individuals with fewer financial resources, with greater effects for those with fewer cognitive resources.[447] The theory of limited attention may be another mechanism implicated in associations between economic disadvantage and poor diet or excess body weight. There is also evidence that economic disadvantage is a form of scarcity that has the psychological effect of causing individuals to limit their attention on domains where resources are scarce and exclude other potentially important decisions.[447] [448] Thus, future epidemiological research could consider examining how executive function, and the interplay with affect, acts as mediator and moderator of the impact of dynamic and chronic experiences of financial hardship on diet quality or body weight.

Finally, future public health research should continue to examine food variety specifically, and separate food groups such as fruits and vegetables. The latter is important for ensuring that gender analyses adequately capture the unique relationships between different contextual factors and variety of intake of food (sub)groups. Food variety (also referred to as diet diversity) is itself an important area deserving more attention in public health research because there is little consensus in the literature on standardised methodology for assessing this long-standing concept and this absence creates difficulty for comparing epidemiological studies of healthful diets in older people.[194] In particular, it is unclear whether social and economic exposures, or health outcomes, differ between the various definitions of the concept used in the literature. Thus, areas for future research in both social and aetiological epidemiology include a comparison of effects of: (a) counts of all individual foods eaten; (b) counts of food groups consumed; (c) sum of each food group score; (d) counts of different foods within every group; and (e) counts of different foods within selected foods groups. There is also scope for investigating the complementary use of potential biomarkers in future food-based analyses given their increased use to assess the effects of a person's overall diet,[449] and possible greater importance for health and longevity

than individual nutritional components.[450-452] For example, plasma flavanols and flavonoid subclasses have known protective effects on health,[453] and are specific to certain items (e.g. citrus fruits, broccoli, beans, pears, grapes) that may be consumed preferentially by individuals with more varied intakes. Similarly, measures of gut microbiota composition might also strengthen research on the drivers of food variety in older adults.

### 9.4.2 Recommendations for public health practice

Common to all the literature is the call for more joined-up action by diverse stakeholders across different areas of policy and for implementation of a mix of interventions targeted at a combination of different determinants of diet and obesity. Such co-ordinated actions need to focus more on structural interventions to limit and redress systematic inequalities in society at large rather than on individual-level behaviour change. Ultimately, it is not just public health professionals but all members of society who must work on developing new paradigms of knowledge and value systems across all domains of the determinants of diet, and the obesity system.

Policies and interventions to increase FV consumption and support healthy ageing need to explicitly call out the importance of variety and consistently include a gender focus that aims to improve fruit variety in women and vegetable variety in men. Promotion of and strategies for healthful eating need to be targeted at not just lower educated or lower class groups, but also consider that everyday financial troubles can limit uptake of the advice across the SES spectrum. More critically, there is a need for interventions that simultaneously improve current economic concerns and social connectivity of older adults who comprise a growing population.

Although knowledge alone does not change behaviour, continuing education directly related to skills for money management could serve as a structural intervention to improve older adults' experience of financial hardships. Medical education and training might benefit from knowledge of broad determinants of disease risk factors, particularly the role of financial hardship, and of existing programs for referral. Education in childhood and adulthood directly related to healthful food shopping and cooking may be an important area for intervention to address gender roles and the generally lower quality diets observed in men. There may also be potential for early education in childhood and adolescence that aims to cultivate a health-oriented ethos rather than a money/consumption-oriented culture. Such broader cultural change would thereby indirectly influence which values are given greater

priority in the food choice decision-making process of the whole population and in turn result in more choices favouring healthful eating behaviours. Interventions to increase the availability of different social relationships might include: organising, and providing free access to, social activities as well as considering how the design of accommodation for older people might support greater social interaction. As social relationships are complex, interventions designed for single or widowed older people will need to be tailored with respect to other social factors beyond marital status.

In terms of recommendations for prevention or reduction of obesity among older adults, public health policies and strategies need to support older people in terms of their more contemporaneous economic concerns, although SES remains a consideration. Interventions and practice standards might include coping strategies and monetary provisions. A focus on meeting bill payments and managing money for needs might be suitable targets for approaches to address obesity in both older women and men. Interventions that help to mitigate prolonged financial concerns would also likely benefit employed women in terms of excess weight gain.

If future research does demonstrate that stress is an important biological pathway for the FH-adiposity link in women, then structural and behavioural interventions to reduce or mitigate stress response mechanisms will be important. Some examples to consider for evaluation research might be free or heavily-subsidised meditation classes, Tai-Chi, laughter therapy, in addition to protected time-out zones in public space and workplaces. Nevertheless, the strong associations of FH with obesity and weight gain suggested a need for a structural intervention to change the culture surrounding money and what values people consider when they structure their existence. Thus, similar to promotion of healthful eating behaviours, early education is an important leverage point to make money matter less and to cultivate health as the ultimate goal for the 'good life', with potentially important implications for healthy ageing.

Since adults over 50 are more likely than other groups in the population to experience changes in their social relationships and also in their financial situations, these moments of change are important to target in assessment and intervention. For example, around the time of widowhood, assessment of risk to healthful eating, or body weight, among older adults will need to consider the individual's gender and financial situation among other factors that characterise their lived experiences.

# REFERENCE LIST


1. Commission of European Communities. Together for health: a strategic approach for the EU 2008-2013. Brussels: European Commission, 2007 (October).
2. Nolte E, McKee M. *Caring for people with chronic conditions: a health systems perspective*. London: Open University Press, 2008.
3. AgeUK. Later Life in the United Kingdom. London, UK: Age UK, 2014:1-34.
4. Department of Health (DH). NHS R&D strategic review: ageing and age-associated disease and disability. Report of topic working group, June 1999. London: Department of Health, 2006 (October).
5. Elissen A, Nolte E, Knai C, Brunn M, Chevreul K, Conklin A, et al. Is Europe putting theory into practice? a qualitative study of the level of self-management support in chronic care management approaches. *BMC Health Services Research* 2013;13(1):117.
6. Knai C, Nolte E, Conklin A. Assessing the policy context for chronic disease management in Europe. In: Nolte E, Hinrichs S, editors. *DISMEVAL – Developing and validating disease management evaluation methods for European healthcare systems. Final Report*. Santa Monica: RAND Corporation, 2012:33-43.
7. Ling T, Brereton L, Conklin A, Newbould J, Roland M. Barriers and facilitators to integrating care: experiences from the English Integrated Care Pilots. *International Journal of Integrated Care* 2012;12:129-41.
8. Department of Health (DH). A new ambition for old age: next steps in implementing the National Service Framework for Older People. London: Department of Health, 2006 (April).
9. Department of Health (DH). A new ambition for old age: next steps in implementing the National Service Framework for Older People. A resource document. London: Department of Health, 2006 (April).
10. LaLonde M. A new perspective of the health of Canadians. Ottawa: Government of Canada, 1974.
11. Bonnefoy J, Morgan A, Kelly M, Butt J, Bergman V. Constructing the evidence based on the social determinants of health: a guide. Report to the World Health Organization Commission on the Social Determinants of Health, from Measurement and Evidence Knowledge Network. [online]

http://www.who.int/social_determinants/knowledge_networks/add_documents/mekn_final_guide_112007.pdf (accessed on 10 August 2012), 2007.
12. Graham H, Kelly M. Health inequalities: concepts, frameworks and policy. London, UK: NHS Health Development Agency, 2004.
13. Killoran A, Kelly M. *Evidence based public health: effectiveness and efficiency*. Oxford, UK: Oxford University Press, 2010.
14. Verloo M. Multiple inequalities, intersectionality and the European Union. *European Journal of Women's Studies* 2006;13(3):211-28.
15. Cairney J, Veldhuizen S, Vigod S, Streiner DL, Wade TJ, Kurdyak P. Exploring the social determinants of mental health service use using intersectionality theory and CART analysis. *Journal of Epidemiology and Community Health* 2014;68(2):145-50.
16. Crenshaw K. Mapping the margins: intersectionality, identity politics, and violence against women of color. *Stanford Law Review* 1991:1241-99.
17. Crooms LA. Indivisible rights and intersectional identities or, what do women's Human Rights have to do with the Race Convention. *Howard Law Journal* 1996;40:619.
18. Conklin A, Meier BM. A 'vector of rights' approach for public health: towards an intersectional Human Rights framework for considering the prevention and treatment of harms to girl child soldiers. *Australian Journal of Human Rights* 2008;13(2):65-98.
19. Blas E, Gilson L, Kelly MP, Labonté R, Lapitan J, Muntaner C, et al. Addressing social determinants of health inequities: what can the state and civil society do? *The Lancet* 2008;372(9650):1684-89.
20. Kelly M. Social differences in populations and their implications for public health. *Perspectives in Public Health* 2009;129(5):207-08.
21. McKie L. Older people and food: independence, locality and diet. *British Food Journal* 1999;101(7):528-36.
22. Vincent H, Vincent K, Lamb K. Obesity and mobility disability in the older adult. *Obesity Reviews* 2010;11(8):568-79.
23. He K, Hu FB, Colditz GA, Manson JE, Willett WC, Liu S. Changes in intake of fruits and vegetables in relation to risk of obesity and weight gain among middle-aged women. *International Journal of Obesity* 2004;28(12):1569-74.
24. McCrory MA, Fuss PJ, McCallum JE, Yao M, Vinken AG, Hays NP, et al. Dietary variety within food groups: association with energy intake and body fatness in men and women. *The American Journal of Clinical Nutrition* 1999;69(3):440-7.
25. Romaguera D, Ängquist L, Du H, Jakobsen MU, Forouhi NG, Halkjær J, et al. Food composition of the diet in relation to changes in waist circumference adjusted for body mass index. *PLOS ONE* 2011;6(8):e23384.
26. World Health Organization. Global health risks: mortality and burden of disease attributable to selected major risks. Geneva: WHO, 2009.
27. World Health Organization. Global strategy on diet, physical activity and health. Geneva, Switzerland: WHO Publications, 2004.
28. Department of Health (DH). Live well for longer: a call to action to reduce avoidable premature mortality. London, UK: Department of Health, 2013.
29. Lo Y-T, Chang Y-H, Wahlqvist ML, Huang H-B, Lee M-S. Spending on vegetable and fruit consumption could reduce all-cause mortality among older adults. *Nutrition Journal* 2012;11(1):113.
30. World Cancer Research Fund. 10 ways to prevent cancer. [online] http://www.wcrf-uk.org/cancer_prevention/recommendations/index.php: WCRF [accessed on: 17 April 2014].

31. National Health Services. 5 a day. [Available online] http://www.nhs.uk/Livewell/5ADAY/Pages/Why5ADAY.aspx (accessed on 3 January 2014), 2011:1-2.
32. Deutsche Gesellschaft für Ernährung eV. „5 am Tag“-Kampagne: Wissenschaftliche Begründung. [online] http://www.dge.de/modules.php?name=News&file=article&sid=290: DGE [accessed on: 17 April 2014], 2012.
33. Ministère des Affaires sociales et de la Santé. Fruits et légumes : au moins 5 par jour. [online] http://www.mangerbouger.fr/bien-manger/les-9-reperes/fruits-et-legumes-au-moins-5-par-jour.html: Programme National Nutrition Santé [accessed on: 17 April 2014].
34. World Health Organization. Promoting fruit and vegetable consumption around the world. [online] http://www.who.int/dietphysicalactivity/fruit/en/: WHO [accessed on: 17 April 2014].
35. World Health Organization. Diet, nutrition and the prevention of chronic diseases: report of a joint FAO/WHO expert consultation. *Technical Report Series 916*. Geneva: WHO, 2003.
36. USDA and DHHS. Dietary guidelines for Americans, 7th ed Washington, DC: Government Printing Office, 2010.
37. Minister of Health Canada. Eating well with Canada's food guide. Ottawa, ON: Health Canada, 2007.
38. USDA and DHHS. Dietary guidelines for Americans, 2005. Washington, DC: US Government Printing Office, 2005.
39. World Health Organization. Preparation and use of food-based dietary guidelines. Report of a joint FAO/WHO consultation. *Technical Report Series 880*. Nicosia, Cyprus, 1998.
40. USDA and DHHS. Nutrition and your health: dietary guidelines for Americans. Washington, DC: US Government Printing Office, 1980.
41. Department of National Health and Welfare. Canada's Food Guide: handbook. Ottawa, ON.: The Ministry of Health and Welfare, Health Promotion Directorate, 1982.
42. Smiciklas-Wright H, Krebs-Smith SM, Krebs-Smith J. Variety in foods. *What is America eating?: Proceedings of a symposium*. Washington, D.C.: National Academies Press, 1986.
43. Savige G, Hsu-Hage B, Wahlqvist ML. Food variety as nutritional therapy. *Current Therapeutics* 1997;38(3):57-67.
44. Bernstein MA, Tucker KL, Ryan ND, O’Neill EF, Clements KM, Nelson ME, et al. Higher dietary variety is associated with better nutritional status in frail elderly people. *Journal of the American Dietetic Association* 2002;102(8):1096-104.
45. Foote JA, Murphy SP, Wilkens LR, Basiotis PP, Carlson A. Dietary variety increases the probability of nutrient adequacy among adults. *The Journal of Nutrition* 2004;134(7):1779-85.
46. Krebs-Smith SM, Smiciklas-Wright H, Guthrie HA, Krebs-Smith J. The effects of variety in food choices on dietary quality. *Journal of the American Dietetic Association* 1987;87(7):897-903.
47. Drescher LS, Thiele S, Mensink GBM. A new index to measure healthy food diversity better reflects a healthy diet than traditional measures. *The Journal of Nutrition* 2007;137(3):647-51.
48. Wahlqvist ML, Darmadi-Blackberry I, Kouris-Blazos A, Jolley D, Steen B, Lukito W, et al. Does diet matter for survival in long-lived cultures? *Asia Pacific Journal Of Clinical Nutrition* 2005;14(1):2-6.

49. Wahlqvist ML, Kouris-Blazos A, Hsu-Hage B. Aging, food, culture and health. *Southeast Asian Journal of Tropical Medicine and Public Health* 1997;28(Suppl 2):100-12.
50. Darmadi-Blackberry I, Wahlqvist ML, Kouris-Blazos A, Steen B, Lukito W, Horie Y, et al. Legumes: the most important dietary predictor of survival in older people of different ethnicities. *Asia Pacific Journal Of Clinical Nutrition* 2004;13(2):217-20.
51. Kant AK, Schatzkin A, Ziegler RG. Dietary diversity and subsequent cause-specific mortality in the NHANES I epidemiologic follow-up study. *Journal of the American College of Nutrition* 1995;14(3):233-8.
52. Lee M-S, Huang Y, Su H, Lee M, Wahlqvist M. A simple food quality index predicts mortality in elderly Taiwanese. *The Journal of Nutrition, Health & Aging* 2011;15(10):815-21.
53. Trichopoulou A, Kouris-Blazos A, Wahlqvist M, Gnardellis C, Lagiou P, Polychronopoulos E, et al. Diet and overall survival in elderly people. *British Medical Journal* 1995;311(7018):1457-60.
54. Chen R, Chang Y, Lee M-S, Wahlqvist ML. Dietary quality may enhance survival related to cognitive impairment in Taiwanese elderly. *Food & Nutrition Research* 2011;55:7387-97.
55. Kouris-Blazos A, Gnardellis C, Wahlqvist ML, Trichopoulos D, Lukito W, Trichopoulou A. Are the advantages of the Mediterranean diet transferable to other populations? a cohort study in Melbourne, Australia. *British Journal of Nutrition* 1999;82(1):57-61.
56. Lo Y-T, Wahlqvist ML, Chang Y-H, Kao S, Lee M-S. Dietary diversity predicts type of medical expenditure in elders. 2013.
57. Kant AK. Indexes of overall diet quality: a review. *Journal of the American Dietetic Association* 1996;96(8):785-91.
58. Waijers P, Feskens E, Ocké MC. A critical review of predefined diet quality scores. *British Journal of Nutrition* 2007;97:219-31.
59. Thiele S, Mensink GBM, Beitz R. Determinants of diet quality. *Public Health Nutrition* 2004;7(1):29-37.
60. Drewnowski A, Henderson SA, Shore A, Fischler C, Preziosi P, Hercberg S. Diet quality and dietary diversity in France: implications for the French paradox. *Journal of the American Dietetic Association* 1996;96(7):663-69.
61. Cooper A, Sharp S, Lentjes M, Luben R, Khaw K, Wareham N, et al. A prospective study of the association between quantity and variety of fruit and vegetable intake and incident type 2 diabetes. *Diabetes Care* 2012;35(6):1293-300.
62. Jeurnink SM, Büchner FL, Bueno-de-Mesquita HB, Siersema PD, Boshuizen HC, Numans ME, et al. Variety in vegetable and fruit consumption and the risk of gastric and esophageal cancer in the European prospective investigation into cancer and nutrition. *International Journal of Cancer* 2012;131(6):E963-E73.
63. Büchner FL, Bueno-de-Mesquita HB, Ros MM, Overvad K, Dahm CC, Hansen L, et al. Variety in fruit and vegetable consumption and the risk of lung cancer in the European Prospective Investigation into Cancer and Nutrition. *Cancer Epidemiology Biomarkers & Prevention* 2010;19(9):2278-86.
64. Drewnowski A, Henderson SA, Driscoll A, Rolls BJ. The dietary variety score: assessing diet quality in healthy young and older adults. *Journal of the American Dietetic Association* 1997;97(3):266-71.
65. Chapman IM. Obesity paradox during aging. In: Mobbs C, Hof P, editors. *Body composition and aging*. Basel: Karger, 2010:20-36.
66. Finkelstein EA, Ruhm CJ, Kosa KM. Economic causes and consequences of obesity. *Annual Review of Public Health* 2005;26(1):239-57.

67. Finkelstein EA, Trogdon JG, Brown DS, Allaire BT, Dellea PS, Kamal-Bahl SJ. The lifetime medical cost burden of overweight and obesity: implications for obesity prevention. *Obesity* 2008;16(8):1843-48.
68. World Health Organization. Closing the gap in a generation: health equity through action on the social determinants of health. Geneva: WHO, 2008.
69. Gortmaker SL, Swinburn BA, Levy D, Carter R, Mabry PL, Finegood DT, et al. Changing the future of obesity: science, policy, and action. *The Lancet* 2011;378(9793):838-47.
70. Sutton R. Health Survey for England (HSE) - 2011: Chapter 10, Adult anthropometric measures, overweight and obesity. [online: http://www.hscic.gov.uk/catalogue/PUB09300]: Health and Social Care Information Centre, 2012 [accessed on: 3/02/2014].
71. International Agency for Research on Cancer. *World Cancer Report*. Geneva: WHO, 2014.
72. Mozaffarian D, Hao T, Rimm EB, Willett WC, Hu FB. Changes in diet and lifestyle and long-term weight gain in women and men. *New England Journal of Medicine* 2011;364(25):2392-404.
73. Martikainen PT, Marmot MG. Socioeconomic differences in weight gain and determinants and consequences of coronary risk factors. *American Journal of Clinical Nutrition* 1999;69(4):719-26.
74. Proper KI, Picavet SH, Bogers RP, Verschuren MW, Bemelmans WJ. The association between adverse life events and body weight change: results of a prospective cohort study. *BMC Public Health* 2013;13(1):957.
75. Baltrus PT, Everson-Rose SA, Lynch JW, Raghunathan TE, Kaplan GA. Socioeconomic position in childhood and adulthood and weight gain over 34 years: the Alameda County Study. *Annals of Epidemiology* 2007;17(8):608-14.
76. Steen B. Body composition and aging. *Nutrition Reviews* 1988;46(2):45-51.
77. Fogelholm M, Kujala U, Kaprio J, Sarna S. Predictors of weight change in middle-aged and old men. *Obesity* 2000;8(5):367-73.
78. Lahmann P, Lissner L, Gullberg B, Berglund G. Sociodemographic factors associated with long-term weight gain, current body fatness and central adiposity in Swedish women. *International Journal of Obesity & Related Metabolic Disorders* 2000;24(6).
79. Dugravot A, Sabia S, Stringhini S, Kivimaki M, Westerlund H, Vahtera J, et al. Do socioeconomic factors shape weight and obesity trajectories over the transition from midlife to old age? Results from the French GAZEL cohort study. *The American Journal of Clinical Nutrition* 2010;92(1):16-23.
80. Peeters A, Magliano DJ, Backholer K, Zimmet P, Shaw JE. Changes in the rates of weight and waist circumference gain in Australian adults over time: a longitudinal cohort study. *BMJ Open* 2014;4(1).
81. Dewan S, Wilding JP. Obesity and type-2 diabetes in the elderly. *Gerontology* 2003;49(3):137-45.
82. Newman AB, Lee JS, Visser M, Goodpaster BH, Kritchevsky SB, Tylavsky FA, et al. Weight change and the conservation of lean mass in old age: the Health, Aging and Body Composition Study. *The American Journal of Clinical Nutrition* 2005;82(4):872-78.
83. Newman AB, Kupelian V, Visser M, Simonsick EM, Goodpaster BH, Kritchevsky SB, et al. Strength, but not muscle mass, is associated with mortality in the Health, Aging and Body Composition Study cohort. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences* 2006;61(1):72-77.
84. Darmon N, Drewnowski A. Does social class predict diet quality? *The American Journal of Clinical Nutrition* 2008;87(5):1107-17.

85. Herne S. Research on food choice and nutritional status in elderly people: a review. *British Food Journal* 1995;97(9):12-29.
86. Krondl M, Coleman P. Social and biocultural determinants of food selection. *Progress in Food and Nutrition Science* 1986;10:179-203.
87. Lee JH, Ralston RA, Truby H. Influence of food cost on diet quality and risk factors for chronic disease: a systematic review. *Nutrition & Dietetics* 2011;68:248-61.
88. Lo Y-T, Chang Y-H, Lee M-S, Wahlqvist ML. Health and nutrition economics: diet costs are associated with diet quality. *Asia Pacific Journal Of Clinical Nutrition* 2009;18(4):598-604.
89. Swinburn B, Egger G, Raza F. Dissecting obesogenic environments: the development and application of a framework for identifying and prioritizing environmental interventions for obesity. *Preventive Medicine* 1999;29:563-70.
90. Schulz AJ, Zenk S, Odoms-Young A, Hollis-Neely T, Nwankwo R, Lockett M, et al. Healthy eating and exercising to reduce diabetes: exploring the potential of social determinants of health frameworks within the context of community-based participatory diabetes prevention. *American Journal of Public Health* 2005;95(4):645-51.
91. Stylianos N. Metabolic and humoral mechanisms of feeding and genesis of the ATP/ADP/AMP concept. *Physiology & Behavior* 2011;104(1):8-14.
92. Eertmans A, Baeyens F, Van den Bergh O. Food likes and their relative importance in human eating behavior: review and preliminary suggestions for health promotion. *Health Education Research* 2001;16(4):443-56.
93. Yeomans MR, Blundell JE, Leshem M. Palatability: response to nutritional need or need-free stimulation of appetite? *British Journal of Nutrition* 2004;92(SupplementS1):S3-S14.
94. Epstein LH, Salvy SJ, Carr KA, Dearing KK, Bickel WK. Food reinforcement, delay discounting and obesity. *Physiology & Behavior* 2010;100(5):438-45.
95. Bernardes S, Caramori PRA. Stages of change for fruit and vegetable intake among patients with atherosclerotic disease. *Appetite* 2011;57(3):656-60.
96. de Bruijn G-J, Kremers SPJ, de Vries H, van Mechelen W, Brug J. Associations of social–environmental and individual-level factors with adolescent soft drink consumption: results from the SMILE study. *Health Education Research* 2007;22(2):227-37.
97. Delormier T, Frohlich KL, Potvin L. Food and eating as social practice – understanding eating patterns as social phenomena and implications for public health. *Sociology of Health & Illness* 2009;31(2):215-28.
98. Glanz K, Sallis J, Saelens B, Frank L. Healthy nutrition environments: concepts and measures. *American Journal of Health Promotion* 2005;19(5):330-3.
99. Kamphuis CBM. Explaining socioeconomic inequalities in health behaviours: the role of environmental factors. Erasmus, 2008.
100. Cheadle A, Psaty BM, Curry S, Wagner E, Diehr P, Koepsell T, et al. Community-level comparisons between the grocery store environment and individual dietary practices. *Preventive Medicine* 1991;20(2):250-61.
101. Pomerlau J, Knai C, Branca F, Robertson A, Rutter H, McKee M, et al. Tackling the social and economic determinants of nutrition and physical activity for the prevention of obesity across Europe: D3.1 Review of the literature of obesity (and inequalities in obesity) in Europe and of its main determinatns: nutrition and physical activity. London, UK: London School of Hygiene& Tropical Medicine, 2008:1-55.
102. Yudkin J. Man's choice of food. *Lancet* 1956;i:645-49.

103. Stuckler D, Nestle M. Big food, food systems, and global health. *PLOS Medicine* 2012;9(6):e1001242.
104. Beydoun MA, Kuczmarski MTF, Mason MA, Ling SM, Evans MK, Zonderman AB. Role of depressive symptoms in explaining socioeconomic status disparities in dietary quality and central adiposity among US adults: a structural equation modeling approach. *The American Journal of Clinical Nutrition* 2009;90(4):1084-95.
105. Arvola A, Vassallo M, Dean M, Lampila P, Saba A, Lähteenmäki L, et al. Predicting intentions to purchase organic food: The role of affective and moral attitudes in the Theory of Planned Behaviour. *Appetite* 2008;50(2-3):443-54.
106. Vannoppen J, Verbeke W. Consumer value structures towards supermarket versus farm shop purchase of apples from integrated production in Belgium. *British Food Journal* 2002;104(10/11):828-28-44.
107. Furst T, Connors M, Bisogni CA, Sobal J, Winter Falk L. Food choice: a conceptual model of the process. *Appetite* 1996;26:247-66.
108. Sobal J, Bisogni C. Constructing food choice decisions. *Annals of Behavioral Medicine* 2009;38(0):37-46.
109. Arvola A, LÄHteenmÄKi L, Tuorila H. Predicting the intent to purchase unfamiliar and familiar cheeses: the effects of attitudes, expected liking and food neophobia. *Appetite* 1999;32(1):113-26.
110. Hall MRP. A good mixed diet. *Age & Ageing* 1973;2(3):135-38.
111. Booker CL, Sacker A. Health over the life course: associations between age, employment status and well-being. In: McFall SL, Garrington C, editors. *Early findings from the first wave of the UK's household longitudinal study*. Colchester: Institute for Social and Economic Research, University of Essex, 2011:75-85.
112. Cohen C. Social and economic factors in the nutrition of the elderly. *Proceedings of the Nutrition Society* 1974;33:51-57.
113. Joseph Rowntree Foundation. Pensioners' spending patterns and living standards: findings. *Social Policy Research*, 1995.
114. Brennan DS, Singh KA. Grocery purchasing among older adults by chewing ability, dietary knowledge and socio-economic status. *Public Health Nutrition* 2011;14(7):1279-84.
115. Burns C, Bentley R, Thornton L, Kavanagh A. Reduced food access due to a lack of money, inability to lift and lack of access to a car for food shopping: a multilevel study in Melbourne, Victoria. *Public Health Nutrition* 2011;14(06):1017-23.
116. Lumbers M, Raats M. Food choices in later life. In: Shepherd R, Raats M, editors. *The psychology of food choice*. Wallingford, UK: CABI Publishing, 2006:280-310.
117. Murcott A. *The sociology of food and eating*. Aldershot, UK: Gower Publishing Company Ltd., 1993.
118. O'Doherty Jensen K, Holm L. Preferences, quantities and concerns: socio-cultural perspectives on the gendered consumption of foods. *European Journal of Clinical Nutrition* 1999;53(5):351-59.
119. Pollard J, Greenwood D, Kirk S, Cade J. Motivations for fruit and vegetable consumption in the UK Women's Cohort Study. *Public Health Nutrition* 2002;5(03):479-86.
120. Wenrich TR, Brown JL, Miller-Day M, Kelley KJ, Lengerich EJ. Family members' influence on family meal vegetable choices. *Journal of Nutrition Education and Behavior* 2010;42(4):225-34.
121. Wolfe WS, Frongillo EA, Valois P. Understanding the experience of food insecurity by elders suggests ways to improve its measurement. *The Journal of Nutrition* 2003;133(9):2762-69.

122. Sharkey JR, Johnson CM, Dean WR. Food access and perceptions of the community and household food environment as correlates of fruit and vegetable intake among rural seniors. *BMC Geriatrics* 2010;10(1):32.
123. Keller HH, Ostbye T, Bright-See E. Predictors of dietary intake in Ontario seniors. *Canadian journal of public health. Revue canadienne de sante publique* 1996;88(5):305-09.
124. Payette H, Shatenstein B. Determinants of healthy eating in community-dwelling elderly people. *Canadian Journal of Public Health* 2005;96(Jul/Aug):S27-S31.
125. Pollard J, Kirk S, Cade J. Factors affecting food choice in relation to fruit and vegetable intake: a review. *Nutrition Research Reviews* 2002;15(2):373-87.
126. Beydoun MA, Wang Y. How do socio-economic status, perceived economic barriers and nutritional benefits affect quality of dietary intake among US adults? *European Journal of Clinical Nutrition* 2007;62(3):303-13.
127. Bihan H, Castetbon K, Mejean C, Peneau S, Pelabon L, Jellouli F, et al. Sociodemographic factors and attitudes toward food affordability and health are associated with fruit and vegetable consumption in a low-income French population. *The Journal of Nutrition* 2010;140(4):823-30.
128. Dean M, Raats M, Grunert KG, Lumbers M, The Food in Later Life Team. Factors influencing eating a varied diet in old age. *Public Health Nutrition* 2009;12(12):2421-27.
129. Blaylock J, Smallwood D, Kassel K, Variyam J, Aldrich L. Economics, food choices and nutrition. *Food Policy* 1999;24:269-86.
130. Stávková J, Stejskal L, Procházková Z. Application of behavioural economy principles in the grocery market. *Agricultural Economics* 2009;55(7):314-20.
131. Homenko DR, Morin PC, Eimicke JP, Teresi JA, Weinstock RS. Food insecurity and food choices in rural older adults with diabetes receiving nutrition education via telemedicine. *Journal of Nutrition Education and Behavior* 2010;42(6):404-09.
132. Donkin AJM, Johnson AE, Lilley JM, Morgan K, Neale RJ, Page RM, et al. Gender and living alone as determinants of fruit and vegetable consumption among the elderly living at home in urban Nottingham. *Appetite* 1998;30(1):39-51.
133. Brinberg D, Axelson ML, Price S. Changing food knowledge, food choice, and dietary fiber consumption by using tailored messages. *Appetite* 2000;35(1):35-43.
134. Pearson N, Atkin AJ, Biddle SJ, Gorely T. A family-based intervention to increase fruit and vegetable consumption in adolescents: a pilot study. *Public Health Nutrition* 2010;13(06):876-85.
135. Salvy S-J, Nitecki L, Epstein L. Do social activities substitute for food in youth? *Annals of Behavioral Medicine* 2009;38(3):205-12.
136. Barker M, Thompson K, McClean S. Attitudinal dimensions of food choice and nutrient intake. *British Journal of Nutrition* 1995;74:649-59.
137. Bissonnette MM, Contento IR. Adolescents' perspectives and food choice behaviors in terms of the environmental impacts of food production practices: application of a psychosocial model. *Journal of Nutrition Education* 2001;33(2):72-82.
138. Di Noia J, Schinke S, Prochaska J, Contento I. Application of the Transtheoretical Model to fruit and vegetable consumption among economically disadvantaged African-American adolescents: preliminary findings. *American Journal of Health Promotion* 2006;20(5):342-48.
139. Horwath CC, Nigg CR, Motl RW, Wong KT, Dishman RK. Investigating fruit and vegetable consumption using the Transtheoretical Model. *American Journal of Health Promotion* 2010;24(5):324-33.

140. Kasila K, Poskiparta M, Karhila P, Kettunen T. Patients' readiness for dietary change at the beginning of counselling: a transtheoretical model-based assessment. *Journal of Human Nutrition and Dietetics* 2003;16(3):159-66.
141. Kim K, Reicks M, Sjoberg S. Applying the Theory of Planned Behavior to predict dairy product consumption by older adults. *Journal of Nutrition Education and Behavior* 2003;35(6):294-301.
142. Kiviniemi MT, Duangdao KM. Affective associations mediate the influence of cost–benefit beliefs on fruit and vegetable consumption. *Appetite* 2009;52(3):771-75.
143. Kronick I, Knäuper B. Temptations elicit compensatory intentions. *Appetite* 2010;54(2):398-401.
144. Krutulyte R, Grunert KG, Scholderer J, Hagemann KS, Elgaard P, Nielsen B, et al. Motivational factors for consuming omega-3 PUFAs: an exploratory study with Danish consumers. *Appetite* 2008;51(1):137-47.
145. Michael M. How emotions affect eating: a five-way model. *Appetite* 2008;50(1):1-11.
146. Saba A, Vassallo M, Turrini A. The role of attitudes, intentions and habit in predicting actual consumption of fat containing foods in Italy. *European Journal of Clinical Nutrition* 2000;54:540-45.
147. Sun X, Guo Y, Wang S, Sun J. Predicting iron-fortified soy sauce consumption intention: application of the Theory of Planned Behavior and Health Belief Model. *Journal of Nutrition Education and Behavior* 2006;38(5):276-85.
148. Tuu HH, Olsen SO, Thao DT, Anh NTK. The role of norms in explaining attitudes, intention and consumption of a common food (fish) in Vietnam. *Appetite* 2008;51(3):546-51.
149. Webber CB, Sobal J, Dollahite JS. Shopping for fruits and vegetables: food and retail qualities of importance to low-income households at the grocery store. *Appetite* 2010;54(2):297-303.
150. Hamlin R. Cue-based decision making: a new framework for understanding the uninvolved food consumer. *Appetite* 2010;55(1):89-98.
151. Jaeger SR, Bava CM, Worch T, Dawson J, Marshall DW. The food choice kaleidoscope: a framework for structured description of product, place and person as sources of variation in food choices. *Appetite* 2011;56(2):412-23.
152. Chang M-W, Brown RL, Nitzke S, Baumann LC. Development of an instrument to assess predisposing, enabling, and reinforcing constructs associated with fat intake behaviors of low-income mothers. *Journal of Nutrition Education and Behavior* 2004;36(1):27-34.
153. Chang M-W, Nitzke S, Brown R, Baumann L. Predictors of low-income, obese mothers' use of healthful weight management behaviors. *Journal of Nutrition Education and Behavior* 2011;43(2):87-95.
154. Bava CM, Jaeger SR, Park J. Constraints upon food provisioning practices in 'busy' women's lives: Trade-offs which demand convenience. *Appetite* 2008;50(2-3):486-98.
155. Clark AM, Duncan AS, Trevoy JE, Heath S, Chan M. Healthy diet in Canadians of low socioeconomic status with coronary heart disease: not just a matter of knowledge and choice. *Heart & Lung: The Journal of Acute and Critical Care* 2011;40(2):156-63.
156. Lloyd B, Dumbrell S. Modifying the food supply at a community swimming pool: a case study. *Health Promotion Journal of Australia* 2011;22(1):22-6.
157. Schäfer RB, Keith PM. Social-psychological factors in the dietary quality of married and single elderly. *Journal of the American Dietetic Association* 1982;81(1):30-34.
158. Schäfer RB, Schäfer E, Dunbar M, Keith PM. Marital food interaction and dietary behavior. *Soc Sci Med* 1999;48(6):787-96.

159. Story M, Neumark-Sztainer D, French S. Individual and environmental influences on adolescent eating behaviors. *Journal of the American Dietetic Association* 2002;102(3, Supplement):S40-S51.
160. Sallis J, Owen N, Fisher E. Ecological models of health behavior. In: Glanz K, Rimer B, Viswanath K, editors. *Health behavior and health education: theory, research and practice*. 4th ed. San Francisco, CA.: John Wiley & Sons, Inc., 2008:465-85.
161. Swinburn BA, Sacks G, Hall KD, McPherson K, Finegood DT, Moodie ML, et al. The global obesity pandemic: shaped by global drivers and local environments. *The Lancet* 2011;378(9793):804-14.
162. Sorensen G, Stoddard AM, Dubowitz T, Barbeau EM, Bigby J, Emmons KM, et al. The influence of social context on changes in fruit and vegetable consumption: results of the healthy directions studies. *American Journal of Public Health* 2007;97(7):1216-27.
163. Bisogni CA, Jastran M, Shen L, Devine CM. A biographical study of food choice capacity: standards, circumstances, and food management skills. *Journal of Nutrition Education and Behavior* 2005;37(6):284-91.
164. Travis S, Bisogni C, Ranzenhofer L. A conceptual model of how US families with athletic adolescent daughters manage food and eating. *Appetite* 2010;54(1):108-17.
165. Vandenbroeck I, Goossens J, Clemens M. Foresight. Tackling obesities: future choices - building the Obesity System Map. London: Government Office for Science, 2007.
166. Lawlor DA, Tooth L, Lee C, Dobson A. A comparison of the association between socioeconomic position and cardiovascular disease risk factors in three age cohorts of Australian women: findings from the Australian Longitudinal Study on Women's Health. *Journal of Public Health* 2005;27(4):378-87.
167. Schumann B, Kluttig A, Tiller D, Werdan K, Haerting J, Greiser KH. Association of childhood and adult socioeconomic indicators with cardiovascular risk factors and its modification by age: the CARLA Study 2002-2006. *BMC Public Health* 2011;11(1):289.
168. Schäfer Elinder L, Jansson M. Obesogenic environments – aspects on measurement and indicators. *Public Health Nutrition* 2009;12(03):307-15.
169. World Health Organization. A conceptual framework for action on the social determinants of health. Geneva: WHO, 2010.
170. Bronfenbrenner U. *The ecology of human development*. Boston, MA: Harvard University Press, 1977.
171. Rehm CD, Moudon AV, Hurvitz PM, Drewnowski A. Residential property values are associated with obesity among women in King County, WA, USA. *Soc Sci Med* 2012;75(3):491-95.
172. McKeown T. *The origins of human disease*. Oxford: Basil Blackwell Ltd, 1988.
173. Link BG, Phelan J. Social conditions as fundamental causes of disease. *Journal of Health and Social Behavior* 1995:80-94.
174. Braveman P, Egerter S, Williams DR. The social determinants of health: coming of age. *Annual Review of Public Health* 2011;32:381-98.
175. Carlson P. The European health divide: a matter of financial or social capital? *Soc Sci Med* 2004;59(9):1985-92.
176. McLaren L. Socioeconomic status and obesity. *Epidemiologic Reviews* 2007;29(1):29-48.
177. Ball K, Crawford D. Socioeconomic status and weight change in adults: a review. *Soc Sci Med* 2005;60(9):1987-2010.
178. Langenberg C, Hardy R, Kuh D, Brunner E, Wadsworth M. Central and total obesity in middle aged men and women in relation to lifetime socioeconomic status: evidence from a national birth cohort. *Journal of Epidemiology and Community Health* 2003;57(10):816-22.

179. Braveman P, Cubbin C, Egerter S, Chideya S, Marchi K, Metzler M, et al. Socioeconomic status in health research: one size does not fit all. *Journal of the American Medical Association* 2005;294(22):2879-88.
180. Bird CE, Rieker PP. *Gender and health: the effects of constrained choices and social policies*. New York, US: Cambridge University Press, 2008.
181. Sobal J. Obesity and socioeconomic status: a framework for examining relationships between physical and social variables. *Medical Anthropology* 1991;13(3):231-47.
182. Ball K, Mishra GD, Crawford D. Social factors and obesity: an investigation of the role of health behaviours. *International Journal of Obesity* 2003;27(3):394-403.
183. Ward H, Tarasuk V, Mendelson R, McKeown-Eyssen G. An exploration of socioeconomic variation in lifestyle factors and adiposity in the Ontario Food Survey through structural equation modeling. *International Journal of Behavioral Nutrition and Physical Activity* 2007;4(1):8.
184. Khlat M, Jusot F, Ville I. Social origins, early hardship and obesity: a strong association in women, but not in men? *Soc Sci Med* 2009;68(9):1692-99.
185. Borodulin K, Zimmer C, Sippola R, Mäkinen TE, Laatikainen T, Prättälä R. Health behaviours as mediating pathways between socioeconomic position and body mass index. *International Journal of Behavioral Medicine* 2012;19(1):14-22.
186. Giskes K, Lenthe FJ, Turrell G, Kamphuis C, Brug J, Mackenbach JP. Socioeconomic position at different stages of the life course and its influence on body weight and weight gain in adulthood: a longitudinal study with 13-year follow-up. *Obesity* 2008;16(6):1377-81.
187. Corna LM. A life course perspective on socioeconomic inequalities in health: a critical review of conceptual frameworks. *Advances in Life Course Research* 2013;18(2):150-59.
188. Brug J, Kremers SP, Lenthe Fv, Ball K, Crawford D. Environmental determinants of healthy eating: in need of theory and evidence. *Proceedings of the Nutrition Society* 2008;67(03):307-16.
189. Shadel W, Cervone D. The role of the self in smoking initiation and smoking cessation: a review and blueprint for research at the intersection of social-cognition and health. *Self and Identity* 2011;10(3):386-95.
190. Pikora T, Giles-Corti B, Bull F, Jamrozik K, Donovan R. Developing a framework for assessment of the environmental determinants of walking and cycling. *Soc Sci Med* 2003;56(8):1693-703.
191. Hendy HM. Social cognitive predictors of nutritional risk in rural elderly adults. *International Journal of Ageing and Human Development* 1998;47(4):299-327.
192. Consumer & nutrition: challenges and chances for research and society. 9th Karlsruhe Nutrition Congress, 10-12 October; 2004; Karlsruhe. Bundesforschungsanstalt für Ernährung und Lebensmittel.
193. Phillips CV. Complex systems model of dietary choice with implications for improving diets and promoting vegetarianism. *The American Journal of Clinical Nutrition* 1999;70(3):608S-14S.
194. Maynard M. Healthy diet at post-retirement ages: a life course perspective. *The Journal of The Royal Society for the Promotion of Health* 2002;122(3):142-43.
195. Carol M D. A life course perspective: understanding food choices in time, social location, and history. *Journal of Nutrition Education and Behavior* 2005;37(3):121-28.
196. Devine CM, Wolfe WS, Frongillo Jr EA, Bisogni CA. Life-course events and experiences: association with fruit and vegetable consumption in 3 ethnic groups. *Journal of the American Dietetic Association* 1999;99(3):309-14.

197. Graham H. Building an inter-disciplinary science of health inequalities: the example of lifecourse research. *Soc Sci Med* 2002;55(11):2005-16.
198. McDonough P, Berglund P. Histories of poverty and self-rated health trajectories. *Journal of Health and Social Behavior* 2003:198-214.
199. Adler NE, Stewart J. Health disparities across the lifespan: Meaning, methods, and mechanisms. *Annals of the New York Academy of Sciences* 2010;1186(1):5-23.
200. Department of Health (DH). New horizons: a shared vision for mental health. London: Department of Health, 2009 (December).
201. Roering KJ, Boush DM, Shipp SH. Factors that shape eating patterns: a consumer behavior perspective. *What is America eating? Proceedings of a symposium*. Washington, D.C.: National Academy Press, 1986:72-84.
202. Scheibehenne B, Miesler L, Todd PM. Fast and frugal food choices: uncovering individual decision heuristics. *Appetite* 2007;49(3):578-89.
203. Shiv B, Fedorikhin A. Heart and mind in conflict: the interplay of affect and cognition in consumer decision making. *Journal of Consumer Research* 1999;26(3):278-92.
204. Beatty TK, Blow L, Crossley TF. Is there a 'heat-or-eat'trade-off in the UK? *Journal of the Royal Statistical Society: Series A (Statistics in Society)* 2014;177(1):281-94.
205. Ling T, Villalba van Dijk L. Performance audit handbook: routes to effective evaluation. Santa Monica: RAND Corporation, 2009.
206. Denton M, Prus S, Walters V. Gender differences in health: a Canadian study of the psychosocial, structural and behavioural determinants of health. *Soc Sci Med* 2004;58(12):2585-600.
207. Bourdieu P. La distinction: critique sociale du jugement. 1979.
208. Pearlin LI. The sociological study of stress. *Journal of Health and Social Behavior* 1989;30(September):241-56.
209. Pudrovska T, Schieman S, Pearlin LI, Nguyen K. The sense of mastery as a mediator and moderator in the association between economic hardship and health in late life. *Journal of Aging and Health* 2005;17(5):634-60.
210. Hank K, Erlinghagen M. Perceptions of job security in Europe's ageing workforce. *Social Indicators Research* 2011;103:427-42.
211. Office of National Statistics. *Family Spending: a report on the 2010 Living Costs and Food Survey*. London: The Stationery Office, 2011.
212. Day N, Oakes S, Luben R, Khaw KT, Bingham S, Welch A, et al. EPIC-Norfolk: study design and characteristics of the cohort. European Prospective Investigation of Cancer. *British Journal of Cancer* 1999;80 Suppl 1:95-103.
213. NatCen. English Longitudinal Study of Ageing (ELSA). [online] http://www.natcen.ac.uk/our-research/research/english-longitudinal-study-of-ageing/: NatCen Social Research [accessed on 15/11/2012].
214. Health and Retirement Study. A Longitudinal study of health, retirement, and aging. Sponsored by the National Institute on Aging. [online] http://hrsonline.isr.umich.edu/: University of Michigan [accessed on 15/11/2012].
215. World Health Organization. WHO study on global ageing and adult health (SAGE). [online] http://www.who.int/healthinfo/sage/en/: WHO [acessed on: 15/11/2012].
216. Marmot M, Brunner E. Cohort profile: the Whitehall II study. *International Journal of Epidemiology* 2005;34(2):251-56.
217. Office of Population Censuses and Surveys. General Household Survey. London: HMSO, 1992.
218. McFadden E, Luben R, Wareham N, Bingham S, Khaw K-T. Occupational social class, risk factors and cardiovascular disease incidence in men and women: a prospective study

in the European Prospective Investigation of Cancer and Nutrition in Norfolk (EPIC-Norfolk) cohort. *Eur J Epidemiol* 2008;23(7):449-58.
219. Pollack CE, Chideya S, Cubbin C, Williams B, Dekker M, Braveman P. Should health studies measure wealth? a systematic review. *American Journal of Preventive Medicine* 2007;33(3):250-64.
220. Maynard M, Gunnell D, Ness AR, Abraham L, Bates CJ, Blane D. What influences diet in early old age? Prospective and cross-sectional analyses of the Boyd Orr cohort. *The European Journal of Public Health* 2006;16(3):315-23.
221. Li F, Harmer PA, Cardinal BJ, Bosworth M, Acock A, Johnson-Shelton D, et al. Built environment, adiposity, and physical activity in adults aged 50–75. *American Journal of Preventive Medicine* 2008;35(1):38-46.
222. Surtees PG, Wainwright NWJ. The shackles of misfortune: social adversity assessment and representation in a chronic-disease epidemiological setting. *Soc Sci Med* 2007;64(1):95-111.
223. Surtees PG, Wainwright NWJ, Brayne C. Psychosocial aetiology of chronic disease: a pragmatic approach to the assessment of lifetime affective morbidity in an EPIC component study. *Journal of Epidemiology and Community Health* 2000;54(2):114-22.
224. Dillman D. *Mail and telephone surveys: the total design method*. New York: Wiley, 1978.
225. Pearlin LI, Schooler C. The structure of coping. *Journal of Health and Social Behavior* 1978;19(March):2-21.
226. Bingham SA, Gill C, Welch A, Day K, Cassidy A, Khaw K, et al. Comparison of dietary assessment methods in nutritional epidemiology: weighed records v. 24 h recalls, food-frequency questionnaires and estimated-diet records. *British Journal of Nutrition* 1994;72(4):619-43.
227. Day N, McKeown N, Wong M, Welch A, Bingham S. Epidemiological assessment of diet: a comparison of a 7-day diary with a food frequency questionnaire using urinary markers of nitrogen, potassium and sodium. *International Journal of Epidemiology* 2001;30(2):309-17.
228. McKeown NM, Day NE, Welch AA, Runswick SA, Luben RN, Mulligan AA, et al. Use of biological markers to validate self-reported dietary intake in a random sample of the European Prospective Investigation into Cancer United Kingdom Norfolk cohort. *The American Journal of Clinical Nutrition* 2001;74(2):188-96.
229. Bingham SA, Welch A, McTaggart A, Mulligan A, Runswick S, Luben R, et al. Nutritional methods in the European Prospective Investigation of Cancer in Norfolk. *Public Health Nutrition* 2001;4(3):847-58.
230. Willett W. *Nutritional epidemiology. Third edition*. Oxford: Oxford University Press, 2013.
231. Welch AA, Luben R, Khaw KT, Bingham SA. The CAFE computer program for nutritional analysis of the EPIC-Norfolk food frequency questionnaire and identification of extreme nutrient values. *Journal of Human Nutrition and Dietetics* 2005;18(2):99-116.
232. StataCorp. *Stata statistical software: release 12*. College Station, TX: StataCorp LP, 2011.
233. Mozaffarian D, Appel LJ, Van Horn L. Components of a cardioprotective diet: new insights. *Circulation* 2011;123(24):2870-91.
234. Shepherd A. Nutrition through the life span. Part 3: adults aged 65 years and over. *British Journal of Nursing* 2009;18(5):301-07.
235. Scientific Advisory Committee on Nutrition (SACN). The nutritional wellbeing of the British population. London: SACN, 2008.

236. Millen BE, Silliman RA, Cantey-Kiser J, Copenhafer DL, Ewart CV, Ritchie CS, et al. Nutritional risk in an urban homebound older population: the nutrition and healthy aging project. *Journal of Nutrition Health and Aging* 2001;5(4):269-77.
237. Szczeciñska A, Kozlowska K, Roszkowski W, Brzozowska A, Raats M, Lumbers M. Differences in frequency of fruit and vegetables intake among older Europeans: Food in Later Life Project. *Polish Journal of Natural Science* 2007;Supplement 4:244-51.
238. McGandy RB, Russell RM, Hartz SC, Jacob RA, Tannenbaum S, Peters H, et al. Nutritional status survey of healthy noninstitutionalized elderly: energy and nutrient intakes from three-day diet records and nutrient supplements. *Nutrition Research* 1986;6(7):785-98.
239. World Health Organization. Keep fit for life: meeting the nutritonal needs of older persons. Geneva: World Health Organization, 2002.
240. McKenzie JC. Economic influences on food choice. *Nutrition & Food Science* 1979;79(5):4-7.
241. Lallukka T, Laaksonen M, Rahkonen O, Roos E, Lahelma E. Multiple socio-economic circumstances and healthy food habits. *European Journal of Clinical Nutrition* 2006;61(6):701-10.
242. Denny A. An overview of the role of diet during the ageing process. *British Journal of Community Nursing* 2008;13(2):58-67.
243. Darmon N, Ferguson EL, Briend A. A cost constraint alone has adverse effects on food selection and nutrient density: an analysis of human diets by linear programming. *The Journal of Nutrition* 2002;132(12):3764-71.
244. Leather S. Less money, less choice: poverty and diet in the UK today. In: Council NC, editor. *Your food - Whose choice?* London: Stationery Office (HMSO), 1992:72-94.
245. Hanes FA, De Looy AE. Can I afford the diet? *Human Nutrition: Applied Nutrition* 1987;41(A):1-12.
246. Anderson W, White V, Finney A. "You just have to get by": coping with low incomes and cold homes. Bristol: Centre for Sustainable Energy, 2010.
247. Anderson A, Morris SE. Changing fortunes: changing food choices. *Nutrition & Food Science* 2000;30(1):12-15.
248. Shepherd R, Paisley CM, Sparks P, Anderson A, Eley S, Lean M. Constraints on dietary choice: the role of income. *Nutrition & Food Science* 1996;Sept/Oct(5):19-21.
249. Senauer B. Economics and nutrition. *What is America eating? Proceedings of a symposium*. Washington, D.C.: National Academy Press, 1986:46-57.
250. Dellava JE, Bulik CM, Popkin BM. Prices changes alone are not adequate to produce long-term dietary change. *The Journal of Nutrition* 2010;140:1887-91.
251. Chouinard HH, Davis DE, LaFrance JT, Perloff JM. Fat taxes: big money for small change. *Forum for Health Economics & Policy* 2007;10(2):1-28.
252. Smed S, Jensen JD, Denver S. Socio-economic characteristics and the effect of taxation as a health policy instrument. *Food Policy* 2007;32(5–6):624-39.
253. Nordström J, Thunström L. Can targeted food taxes and subsidies improve the diet? Distributional effects among income groups. *Food Policy* 2010;36:259-71.
254. Schünemann HJ, Oxman AD, Vist GE, Higgins JPT, Deeks J, Glasziou P, et al. Chapter 12: Interpreting results and drawing conclusions. In: Higgins JPT GS, editor. *Cochrane handbook for systematic reviews of interventions version 5.1.0*. online: The Cochrane Collaboration (Available from www.cochrane-handbook.org), 2008.
255. Deeks J, Dinnes J, D'Amico R, Sowden A, Sakarovitch C, Song F, et al. Evaluating non-randomised intervention studies. *Health Technology Assessment* 2003;7(27):1-192.

256. Davies L, Holdsworth D, Macfarlane D. Dietary fibre intakes in the United Kingdom before and after retirement from work. *Human Nutrition: Applied Nutrition* 1986;10:431-39.
257. Steen B, Nilsson K, Robertsson E, Östberg H. Age retirement in women II. Dietary habits and body composition. *Comprehensive Gerontology* 1988;2:78-82.
258. Lauque S, Nourashémi F, Soleilhavoup C, Guyonnet S, Bertiere MC, Sachet P, et al. A prosptective study of changes on nutritional patterns 6 months before and 18 months after retirement. *Journal of Nutrition Health and Aging* 1998;2(2):88-91.
259. Lundberg S, Startz R, Stillman S. The retirement-consumption puzzle: a marital bargaining approach. *Journal of Public Economics* 2003;87:1199-218.
260. Nooyens A, Visscher T, Schuit A, van Rossum C, Verschuren W, van Mechelen W, et al. Effects of retirement on lifestyle in relation to changes in weight and waist circumference in Dutch men: a prospective study. *Public Health Nutrition* 2005;8(8):1266-74.
261. Smith S. The retirement-consumption puzzle and involuntary early retirement: evidence from the British household panel survey. *The Economic Journal* 2006;116(March):C130-C48.
262. Chung S, Popkin BM, Domino ME, Stearns SC. Effect of retirement on eating out and weight change: an analysis of gender differences. *Obesity* 2007;15(4):1053-60.
263. Abusabha R, Namjoshi D, Klein A. Increasing access and affordability of produce improves perceived consumption of vegetables in low-income seniors. *Journal of the American Dietetic Association* 2011;111(October):1549-55.
264. Helldán A, Lallukka T, Rahkonen O, Lahelma E. Changes in healthy food habits after transition to old age retirement. *European Journal of Public Health* 2012;22(4):582-86.
265. Adams L, West S. *Just above the breadline: living on a low income in later life*. London: Age Concern England, 2006.
266. Brown NA, Smith KC, Kromm EE. Women's perceptions of the relationship between recent life events, transitions, and diet in midlife: findings from a focus group study. *Women & Health* 2012;52(3):234-51.
267. Wang M, Shultz KS. Employee retirement: a review and recommendations for future investigation. *Journal of Management* 2010;36(1):172-206.
268. Galobardes B, Morabia A, Bernstein MS. Diet and socioeconomic position: does the use of different indicators matter? *International Journal of Epidemiology* 2001;30(2):334-40.
269. Giskes K, Turrell G, Patterson C, Newman B. Socioeconomic differences among Australian adults in consumption of fruit and vegetables and intakes of vitamins A, C and folate. *Journal of Human Nutrition and Diet* 2002;15(5):375-85.
270. Ahn BC, Engelhardt K, Joung H. Diet variety is associated with socio-economic factors. *Ecology of Food and Nutrition* 2006;45:417-30.
271. Rydén P. Toward an understanding of the barriers to and facilitators of dietary change. Umeå University, 2011.
272. Lo Y-T, Chang Y-H, Lee M-S, Wahlqvist ML. Dietary diversity and food expenditure as indicators of food security in older Taiwanese. *Appetite* 2012;58:180-87.
273. Lallukka T, Laaksonen M, Rahkonen O. Healthy eating: what is the role of the economic situation? In: Watson R, Preedy V, editors. *Bioactive foods in promoting health: fruits and vegetables*. London, UK: Elsevier, 2010:99-110.

274. Temple JB. Household factors associated with older Australian's purchasing a varied diet: results from household expenditure data. *Nutrition & Dietetics* 2006;63(1):28-35.
275. Turrell G. Structural, material and economic influences on the food-purchasing choices of socioeconomic groups. *Australian and New Zealand Journal of Public Health* 1996;20(6):611-17.
276. Sullivan JX, Turner L, Danziger S. The relationship between income and material hardship. *Journal of Policy Analysis and Managemant* 2008;27(1):63-81.
277. Corman H, Noonan K, Reichman NE, Schultz J. Effects of financial insecurity on social interactions. *The Journal of Socio-Economics* 2012;41(5):574-83.
278. Ouellette T, Burstein N, Long D, Beecroft E. *Measures of material hardship: final report*. Washington: U.S. Department of Health and Human Services, 2004.
279. Rahkonen O, Laaksonen M, Karvonen S. The contribution of lone parenthood and economic difficulties to smoking. *Soc Sci Med* 2005;61(1):211-16.
280. Davis MA, Murphy SP, Neuhaus JM, Lein D. Living arrangements and dietary quality of older U.S. adults. *Journal of the American Dietetic Association* 1990;90(12):1667-72.
281. Irz X, Fratiglioni L, Kuosmanen N, Mazzocchi M, Modugno L, Nocella G, et al. Sociodemographic determinants of diet quality of the EU elderly: a comparative analysis in four countries. *Public Health Nutrition* 2013:1-13.
282. Kahn JR, Pearlin LI. Financial strain over the life course and health among older adults. *Journal of Health and Social Behavior* 2006;47(1):17-31.
283. Ferrie J, Martikainen P, Shipley M, Marmot M. Self-reported economic difficulties and coronary events in men: evidence from the Whitehall II study. *International Journal of Epidemiology* 2005;34(3):640-48.
284. Lallukka T, Ferrie JE, Kivimäki M, Shipley MJ, Rahkonen O, Lahelma E. Economic difficulties and subsequent sleep problems: evidence from British and Finnish occupational cohorts. *Sleep Medicine* 2012;13(6):680-85.
285. Locher JL, Ritchie CS, Roth DL, Baker PS, Bodner EV, Allman RM. Social isolation, support, and capital and nutritional risk in an older sample: ethnic and gender differences. *Soc Sci Med* 2005;60(4):747-61.
286. Conklin AI, Forouhi NG, Surtees P, Khaw K-T, Wareham NJ, Monsivais P. Social relationships and healthful dietary behaviour: Evidence from over-50s in the EPIC cohort, UK. *Soc Sci Med* 2013:1-9.
287. Stringhini S, Berkman L, Dugravot A, Ferrie JE, Marmot M, Kivimaki M, et al. Socioeconomic status, structural and functional measures of social support, and mortality: the British Whitehall II Cohort Study, 1985–2009. *American Journal of Epidemiology* 2012;175(12):1275-83.
288. Turrell G, Hewitt B, Patterson C, Oldenburg B. Measuring socio-economic position in dietary research: is choice of socio-economic indicator important? *Public Health Nutrition* 2003.
289. Wahlqvist ML, Lo CS, Myers K. Food variety is associated with less macrovascular disease in those with type II diabetes and their healthy controls. *Journal of the American College of Nutrition* 1989;8(6):515-23.
290. Mente A, de Koning L, Shannon HS, Anand SS. A systematic review of the evidence supporting a causal link between dietary factors and coronary heart disease. *Archives of Internal Medicine* 2009;169(7):659-69.
291. Claesson MJ, Jeffery IB, Conde S, Power SE, O'Connor EM, Cusack S, et al. Gut microbiota composition correlates with diet and health in the elderly. *Nature* 2012;488(7410):178-84.

292. Randall E, Nichaman M, Contant C. Diet diversity and nutrient intake. *Journal of the American Dietetic Association* 1985;85(7):830-36.
293. Hodgson JM, Hsu-Hage B, Wahlqvist ML. Food variety as a quantitative descriptor of food intake. *Ecology of Food and Nutrition* 1994;32(3-4):137-48.
294. Marks S, Wahlqvist M. Practical dietary advice in primary care medicine. *Modern Medicine of Australia* 1991;November:43-57.
295. Kant A, Schatzkin A, Harris T, Ziegler R, Block G. Dietary diversity and subsequent mortality in the First National Health and Nutrition Examination Survey Epidemiologic Follow-up Study. *The American Journal of Clinical Nutrition* 1993;57(3):434-40.
296. Shohaimi S, Welch A, Bingham S, Luben R, Day N, Wareham N, et al. Residential area deprivation predicts fruit and vegetable consumption independently of individual educational level and occupational social class: a cross sectional population study in the Norfolk cohort of the European Prospective Investigation into Cancer (EPIC-Norfolk). *Journal of Epidemiology and Community Health* 2004;58(8):686-91.
297. Lyon P, Colquhoun A. Home, hearth and table: a centennial review of the nutritional circumstances of older people living alone. *Ageing & Society* 1999;19:53-67.
298. Wiig K, Smith C. The art of grocery shopping on a food stamp budget: factors influencing the food choices of low-income women as they try to make ends meet. *Public Health Nutrition* 2009;12(10):1726-34.
299. Tarasuk V. Discussion paper on household and individual food insecurity. *Health Canada* 2001:13.
300. Leibtag ES, Kaufman PR. Exploring food purchase behavior of low-income households: how do they economize?: United States Department of Agriculture, Economic Research Service, 2003.
301. Laaksonen M, Sarlio-Lähteenkorva S, Lahelma E. Multiple dimensions of socioeconomic position and obesity among employees: The Helsinki Health Study. *Obesity Research* 2004;12(11):1851-58.
302. Loman T, Lallukka T, Laaksonen M, Rahkonen O, Lahelma E. Multiple socioeconomic determinants of weight gain: the Helsinki Health Study. *BMC Public Health* 2013;13:259-66.
303. Averett SL, Smith JK. Financial hardship and obesity: the link between weight and household debt. *Women* 2013;100(100):100.
304. Conklin AI, Forouhi NG, Suhrcke M, Surtees P, Wareham N, Monsivais P. Socioeconomic status, financial hardship and measured obesity in older adults: a cross-sectional study of the EPIC-Norfolk cohort. *BMC Public Health* 2013;13(1):1039.
305. Buijsse B, Feskens EJ, Schulze MB, Forouhi NG, Wareham NJ, Sharp S, et al. Fruit and vegetable intakes and subsequent changes in body weight in European populations: results from the project on Diet, Obesity, and Genes (DiOGenes). *The American Journal of Clinical Nutrition* 2009;90(1):202-09.
306. Berkman LF, Glass T, Brissette I, Seeman TE. From social integration to health: Durkheim in the new millennium. *Soc Sci Med* 2000;51(6):843-57.
307. Blakely T, Ni Mhurchu C, Jiang Y, Matoe L, Funaki-Tahifote M, Eyles HC, et al. Do effects of price discounts and nutrition education on food purchases vary by ethnicity, income and education? Results from a randomised, controlled trial. *Journal of Epidemiology and Community Health* 2011;65(10):902-08.
308. Rao M, Afshin A, Singh G, Mozaffarian D. Do healthier foods and diet patterns cost more than less healthy options? A systematic review and meta-analysis. *BMJ Open* 2013;3(12).

309. AgeUK website. Money matters. *Internet: http://www.ageuk.org.uk/money-matters/*: Internet: http://www.ageuk.org.uk/money-matters/ (accessed 4 November 2013).
310. FRAC website. Seniors and SNAP/Food Stamps. Internet: http://frac.org/initiatives/addressing-senior-hunger/seniors-and-snapfood-stamps/ (accessed on 9 November 2013).
311. Holt-Lunstad J, Smith TB, Layton JB. Social relationships and mortality risk: a meta-analytic review. *PLOS Medicine* 2010;7(7):e1000316.
312. Fuhrer R, Stansfeld SA, Chemali J, Shipley MJ. Gender, social relations and mental health: prospective findings from an occupational cohort (Whitehall II study). *Soc Sci Med* 1999;48(1):77-87.
313. Hessler RM, Jia S, Madsen R, Pazaki H. Gender, social networks and survival time: a 20-year study of the rural elderly. *Archives of Gerontology and Geriatrics* 1995;21:291-306.
314. Kimmel PL, Peterson RA, Weihs KL, Shidler N, Simmens SJ, Alleyne S, et al. Dyadic relationship conflict, gender, and mortality in urban hemodialysis patients. *Journal of the American Society of Nephrology* 2000;11(8):1518-25.
315. Shye D, Mullooly JP, Freeborn DK, Pope CR. Gender differences in the relationship between social network support and mortality: a longitudinal study of an elderly cohort. *Soc Sci Med* 1995;41(7):935-47.
316. Chuang Y-C, Chuang K-Y. Gender differences in relationships between social capital and individual smoking and drinking behavior in Taiwan. *Soc Sci Med* 2008;67(8):1321-30.
317. De Castro J, De Castro E. Spontaneous meal patterns of humans: influence of the presence of other people. *The American Journal of Clinical Nutrition* 1989;50(2):237-47.
318. De Castro J, Brewer E, Elmore DK, Orozco S. Social facilitation of the spontaneous meal size of humans occurs regardless of time, place, alcohol or snacks. *Appetite* 1990;15(2):89-101.
319. De Castro J. Family and friends produce greater social facilitation of food intake than other companions. *Physiology & Behavior* 1994;56(3):445-55.
320. Wansink B, Park S. At the movies: how external cues and perceived taste impact consumption volume. *Food quality and preference* 2001;12:69-74.
321. Turrini A, D'Addezio L, Maccati F, Davy B, Arber S, Davidson K, et al. The informal networks in food procurement by older people—a cross European comparison. *Ageing Int* 2010;35(4):253-75.
322. Pachucki MA, Jacques PF, Christakis NA. Social network concordance in food choice among spouses, friends, and siblings. *American Journal of Public Health* 2011;101(11):2170-77.
323. Tucker K, Spiro III A, Weiss ST. Variation in food and nutrient intakes among older men: age, and other socio-demographic factors. *Nutrition Research* 1995;15(2):161-76.
324. Barrera M, Strycker LA, MacKinnon DP, Toobert DJ. Social-ecological resources as mediators of two-year diet and physical activity outcomes in type 2 diabetes patients. *Health Pyschology* 2008;27(2, Suppl):S118-S25.
325. Kelsey KS, Kirkley BG, De Vellis RF, Earp JA, Ammerman AS, Keyserling TC, et al. Social support as a predictor of dietary change in a low-income population. *Health Education Research* 1996;11(3):383-95.
326. Laitinen J, Ek E, Sovio U. Stress-related eating and drinking behavior and body mass index and predictors of this behavior. *Preventive Medicine* 2002;34(1):29-39.
327. Adam TC, Epel ES. Stress, eating and the reward system. *Physiology & Behavior* 2007;91(4):449-58.

328. Willis L, Thomas P, Garry P, Goodwin J. A prospective study of response to stressful life events in initially healthy elders. *Journal of Gerontology* 1987;42(6):627-30.
329. Thoits PA. Mechanisms linking social ties and support to physical and mental health. *Journal of Health and Social Behavior* 2011;52(2):145-61.
330. Uchino BN, Bowen K, Carlisle M, Birmingham W. Psychological pathways linking social support to health outcomes: A visit with the "ghosts" of research past, present, and future. *Soc Sci Med* 2012;74(7):949-57.
331. Davis M, Murphy S, Neuhaus J, Gee L, SS. Q. Living arrangements affect dietary quality for US adults aged 50 years and older: NHANES III 1988-1994. *The Journal of Nutrition* 2000;130:2256-64.
332. Kaplan G, Salonen J, Cohen R, Brand R, Syme S, Puska P. Social connections and mortality from all causes and from cardiovascular disease: prospective evidence from Eastern Finland. *American Journal of Epidemiology* 1988;128(2):370-80.
333. Marshall TA, Stumbo PJ, Warren JJ, Xie XJ. Inadequate nutrient intakes are common and are associated with low diet variety in rural, community-dwelling elderly. *The Journal of Nutrition* 2001;131(8):2192-6.
334. Kuzma JW, Lindsted KD. Determinants of eight-year diet recall ability. *Epidemiology* 1990;1(5):386-91.
335. Mitchell J. The British main meal in the 1990s: has it changed its identity? *British Food Journal* 1999;101(11):871-83.
336. Eng PM, Kawachi I, Fitzmaurice G, Rimm EB. Effects of marital transitions on changes in dietary and other health behaviours in US male health professionals. *Journal of Epidemiology and Community Health* 2005;59(1):56-62.
337. Lee S, Cho E, Grodstein F, Kawachi I, Hu FB, Colditz GA. Effects of marital transitions on changes in dietary and other health behaviours in US women. *International Journal of Epidemiology* 2005;34(1):69-78.
338. Rosenbloom C, Whittington F. The effects of bereavement on eating behaviors and nutrient intakes in elderly widowed persons. *Journal of Gerontology* 1993;48(4):S223-S29.
339. Lilley JM. Food choice in later life. *Nutrition & Food Science* 1996;March/April(2):4-7.
340. Holmes BA, Roberts CL, Nelson M. How access, isolation and other factors may influence food consumption and nutrient intake in materially deprived older men in the UK. *Nutrition Bulletin* 2008;33(3):212-20.
341. Sidenvall B, Nydahl M, Fjellström C. Managing food shopping and cooking: the experiences of older Swedish women. *Ageing & Society* 2001;21(02):151-68.
342. Bennett K, Hughes G, Smith P. "I think a woman can take it": Widowed men's views and experiences of gender differences in bereavement. *Ageing Int* 2003;28(4):408-24.
343. Davidson K. Late life widowhood, selfishness and new partnership choices: a gendered perspective. *Ageing & Society* 2001;21(03):297-317.
344. Shatenstein B, Nadon S, Ferland G. Determinants of diet quality among Quebecers aged 55-74. *The Journal of Nutrition, Health & Aging* 2004;8(2):83-91.
345. McIntosh WA, Shifflett PA, Picou JS. Social support, stressful events, strain, dietary intake and the elderly. *Medical Care* 1989;27(2):140-53.
346. Nicklett E, Semba RD, Simonsick EM, Szanton S, Bandeen-Roche K, Ferrucci L, et al. Diet quality and social support: factors associated with serum carotenoid concentrations among older disabled women (the Women's Health and Aging Study). *The Journal of Nutrition, Health & Aging* 2012;16(6):511-18.

347. Steptoe A, Shankar A, Demakakos P, Wardle J. Social isolation, loneliness, and all-cause mortality in older men and women. *Proceedings of the National Academy of Sciences* 2013.
348. Sallis JF, Grossman RM, Pinski RB, Patterson TL, Nader PR. The development of scales to measure social support for diet and exercise behaviors. *Preventive Medicine* 1987;16(6):825-36.
349. Cohen S, Syme SL. Issues in the study and application of social support. *Social Support and Health* 1985;3:3-22.
350. Kessler RC, McLeod JD. Sex differences in vulnerability to undesirable life events. *American Sociological Review* 1984:620-31.
351. Skafida V, Treanor MC. Do changes in objective and subjective family income predict change in children's diets over time? Unique insights using a longitudinal cohort study and fixed effects analysis. *Journal of Epidemiology and Community Health* 2014:jech-2013-203308.
352. Ahnquist J, Fredlund P, Wamala SP. Is cumulative exposure to economic hardships more hazardous to women's health than men's? A 16-year follow-up study of the Swedish Survey of Living Conditions. *Journal of Epidemiology and Community Health* 2007;61(4):331-36.
353. Sun X, Rehnberg C, Meng Q. How are individual-level social capital and poverty associated with health equity? A study from two Chinese cities. *International Journal for Equity in Health* 2009;8(2).
354. Ahnquist J, Wamala SP, Lindstrom M. Social determinants of health–a question of social or economic capital? Interaction effects of socioeconomic factors on health outcomes. *Soc Sci Med* 2012;74(6):930-39.
355. Barnes MG, Smith TG, Yoder JK. Effects of household composition and income security on body weight in working-age men. *Obesity* 2013;21(9):E483-E89.
356. Stafford M, De Silva M, Stansfeld S, Marmot M. Neighbourhood social capital and common mental disorder: testing the link in a general population sample. *Health & Place* 2008;14(3):394-405.
357. Fone D, Dunstan F, Lloyd K, Williams G, Watkins J, Palmer S. Does social cohesion modify the association between area income deprivation and mental health? A multilevel analysis. *International Journal of Epidemiology* 2007;36(2):338-45.
358. Kawachi I, Kennedy BP, Lochner K, Prothrow-Stith D. Social capital, income inequality, and mortality. *American Journal of Public Health* 1997;87(9):1491-98.
359. Woolcock M, Narayan D. Social capital: implications for development theory, research, and policy. *The World Bank Research Observer* 2000;15(2):225-49.
360. Cleaver F. The inequality of social capital and the reproduction of chronic poverty. *World Development* 2005;33(6):893-906.
361. Larsen A. Social capital as a poverty reduction strategy? a case study of Spitzkoppe community, Namibia. Aalborg University, 2008.
362. McLeod JD, Kessler RC. Socioeconomic status differences in vulnerability to undesirable life events. *Journal of Health and Social Behavior* 1990:162-72.
363. Tamayo T, Herder C, Rathmann W. Impact of early psychosocial factors (childhood socioeconomic factors and adversities) on future risk of type 2 diabetes, metabolic disturbances and obesity: a systematic review. *BMC Public Health* 2010;10(1):525.
364. Sen A. Commodities and capabilities. *Oxford University Press Catalogue* 1999.
365. Sassi F. *Obesity and the economics of prevention: fit not fat*: OECD Publishing, 2010.

366. Purslow LR, Young EH, Wareham NJ, Forouhi N, Brunner EJ, Luben RN, et al. Socioeconomic position and risk of short-term weight gain: prospective study of 14,619 middle-aged men and women. *BMC Public Health* 2008;8(1):112.
367. Dinour LM, Bergen D, Yeh M-C. The food insecurity–obesity paradox: a review of the literature and the role food stamps may play. *Journal of the American Dietetic Association* 2007;107(11):1952-61.
368. Townsend MS, Peerson J, Love B, Achterberg C, Murphy SP. Food insecurity is positively related to overweight in women. *The Journal of Nutrition* 2001;131(6):1738-45.
369. US Department of Agriculture & US Department of Health and Human Services. Summary health statistics for US adults: National Health Interview Survey, 2012. *Vital and Health Statistic Series 10, Number 260*. Hyattsville, Maryland: DHSS, 2014.
370. Grafova IB, Freedman VA, Kumar R, Rogowski J. Neighborhoods and obesity in later life. *American Journal of Public Health* 2008;98(11):2065.
371. Lister R. *Poverty*. Cambridge: Polity Press, 2004.
372. Monsivais P, Drewnowski A. The rising cost of low-energy-density foods. *Journal of the American Dietetic Association* 2007;107(12):2071-76.
373. Rehm CD, Monsivais P, Drewnowski A. The quality and monetary value of diets consumed by adults in the United States. *The American Journal of Clinical Nutrition* 2011;94(5):1333-39.
374. Keenan DP, Abusabha R, Sigman-Grant M, Achterberg C, Ruffing J. Factors perceived to influence dietary fat reduction behaviors. *Journal of Nutrition Education* 1999;31(3):134-44.
375. Paisley J, Beanlands H, Goldman J, Evers S, Chappell J. Dietary change: what are the responses and roles of significant others? *Journal of Nutrition Education and Behavior* 2008;40(2):80-88.
376. Jabs J, Devine CM. Time scarcity and food choices: an overview. *Appetite* 2006;47(2):196-204.
377. Turner J, Grieco M. Gender and time poverty: the neglected social policy implications of gendered time, transport and travel. *Time and Society* 2000;9(1):129-36.
378. Moore ME, Stunkard A, Srole L. Obesity, social class, and mental illness. *Journal of the American Medical Association* 1962;181(11):962-66.
379. Blane D, Hart CL, Smith GD, Gillis CR, Hole DJ, Hawthorne VM. Association of cardiovascular disease risk factors with socioeconomic position during childhood and during adulthood. *British Medical Journal* 1996;313(7070):1434-38.
380. Dollman J, Ridley K, Magarey A, Martin M, Hemphill E. Dietary intake, physical activity and TV viewing as mediators of the association of socioeconomic status with body composition: a cross-sectional analysis of Australian youth. *Internaitonal Journal of Obesity* 2006;31(1):45-52.
381. Siahpush M, Huang TTK, Sikora A, Tibbits M, Shaikh RA, Singh GK. Prolonged financial stress predicts subsequent obesity: results from a prospective study of an Australian national sample. *Obesity* 2013.
382. Mirowsky J, Ross CE. Economic hardship across the life course. *American Sociological Review* 1999:548-69.
383. Heflin CM, Iceland J. Poverty, material hardship, and depression. *Social Science Quarterly* 2009;90(5):1051-71.
384. Laaksonen E, Lallukka T, Lahelma E, Ferrie JE, Rahkonen O, Head J, et al. Economic difficulties and physical functioning in Finnish and British employees: contribution of social and behavioural factors. *European Journal of Public Health* 2011;21(4):456-62.

385. Laaksonen E, Martikainen P, Lallukka T, Lahelma E, Ferrie J, Rahkonen O, et al. Economic difficulties and common mental disorders among Finnish and British white-collar employees: the contribution of social and behavioural factors. *Journal of Epidemiology and Community Health* 2009;63(6):439-46.
386. Laaksonen M, Rahkonen O, Karvonen S, Lahelma E. Socioeconomic status and smoking: analysing inequalities with multiple indicators. *European Journal of Public Health* 2005;15(3):262-69.
387. Lallukka T, Ferrie JE, Rahkonen O, Shipley MJ, Pietiläinen O, Kivimäki M, et al. Change in economic difficulties and physical and mental functioning: evidence from British and Finnish employee cohorts. *Scandinavian Journal of Work, Environment & Health* 2013;online first.:doi:10.5271/sjweh.3366.
388. Lallukka T, Lahelma E, Rahkonen O. Changes in economic difficulties and subsequent sickness absence: a prospective register-linkage study. *BMJ Open* 2013;3(1):e002212.
389. Lynch JW, Kaplan GA, Shema SJ. Cumulative impact of sustained economic hardship on physical, cognitive, psychological, and social functioning. *New England Journal of Medicine* 1997;337(26):1889-95.
390. Kamphuis C, Turrell G, Giskes K, Mackenbach JP, van Lenthe FJ. Life course socioeconomic conditions, adulthood risk factors and cardiovascular mortality among men and women: a 17-year follow up of the GLOBE study. *International Journal of Cardiology* 2013;168(3):2207-13.
391. Bartley M, Martikainen P, Shipley M, Marmot M. Gender differences in the relationship of partner's social class to behavioural risk factors and social support in the Whitehall II study. *Soc Sci Med* 2004;59(9):1925-36.
392. Surtees PG, Wainwright NWJ, Khaw KT. Obesity, confidant support and functional health: cross-sectional evidence from the EPIC-Norfolk cohort. *International Journal of Obesity and Related Metabolic Disorders* 2004;28(6):748-58.
393. Brunner EJ, Chandola T, Marmot MG. Prospective effect of job strain on general and central obesity in the Whitehall II study. *American Journal of Epidemiology* 2007;165(7):828-37.
394. Diana FI, Su H, Winters PC, Liang H. Association of workplace chronic and acute stressors with employee weight status: data from worksites in turmoil. *Journal of Occupational and Environmental Medicine* 2010;52(Suppl 1):S34.
395. Kahn HS, Williamson DF, Stevens JA. Race and weight change in US women: the roles of socioeconomic and marital status. *American Journal of Public Health* 1991;81:319-23.
396. Kouvonen A, Stafford M, De Vogli R, Shipley MJ, Marmot MG, Cox T, et al. Negative aspects of close relationships as a predictor of increased body mass index and waist circumference: the Whitehall II study. *American Journal of Public Health* 2011;101(8):1474-80.
397. Wareham NJ, Jakes RW, Rennie KL, Mitchell J, Hennings S, Day NE. Validity and repeatability of the EPIC-Norfolk Physical Activity Questionnaire. *International Journal of Epidemiology* 2002;31(1):168-74.
398. Cawley J, Moran J, Simon K. The impact of income on the weight of elderly Americans. *Health Economics* 2010;19(8):979-93.
399. Yoon YS, Oh SW, Park HS. Socioeconomic status in relation to obesity and abdominal obesity in Korean adults: a focus on sex differences. *Obesity* 2006;14(5):909-19.
400. Gunderson EP. Childbearing and obesity in women: weight before, during, and after pregnancy. *Obstetrics and Gynecology Clinics of North America* 2009;36(2):317.

401. Weng HH, Bastian LA, Taylor Jr DH, Moser BK, Ostbye T. Number of children associated with obesity in middle-aged women and men: results from the Health and Retirement Study. *Journal of Women's Health* 2004;13(1):85-91.
402. Burkhauser RV, Cawley J. Beyond BMI: The value of more accurate measures of fatness and obesity in social science research. *Journal of Health Economics* 2008;27(2):519-29.
403. Klein S, Allison DB, Heymsfield SB, Kelley DE, Leibel RL, Nonas C, et al. Waist circumference and cardiometabolic risk: a consensus statement from Shaping America's Health: Association for Weight Management and Obesity Prevention; NAASO, The Obesity Society; the American Society for Nutrition; and the American Diabetes Association. *The American Journal of Clinical Nutrition* 2007;85(5):1197-202.
404. Janssen I, Katzmarzyk PT, Ross R. Waist circumference and not body mass index explains obesity-related health risk. *The American Journal of Clinical Nutrition* 2004;79(3):379-84.
405. Manios Y, Panagiotakos DB, Pitsavos C, Polychronopoulos E, Stefanadis C. Implication of socio-economic status on the prevalence of overweight and obesity in Greek adults: the ATTICA study. *Health Policy* 2005;74(2):224-32.
406. Mackenbach JP, Stirbu I, Roskam A-JR, Schaap MM, Menvielle G, Leinsalu M, et al. Socioeconomic inequalities in health in 22 European countries. *New England Journal of Medicine* 2008;358(23):2468-81.
407. Katz E. The intra-household economics of voice and exit. *Feminist Economics* 1997;3(3):25-46.
408. Brines J. Economic dependency, gender, and the division of labor at home. *American Journal of Sociology* 1994;100(3):652-88.
409. Rodriguez Martin A, Martinez J, Novalbos Ruiz J, Escobar Jimenez L. Overweight and obesity: the role of education, employment and income in Spanish adults. *Appetite* 2008;51(2):266-72.
410. Rosmond R, Björntorp P. Psychosocial and socio-economic factors in women and their relationship to obesity and regional body fat distribution. *International journal of obesity* 1999;23(2):138-45.
411. Björntorp P. Do stress reactions cause abdominal obesity and comorbidities? *Obesity Reviews* 2001;2(2):73-86.
412. Bose M, Olivan B, Laferrere B. Stress and obesity: the role of the hypothalamic-pituitary-adrenal axis in metabolic disease. *Current Opinion in Endocrinology, Diabetes and Obesity* 2009;16(5):340-46.
413. Cappuccio FP, Taggart FM, Kandala N-B, Currie A, Peile E, Stranges S, et al. Meta-analysis of short sleep duration and obesity in children and adults. *Sleep* 2008;31(5):619-26.
414. Flegal KM, Troiano RP, Pamuk ER, Kuczmarski RJ, Campbell SM. The influence of smoking cessation on the prevalence of overweight in the United States. *New England Journal of Medicine* 1995;333(18):1165-70.
415. Stadler M, Tomann L, Storka A, Wolzt M, Peric S, Bieglmayer C, et al. Effects of smoking cessation on β-cell function, insulin sensitivity, body weight, and appetite. *European Journal of Endocrinology* 2014;170(2):219-27.
416. Sobal J, Rauschenbach BS, Frongillo Jr EA. Marital status, fatness and obesity. *Soc Sci Med* 1992;35(7):915-23.
417. Akbaraly TN, Kivimäki M, Brunner EJ, Chandola T, Marmot MG, Singh-Manoux A, et al. Association between metabolic syndrome and depressive symptoms in middle-aged adults: results from the Whitehall II study. *Diabetes Care* 2009;32(3):499-504.

418. Luppino FS, de Wit LM, Bouvy PF, et al. Overweight, obesity, and depression: a systematic review and meta-analysis of longitudinal studies. *Archives of General Psychiatry* 2010;67(3):220-29.
419. Brunner E, Marmot M, Nanchahal K, Shipley M, Stansfeld S, Juneja M, et al. Social inequality in coronary risk: central obesity and the metabolic syndrome. Evidence from the Whitehall II study. *Diabetologia* 1997;40(11):1341-49.
420. Baron RM, Kenny DA. The moderator–mediator variable distinction in social psychological research: conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology* 1986;51(6):1173.
421. Westfall P, Hoffman JJ, Xia J. Joint analysis of multiple categorical dependent variables in organizational research. *Organizational Research Methods* 2007;10(4):673-88.
422. Liu K. Measurement error and its impact on partial correlation and multiple linear regression analyses. *American Journal of Epidemiology* 1988;127(4):864-74.
423. Wilde PE, Peterman JN. Individual weight change is associated with household food security status. *The Journal of Nutrition* 2006;136(5):1395-400.
424. Whooley MA, Kiefe CI, Chesney MA, Markovitz JH, Matthews K, Hulley SB. Depressive symptoms, unemployment, and loss of income: the CARDIA study. *Archives of Internal Medicine* 2002;162(22):2614-20.
425. Kivimäki M, Head J, Ferrie J, Shipley M, Brunner E, Vahtera J, et al. Work stress, weight gain and weight loss: evidence for bidirectional effects of job strain on body mass index in the Whitehall II study. *International journal of obesity* 2006;30(6):982-87.
426. Conklin AI, Maguire ER, Monsivais P. Economic determinants of diet in older adults: systematic review. *Journal of Epidemiology and Community Health* 2013;67(9):721-27.
427. McFadden E, Luben R, Khaw K-T. Different measures of social class in women and mortality. *Eur J Epidemiol* 2009;24(5):231-36.
428. Nelson M. Social-class trends in British diet, 1860-1980. In: Geissler C, Oddy D, editors. *Food, diet, and economic change past and present*. London and New York: Leicester University Press, 1993:101-20.
429. Giskes K, Avendaňo M, Brug J, Kunst A. A systematic review of studies on socioeconomic inequalities in dietary intakes associated with weight gain and overweight/obesity conducted among European adults. *Obesity Reviews* 2010;11(6):413-29.
430. Lennernäs M, Fjellström C, Becker W, Giachetti I, Schmitt A, de Winter A, et al. Influences on food choice perceived to be important by nationally-representative samples of adults in the European Union. *European Journal of Clinical Nutrition* 1997;51.
431. Beydoun MA, Powell LM, Wang Y. The association of fast food, fruit and vegetable prices with dietary intakes among US adults: Is there modification by family income? *Soc Sci Med* 2008;66(11):2218-29.
432. Kanter R, Caballero B. Global gender disparities in obesity: a review. *Advances in Nutrition: An International Review Journal* 2012;3(4):491-98.
433. Jeffrey RW, Wing RR. Long-term effects of interventions for weight loss using food provision and monetary incentives. *Journal of Consulting and Clinical Psychology* 1995;63(5):793.
434. Ulijaszek SJ. Human eating behaviour in an evolutionary ecological context. *Proceedings of the Nutrition Society* 2002;61(04):517-26.
435. Smith TG. Economic stressors and the demand for “fattening” foods. *American Journal of Agricultural Economics* 2012;94(2):324-30.

436. Smith TG. Reconciling psychology with economics: obesity, behavioral biology, and rational overeating. *Journal of Bioeconomics* 2009;11(3):249-82.
437. Ruhm CJ. Understanding overeating and obesity. *Journal of Health Economics* 2012;31(6):781-96.
438. Brug J, te Velde SJ, Chinapaw MJ, Bere E, De Bourdeaudhuij I, Moore H, et al. Evidence-based development of school-based and family-involved prevention of overweight across Europe: the ENERGY-project's design and conceptual framework. *BMC Public Health* 2010;10(1):276.
439. Nord M, Kantor LS. Seasonal variation in food insecurity is associated with heating and cooling costs among low-income elderly Americans. *The Journal of Nutrition* 2006;136(11):2939-44.
440. Rössler B. Problems with autonomy. *Hypatia* 2002;17(4):143-62.
441. Grasswick HE. Individuals-in-communities: the search for a feminist model of epistemic subjects. *Hypatia* 2004;19(3):85-120.
442. Yuval-Davis N, Anthias F, Kofman E. Secure borders and safe haven and the gendered politics of belonging: beyond social cohesion. *Ethnic and Racial Studies* 2005;28(3):513-35.
443. Sherwin S. Feminist and medical ethics: two different approaches to contextual ethics. *Hypatia* 1989;4(2):57-72.
444. Martin PM, Glesne C. From the global village to the pluriverse? 'Other' ethics for cross-cultural qualitative research. *Ethics, Place & Environment* 2002;5(3):205-21.
445. Davis MA, Randall E. Social change and food habits of the elderly. *Aging in Society: Selected Reviews of Recent Research* 1983:199-217.
446. Mani A, Mullainathan S, Shafir E, Zhao J. Poverty impedes cognitive function. *Science* 2013;341(6149):976-80.
447. Spears D. Economic decision-making in poverty depletes behavioral control. *The BE Journal of Economic Analysis & Policy* 2011;11(1):1-44.
448. Shah AK, Mullainathan S, Shafir E. Some consequences of having too little. *Science* 2012;338(6107):682-85.
449. van Dam RM. New approaches to the study of dietary patterns. *British Journal of Nutrition* 2005;93(05):573-74.
450. Singh N, Graves J, Taylor PD, MacAllister RJ, Singer DRJ. Effects of a 'healthy' diet and of acute and long-term vitamin C on vascular function in healthy older subjects. *Cardiovascular Research* 2002;56(1):118-25.
451. Van Dyk K, Sano M. The impact of nutrition on cognition in the elderly. *Neurochemical Research* 2007;32(4):893-904.
452. Bourre JM. Effects of nutrients (in food) on the structure and function of the nervous system: update on dietary requirements for brain. Part 1: micronutrients. *The Journal of Nutrition, Health & Aging* 2006;10(5):377-85.
453. Zamora-Ros R, Forouhi NG, Sharp SJ, González CA, Buijsse B, Guevara M, et al. Dietary intakes of individual flavanols and flavonols are inversely associated with incident Type 2 Diabetes in European populations. *The Journal of Nutrition* 2013:jn. 113.184945.

# APPENDICES

# Appendix A Publications and oral presentations

## Publications

### In preparation

**Conklin AI**, Monsivais P, Forouhi NG. Diet diversity, diet cost and incident type 2 diabetes in EPIC-Norfolk (*planned submission to International Journal of Epidemiology*)

### Submitted

**Conklin AI**, Forouhi NG, Brunner R, Monsivais P. Persistent financial hardship in employed women and 11-year weight gain—a prospective investigation of potential mediators (*submitted to Obesity*)

**Conklin AI**, Forouhi NG, Surtees P, Wareham NJ, Monsivais P. Gender, diet quality and the double burden of economic and social disadvantages on diet quality in older adults (*submitted to Journal of Epidemiology and Community Health*)

Jones NRV, **Conklin AI**, Suhrcke M, Monsivais P. Are more healthy foods getting more expensive? Analysis of a novel longitudinal UK dataset. (*submitted to PLOS One*)

**Conklin AI**, Forouhi NG, Surtees P, Suhrcke S, Wareham NJ, Monsivais P. Variety, more than quantity, of fruits and vegetables varies by multiple economic conditions in 9,580 older British adults. (*Journal of Nutrition*, under review)

### 2014

**Conklin AI**, Forouhi NG, Surtees P, Khaw K-T, Wareham NJ, Monsivais P. Social relationships and healthful dietary behaviour: Evidence from over-50s in the EPIC cohort, UK. *Social Science & Medicine* 2014; 100:167-75.

### 2013

**Conklin AI**, Forouhi NG, Suhrcke M, Surtees P, Wareham NJ, Monsivais P. Socioeconomic status, financial hardship and measured obesity in older adults: A cross-sectional study of the EPIC-Norfolk cohort. *BMC Public Health* 2013 Nov 4, 13(1):1039

CEDAR. *Multiple social ties and healthy eating in older people: findings from the EPIC-Norfolk study*. Evidence Brief, October 2013. Cambridge, UK: Centre for Diet and Activity Research

**Conklin AI**, Maguire ER, Monsivais P. Economic determinants of diet in older adults: Systematic review. *Journal of Epidemiology and Community Health* 2013 Sep 6; 67(9): 721-7 doi:10.1136/jech-2013-202513

## Abstracts

**Conklin A**, Forouhi N, Wareham N, Monsivais P. The role of social relationships in understanding healthful dietary behaviours: Evidence from people aged 50 and over in the EPIC-Norfolk cohort. *Journal of Epidemiology and Community Health* 2013; 67(Suppl 1): A37

Jones NRV, **Conklin A**, Monsivais P. An analysis of the changing prices of unhealthy and healthier foods: the first step towards tracking the affordability of a healthy diet. *Journal of Epidemiology and Community Health* 2013; 67(Suppl 1): A45-A46

**Conklin A**, Wareham N, Forouhi N, Monsivais P. Combined effects of social relationships and healthful dietary behaviours in adults aged 50 and over. *Annual Summer Meeting of The Nutrition Society* 2013, Newcastle, UK, OC037

## Oral presentations

### 2014

UK Centres of Excellence 5th Annual conference, Leeds, UK, 19-20 June 2014. "Financial hardship is associated with increased weight gain: what is the role of health behaviours?"

Early Career Researcher Symposium, Public Health at Cambridge Showcase, Cambridge, UK, 27 May 2014. "Persistent financial hardship is associated with increased long-term weight gain: Do health behaviours have a role to play?"

RAND lunchtime seminar, Cambridge, UK, 18 March 2014. "Rethinking economic determinants of obesity: what is the role of material hardships?"

### 2013

UBVO seminar, University of Oxford, UK, 21 November 2013. "Financial hardship, weight gain and obesity: rethinking economic determinants."

CEDAR research policy meeting, Cambridge, UK, 9 October 2013. "Financial hardship is associated with diet quality: Evidence from over-50s in EPIC-Norfolk."

Society for Social Medicine 57th Annual Scientific Meeting 2013, Brighton, UK, 12 September 2013. “The role of social relationships in understanding healthful dietary behaviours: Evidence from people aged 50 and over in the EPIC-Norfolk cohort.”

The Nutrition Society Annual Summer Meeting, “Nutrition and Healthy Ageing”, Newcastle, UK, 17 July 2013. “Combined effects of social relationships & healthful dietary behaviours in over-50s.”

UK Centres of Excellence 4th Annual conference, “Public Health Across the Life Course”, Cardiff, UK, 9 July 2013. “Financial hardship is associated with greater odds of obesity. Evidence from people aged 50 and over in the EPIC cohort, UK.”

MRC Epidemiology Unit Research Away-Day, Cambridge, UK, 21 June 2013. “Social relationships and diet quality in older UK adults.”

iBehave monthly meetup ‘How do you tackle obesity through tech amongst lower income communities?’, London, UK, 13 May 2013. “Meeting the challenge of obesity in UK’s low-income households.”

## 2012

McMenemy seminar, Trinity Hall, University of Cambridge, 14 November 2012. “Shared meals are more than breaking bread: How partnership, lone-living and social contact affect diet variety in older people.”

CEDAR Symposium, Cambridge, UK, 16 October 2012. “Social relationships and food choice: Which aspects most influence variety of fruits & vegetables among older people?”

MRC Epidemiology Unit seminar, Cambridge, UK, 27 February 2012. “Socio-economic influences on food choice in later life. Presented at an internal research seminar.”

# Appendix B Supplemental material for Chapter 3

B-1 Characteristics of women and men in the EPIC-Norfolk cohort & sample of over-50s

B-2 Comparison of entry characteristics between those who responded or not to FH questions in the EPIC-Norfolk cohort and sample of over-50s

B-3 Characteristics of those who responded or not to the FFQ in the over-50 sample

B-4 Adjusted mean quantity of nutrients associated with sex-specific quintiles of quantity and variety of fruit, or vegetable, intake in older adults in the EPIC-Norfolk study

B-5 Adjusted mean quantity and variety of combined FV in older adults in the EPIC-Norfolk study across levels of SES

B-6 Sensitivity analysis of adjusted mean quantity and variety of combined FV in older adults in the EPIC-Norfolk study across levels of SES

B-7 Adjusted mean quantity and variety of combined FV in older adults in the EPIC-Norfolk study across levels of FH

B-8 Sensitivity analysis of adjusted mean quantity of fruits or vegetables in older adults in the EPIC-Norfolk study across levels of FH

B-9 Sensitivity analysis of adjusted mean variety of fruits or vegetables in older adults in the EPIC-Norfolk study across levels of FH

B-1 Characteristics of women and men in the EPIC-Norfolk cohort & sample of over-50s

| | Full cohort | | Over-50s | |
|---|---|---|---|---|
| | Women | Men | Women | Men |
| *1993-1997* | | | | |
| Age (yrs) at entry, mean (SD) | 59 (9.3) | 60 (9.3) | 62 (7.1) | 63 (7.1) |
| Female (%) | 55% | – | 55% | – |
| O-level/ No qualification (%) | 54% | 39% | 52% | 38% |
| Lowest social classes[a] (%) | 17% | 16% | 16% | 15% |
| Deprived[b] (%) | 17% | 16% | 15% | 13% |
| *1996-2000 (HLEQ)* | | | | |
| Renter | 10% | 9% | 9% | 7% |
| Not married (%) | 26% | 12% | 26% | 11% |
| Living alone (%) | 21% | 12% | 23% | 12% |
| Rare friend contact (%) | 8% | 13% | 6% | 12% |
| Rare family contact (%) | 5% | 9% | 4% | 8% |
| Not enough money for needs | 12% | 12% | 9% | 10% |
| Often/ always insufficient money for food/clothing | 6% | 6% | 5% | 4% |
| Great/ very great difficulty paying bills | 2% | 2% | 1% | 1% |
| *1998-2002 (2HC)* | | | | |
| BMI, mean (SD) | 26.5 (4.4) | 26.9 (3.3) | 26.7 (4.4) | 26.8 (3.3) |
| Moderate/ poor self-rated general health (%) | 19% | 17% | 18% | 15% |
| Ever smoker (%) | 41% | 65% | 40% | 66% |
| Total energy intake (kcal/d) | 1840 (518) | 2100 (596) | 1850 (516) | 2087 (583) |
| Fruit variety score, mean (SD) | 7.7 (2.3) | 6.7 (2.6) | 7.7 (2.3) | 6.7 (2.5) |
| Vegetable variety score, mean (SD) | 16.7 (4.0) | 16.0 (4.1) | 16.5 (4.0) | 15.9 (4.1) |

HLEQ, postal Health and Life Experience Questionnaire (1996-2000); 2HC, second health check (1998-2002). [a]Partly skilled (class IV) and unskilled (class V) occupations. [b]Above average (>0.0) Townsend Deprivation Index (from -6.10 to 6.98). Numbers in full cohort were: 25,639 at entry; between 7,883 and 11,232 at HLEQ; and between 15,000 and 17,165 at 2HC. Numbers of over-50s eligible for analysis were 9,580.

B-2 Comparison of entry characteristics between those who responded or not to FH questions in the EPIC-Norfolk cohort and sample of over-50s

| | Over-50s (n=20,274) | | Full cohort (n=25,639) | |
|---|---|---|---|---|
| | Responders | Non-responders | Responders | Non-responders |
| *Hardship exposure – money for needs* | *n=14,307* | *n=5,967* | *n=17,953* | *n=7,686* |
| Age, mean (SD) | 62 (7) | 63 (8) | 59 (9) | 59 (10) |
| Women | 55% | 52% | 56% | 52% |
| No qualification/ O-level | 48% | 56% | 45% | 51% |
| Lowest social classes | 17% | 21% | 16% | 19% |
| Moderate/poor health | 19% | 28% | 18% | 25% |
| Ever smoker | 54% | 59% | 52% | 59% |
| Physically inactive | 60% | 66% | 58% | 62% |
| Total calories, mean (SD) | 2042 (588) | 2015 (604) | 2042 (592) | 2025 (611) |
| BMI, mean (SD) | 26.5 (3.8) | 26.8 (4.0) | 26.3 (3.9) | 26.6 (4.0) |
| *Hardship exposure – frequency of insufficient for food/clothing* | *n=14,324* | *n=5,950* | *n=17,971* | *n=7,668* |
| Age, mean (SD) | 62 (7) | 63 (8) | 59 (9) | 59 (10) |
| Women | 55% | 52% | 56% | 52% |
| No qualification/ O-level | 52% | 44% | 45% | 51% |
| Lowest social classes | 17% | 21% | 16% | 19% |
| Moderate/poor health | 81% | 72% | 18% | 26% |
| Ever smoker | 54% | 59% | 52% | 59% |
| Physically inactive | 61% | 66% | 58% | 62% |
| Total calories, mean (SD) | 2042 (587) | 2014 (604) | 2043 (592) | 2025 (611) |
| BMI, mean (SD) | 26.5 (3.8) | 26.8 (4.0) | 26.3 (3.9) | 26.6 (4.0) |
| *Hardship exposure – difficulty paying bills* | *n=14,347* | *n=5,927* | *n=17,998* | *n= 7,641* |
| Age, mean (SD) | 62 (7) | 63 (8) | 59 (9) | 59 (10) |
| Women | 55% | 52% | 56% | 52% |
| No qualification/ O-level | 48% | 56% | 46% | 51% |
| Lowest social classes | 17% | 21% | 45% | 39% |
| Moderate/poor health | 19% | 28% | 18% | 26% |
| Ever smoker | 54% | 59% | 52% | 59% |
| Physically inactive | 61% | 66% | 58% | 62% |
| Total calories, mean (SD) | 2042 (587) | 2014 (605) | 2043 (592) | 2025 (612) |
| BMI, mean (SD) | 26.5 (3.8) | 26.8 (4.0) | 26.3 (3.9) | 26.6 (4.0) |

B–3 Characteristics of the over–50 sample who responded or not to the FFQ

| | Adults ≥50 years in EPIC | | | |
|---|---|---|---|---|
| | FFQ responders | n | FFQ non-responders | n |
| Women | 56% | *9,933* | 52% | *10,341* |
| No qualification/O-level | 54% | *9,927* | 46% | *10,330* |
| Lowest social classes | 16% | *9,742* | 20% | *10,014* |
| Above-average deprived | 16% | *9,933* | 18% | *10,341* |
| Irregular car use | 78% | *9,547* | 78% | *2,041* |
| BMI (2HC) | 26.8 (3.9) | *9,887* | 27.2 (3.9) | *2,095* |
| Ever smoker (2HC) | 52% | *9,842* | 56% | *3,864* |
| Moderate/ poor health (2HC) | 17% | *9,853* | 24% | *3,507* |
| Not married (2HC) | 21% | *9,883* | 25% | *3,561* |

2HC, Second Health Check (1998-2002)

B-4 Adjusted mean nutrient intake associated with sex-specific quintiles of quantity and variety of fruit, or vegetable, intake in older adults in the EPIC-Norfolk study

| | Fruit quantity | | Fruit variety | | Vegetable quantity | | Vegetable variety | |
|---|---|---|---|---|---|---|---|---|
| | Women | Men | Women | Men | Women | Men | Women | Men |
| Fibre intake (g) | | | | | | | | |
| Q1 | 15.26 | 14.78 | 18.13 | 17.69 | 14.78 | 14.43 | 18.75 | 18.18 |
| Q2 | 16.86 | 16.49 | 18.82 | 17.94 | 16.61 | 16.34 | 18.63 | 17.82 |
| Q3 | 18.37 | 17.60 | 18.87 | 18.28 | 18.21 | 17.73 | 18.64 | 18.08 |
| Q4 | 19.77 | 19.35 | 19.28 | 18.50 | 20.05 | 19.29 | 18.91 | 18.22 |
| Q5 | 23.64 | 22.68 | 19.48 | 18.76 | 24.24 | 23.10 | 19.09 | 18.59 |
| Vitamin C intake (mg) | | | | | | | | |
| Q1 | 101 | 88 | 132 | 110 | 99 | 83 | 137 | 118 |
| Q2 | 115 | 102 | 138 | 116 | 117 | 101 | 139 | 115 |
| Q3 | 132 | 112 | 140 | 122 | 132 | 115 | 138 | 121 |
| Q4 | 149 | 129 | 147 | 125 | 154 | 132 | 143 | 122 |
| Q5 | 200 | 167 | 149 | 131 | 196 | 168 | 141 | 123 |
| Potassium intake (mg) | | | | | | | | |
| Q1 | 3429 | 3485 | 3727 | 3747 | 3448 | 3483 | 3740 | 3772 |
| Q2 | 3600 | 3640 | 3798 | 3797 | 3635 | 3673 | 3820 | 3778 |
| Q3 | 3774 | 3767 | 3853 | 3839 | 3778 | 3788 | 3833 | 3822 |
| Q4 | 3954 | 3941 | 3887 | 3879 | 3969 | 3927 | 3867 | 3874 |
| Q5 | 4380 | 4333 | 3985 | 3957 | 4306 | 4295 | 3909 | 3942 |
| Magnesium intake (mg) | | | | | | | | |
| Q1 | 296 | 305 | 318 | 330 | 306 | 314 | 316 | 324 |
| Q2 | 311 | 319 | 326 | 330 | 313 | 323 | 322 | 326 |
| Q3 | 324 | 331 | 329 | 334 | 324 | 330 | 327 | 331 |

| | Fruit quantity | | Fruit variety | | Vegetable quantity | | Vegetable variety | |
|---|---|---|---|---|---|---|---|---|
| | Women | Men | Women | Men | Women | Men | Women | Men |
| Q4 | 338 | 343 | 331 | 338 | 334 | 338 | 331 | 339 |
| Q5 | 363 | 370 | 338 | 341 | 357 | 363 | 342 | 352 |
| Zinc intake (mg) | | | | | | | | |
| Q1 | 8.71 | 8.99 | 8.68 | 9.11 | 8.24 | 8.62 | 8.64 | 9.09 |
| Q2 | 8.70 | 9.18 | 8.74 | 9.20 | 8.59 | 9.00 | 8.87 | 9.24 |
| Q3 | 8.84 | 9.21 | 8.92 | 9.26 | 8.85 | 9.26 | 8.98 | 9.31 |
| Q4 | 9.00 | 9.36 | 9.06 | 9.44 | 9.07 | 9.45 | 8.90 | 9.28 |
| Q5 | 9.12 | 9.61 | 9.21 | 9.45 | 9.62 | 10.02 | 9.03 | 9.48 |
| Vitamin A intake (µg) | | | | | | | | |
| Q1 | 1327 | 1329 | 1222 | 1263 | 1108 | 1159 | 1220 | 1281 |
| Q2 | 1297 | 1360 | 1264 | 1337 | 1212 | 1255 | 1309 | 1324 |
| Q3 | 1291 | 1338 | 1310 | 1334 | 1273 | 1343 | 1321 | 1345 |
| Q4 | 1284 | 1332 | 1397 | 1372 | 1341 | 1372 | 1363 | 1400 |
| Q5 | 1320 | 1348 | 1430 | 1447 | 1583 | 1579 | 1329 | 1384 |

Gender-specific mean intake of nutrients across quintiles of quantity, or variety, of intake of fruits or vegetables obtained by multivariable linear regression analyses, adjusted for energy intake (continuous), baseline age (continuous), and variety (for quantity) or quantity (for variety). All means were significant at $p<0.001$. Numbers analysed were 5,310 for women and 4,270 for men.

B–5 Adjusted mean quantity and variety of combined FV in older adults in the EPIC–Norfolk study across levels of SES

| | FV quantity | | | | FV variety | | | |
|---|---|---|---|---|---|---|---|---|
| | Women | | Men | | Women | | Men | |
| | *Model A* | *Model B: +FH* | *Model A* | *Model B: +FH* | *Model A* | *Model B: +FH* | *Model A* | *Model B: +FH* |
| Social Class[b] | | | | | | | | |
| Professional | 595 (569, 621) | 599 (571, 626) | 524 (497, 550) | 522 (494, 549) | 25.6 (25.1, 26.2) | 25.6 (25.0, 26.2) | 24.6 (24.0, 25.1) | 24.4 (23.8, 25.0) |
| Managerial and Technical | 596 (585, 607) | 597 (585, 608) | 509 (498, 521) | 509 (497, 521) | 26.3 (25.0, 25.5) | 25.3 (25.0, 25.5) | 23.7 (23.4, 23.9) | 23.6 (23.4, 23.9) |
| Skilled non-manual | 572 (557, 587) | 569 (554, 585) | 488 (468, 508) | 487 (466, 508) | 23.9 (23.5, 24.2) | 23.8 (23.5, 24.2) | 22.2 (21.8, 22.7) | 22.3 (21.8, 22.7) |
| Skilled manual | 581 (566, 596) | 576 (560, 592) | 480 (464, 496) | 481 (464, 498) | 23.4 (23.1, 23.7) | 23.4 (23.1, 23.8) | 21.4 (21.0, 21.7) | 21.5 (21.2, 21.9) |
| Partly skilled | 566 (546, 585) | 567 (547, 588) | 484 (463, 505) | 487 (465, 509) | 23.3 (22.9, 23.7) | 23.3 (22.9, 23.8) | 21.1 (20.6, 21.5) | 21.4 (20.9, 21.8) |
| Unskilled | 563 (527, 599) | 549 (510, 588) | 455 (406, 505) | 455 (402, 508) | 22.1 (21.4, 22.9) | 22.2 (21.4, 23.1) | 20.4 (19.3, 21.4) | 20.5 (19.3, 21.6) |
| Education | | | | | | | | |
| Degree | 598 (578, 618) | 597 (576, 617) | 524 (505, 543) | 520 (500, 540) | 26.0 (25.5, 26.4) | 25.8 (25.4, 26.2) | 24.6 (24.2, 25.0) | 24.4 (24.0, 24.8) |
| A-level | 593 (582, 604) | 593 (581, 604) | 496 (485, 507) | 496 (485, 508) | 25.1 (24.9, 25.3) | 25.1 (24.8, 25.3) | 22.8 (22.6, 23.1) | 22.9 (22.7, 23.2) |
| O-level | 567 (547, 587) | 567 (546, 588) | 492 (467, 517) | 487 (460, 513) | 24.4 (24.0, 24.9) | 24.4 (24.0, 24.9) | 23.0 (22.5, 23.6) | 22.9 (22.3, 23.4) |
| No qualification | 573 (563, 584) | 571 (560, 582) | 483 (469, 497) | 487 (472, 501) | 23.0 (22.7, 23.2) | 23.0 (22.8, 23.2) | 21.1 (20.8, 21.4) | 21.3 (21.0, 21.6) |
| Home-ownership | | | | | | | | |
| Owner occupier | 583 (576, 590) | 583 (576, 590) | 499 (490, 507) | 499 (490, 507) | 24.4 (24.3, 24.6) | 24.4 (24.3, 24.6) | 22.8 (22.7, 23.0) | 22.9 (22.7, 23.0) |
| Renter, private | 576 (532, 620) | 578 (533, 622) | 470 (421, 520) | 472 (422, 522) | 23.2 (22.2, 24.1) | 23.4 (22.5, 24.4) | 21.3 (20.3, 22.4) | 21.5 (19.2, 20.9) |
| Renter, public | 565 (536, 594) | 565 (535, 595) | 475 (434, 513) | 479 (441, 517) | 21.8 (21.2, 22.4) | 22.1 (21.5, 22.8) | 19.8 (19.0, 20.6) | 20.1 (20.5, 22.6) |

Gender-specific means (CI95) obtained by linear regression analysis adjusted for energy intake (continuous), baseline age (continuous), and concurrent marital status (categorical) (Model A), then for FH (money for needs, frequency of insufficient money for food/clothing, difficulty paying bills) (Model B). Model B numbers: social class (8,535); education (8,678); home-ownership (8,538).

B-6 Sensitivity analysis of adjusted mean quantity and variety of combined FV in older adults in the EPIC-Norfolk study across levels of SES

| | FV quantity | | FV variety | |
|---|---|---|---|---|
| | Women | Men | Women | Men |
| Social Class[b] | | | | |
| Professional | 569 (545, 592) | 486 (462, 510) | 25.5 (25.0, 26.0) | 24.3 (23.8, 24.8) |
| Managerial and Technical | 577 (566,587) | 488 (487, 499) | 25.1 (24.9, 25.4) | 23.6 (23.3, 23.8) |
| Skilled non-manual | 580 (566, 593) | 496 (477, 515) | 24.0 (23.7, 24.2) | 22.3 (21.9, 22.7) |
| Skilled manual | 597 (584, 611) | 504 (490, 519) | 23.4 (23.1, 23.7) | 21.5 (21.2, 21.8) |
| Partly skilled | 585 (568, 603) | 515 (496, 534) | 23.4 (23.0, 23.8) | 21.2 (20.8, 21.6) |
| Unskilled | 605 (572, 637) | 500 (455, 545) | 22.3 (21.6, 23.0) | 20.7 (19.8, 21.7) |
| Education | | | | |
| Degree | 564 (546, 582) | 485 (468, 502) | 25.8 (25.4, 26.2) | 24.3 (24.0, 24.7) |
| A-level | 577 (567, 587) | 491 (481, 501) | 25.0 (24.8, 25.2) | 22.8 (22.6, 23.1) |
| O-level | 564 (546, 582) | 483 (460, 506) | 24.6 (24.2, 25.0) | 23.1 (22.6, 23.6) |
| No qualification | 599 (589, 608) | 513 (501, 526) | 23.0 (22.8, 23.2) | 21.2 (20.9, 21.5) |
| Home-ownership | | | | |
| Owner occupier | 579 (573, 586) | 495 (488, 502) | 24.4 (24.3, 24.6) | 22.8 (22.7, 23.0) |
| Renting, private | 596 (557, 636) | 497 (452, 542) | 23.2 (22.4, 24.1) | 21.6 (20.6, 22.5) |
| Renting, public | 613 (587, 639) | 533 (499, 567) | 22.0 (21.4, 22.5) | 20.0 (19.2, 20.7) |

Gender-specific means (CI95) obtained by linear regression models adjusted for energy intake (continuous), baseline age (continuous), concurrent marital status (categorical), and quantity (for variety), or variety (for quantity). Numbers were: social class (9,365); education (9,531); and home-ownership (8,661).

B–7 Adjusted mean quantity and variety of combined FV in older adults in the EPIC–Norfolk study across levels of FH

| | FV quantity | | | | FV variety | | | |
|---|---|---|---|---|---|---|---|---|
| | Women | | Men | | Women | | Men | |
| | *Model A* | *Model B: +SES* | *Model A* | *Model B: +SES* | *Model A* | *Model B: +SES* | *Model A* | *Model B: +SES* |
| Enough money for needs | | | | | | | | |
| More than enough | 577 (561, 593) | 570 (554, 587) | 497 (479, 514) | 489 (471, 507) | 24.9 (24.6, 25.3) | 24.3 (23.9, 24.6) | 23.7 (23.3, 24.1) | 23.1 (22.7, 23.4) |
| Just enough | 583 (575, 591) | 586 (577, 594) | 496 (487, 505) | 500 (490, 509) | 24.2 (24.0, 24.4) | 24.4 (24.2, 24.5) | 22.5 (22.3, 22.7) | 22.7 (22.5, 22.9) |
| Less than enough | 576 (552, 599) | 574 (549, 599) | 498 (473, 524) | 502 (476, 528) | 23.2 (22.6, 23.7) | 23.7 (23.2, 24.2) | 21.6 (21.0, 22.1) | 22.1 (21.6, 22.7) |
| Frequency of insufficient money for food/clothing | | | | | | | | |
| Never | 582 (573, 591) | 581 (572, 590) | 500 (490, 510) | 499 (489, 509) | 24.4 (24.2, 24.6) | 24.2 (24.0, 24.4) | 22.8 (22.6, 23.1) | 22.7 (22.5, 22.9) |
| Seldom | 584 (569, 599) | 588 (573, 603) | 494 (477, 510) | 499 (482, 516) | 24.5 (24.2, 24.8) | 24.7 (24.4, 25.0) | 22.8 (22.4, 23.1) | 23.0 (22.7, 23.4) |
| Sometimes | 585 (565, 604) | 586 (566, 606) | 488 (464, 511) | 491 (467, 515) | 23.8 (23.4, 24.3) | 24.3 (23.9, 24.7) | 22.4 (21.9, 22.9) | 22.9 (22.4, 23.4) |
| Often/ Always | 550 (518, 583) | 549 (515, 583) | 478 (438, 518) | 481 (440, 523) | 22.5 (21.8, 23.2) | 23.1 (22.4, 23.8) | 20.2 (19.3, 21.1) | 20.9 (20.0, 21.8) |
| Difficulty paying bills | | | | | | | | |
| None | 585 (576, 594) | 584 (575, 593) | 499 (489, 509) | 500 (490, 510) | 24.3 (24.1, 24.5) | 24.2 (24.0, 24.4) | 22.7 (22.5, 22.9) | 22.6 (22.4, 22.9) |
| Very little | 580 (565, 595) | 581 (566, 596) | 497 (481, 513) | 500 (484, 516) | 24.7 (24.4, 25.0) | 24.8 (24.5, 25.1) | 22.8 (22.5, 23.1) | 23.0 (22.6, 23.3) |
| Slight | 589 (563, 615) | 594 (568, 621) | 485 (455, 514) | 485 (455, 515) | 24.0 (23.5, 24.6) | 24.4 (23.9, 25.0) | 23.1 (22.4, 23.7) | 23.2 (22.6, 23.8) |
| Some | 560 (535, 586) | 564 (537, 590) | 469 (438, 500) | 474 (442, 507) | 23.4 (22.8, 23.9) | 24.0 (23.4, 24.5) | 21.8 (21.1, 22.5) | 22.4 (21.7, 23.0) |
| Great/ Very great | 543 (485, 601) | 535 (475, 595) | 526 (455, 597) | 530 (456, 603) | 22.0 (20.8, 23.3) | 22.5 (21.2, 23.7) | 20.3 (18.8, 21.9) | 21.2 (19.6, 22.7) |

Gender-specific means (CI95) obtained by linear regression models adjusting for energy intake (continuous), baseline age (continuous), concurrent marital status (categorical) (Model A), then for SES (education, social class and home-ownership) (Model B). Model B numbers were: money for needs (8,413); insufficient money for food/clothing (8,417); difficulty paying bills (8,425).

B-8 Sensitivity analysis of adjusted mean quantity of fruits or vegetables in older adults in the EPIC-Norfolk study across levels of FH

| | Fruit quantity | | | | Vegetable quantity | | | |
|---|---|---|---|---|---|---|---|---|
| | Women | | Men | | Women | | Men | |
| | *Model 1* | *Model 2* | *Model 1* | *Model 2* | *Model 1* | *Model 2* | *Model 1* | *Model 2* |
| Enough money for needs | | | | | | | | |
| More than enough | 294 (281, 306) | 293(281, 304) | 238 (225, 252) | 232 (220, 244) | 276 (268, 285) | 278 (270, 285) | 254 (245, 263) | 250 (242, 258) |
| Just enough | 301 (295, 307) | 300 (294, 306) | 237 (230, 244) | 239 (232, 245) | 287 (283, 292) | 285 (282, 289) | 262 (257, 267) | 262 (258, 266) |
| Less than enough | 300 (282, 319) | 307 (291, 324) | 241 (221, 260) | 245 (228, 263) | 278 (266, 291) | 282 (271, 293) | 267 (253, 280) | 270 (258, 281) |
| Frequency of insufficient enough money for food/clothing | | | | | | | | |
| Never | 301 (294, 308) | 301 (295, 307) | 241 (233, 248) | 241 (234, 248) | 282 (277, 286) | 282 (278, 286) | 259 (254, 264) | 259 (255, 264) |
| Seldom | 303 (291, 314) | 295 (285, 306) | 236 (223, 248) | 233 (222, 245) | 291 (283, 299) | 285 (278, 292) | 263 (254, 271) | 260 (253, 268) |
| Sometimes | 298 (282, 313) | 303 (289, 317) | 226 (207, 244) | 229 (213, 245) | 288 (278, 299) | 286 (277, 295) | 265 (253, 278) | 260 (250, 271) |
| Often/ Always | 269 (243, 295) | 288 (264, 311) | 233 (202, 265) | 245 (216, 273) | 281 (253, 298) | 292 (277, 307) | 253 (232, 275) | 273 (254, 291) |
| Difficulty paying bills | | | | | | | | |
| None | 304 (297, 311) | 303 (297, 310) | 241 (234, 249) | 243 (236, 250) | 283 (278, 288) | 284 (280, 288) | 258 (253, 264) | 259 (255, 264) |
| Very little | 294 (283, 305) | 290 (279, 300) | 236 (223, 248) | 233 (222, 244) | 289 (281, 296) | 283 (276, 289) | 265 (257, 274) | 263 (256, 270) |
| Slight | 301 (281, 321) | 304 (286, 322) | 225 (203, 248) | 222 (201, 242) | 295 (281, 309) | 291 (279, 302) | 262 (246, 277) | 255 (242, 269) |
| Some | 291 (271, 311) | 298 (280, 316) | 219 (195, 244) | 228 (205, 250) | 271 (257, 285) | 275 (263, 287) | 256 (239, 273) | 257 (242, 271) |
| Great/ Very great | 261 (215, 307) | 286 (245, 327) | 246 (191, 301) | 250 (200, 300) | 286 (255, 317) | 295 (268, 322) | 288 (250, 326) | 306 (274, 339) |

Means and CI95. Model 1 adjusted for energy intake (continuous), baseline age (continuous), concurrent marital status (4 categories), education (4 categories), social class (5 categories), home-ownership (3 categories), and three lifestyle variables (total alcohol (continuous); physical activity and energy expenditure (continuous); and smoking status (3 categories)). Model 2 adjusted for energy intake (continuous), baseline age (continuous), concurrent marital status (4 categories), education (4 categories), social class (5 categories), home-ownership (3 categories), and fruit variety (for fruit quantity) or vegetable variety (for vegetable quantity). Numbers were: money for needs (Model 1: 7,997; Model 2: 8,413); insufficient money for food/clothing (Model 1: 8,003; Model 2: 8,417); difficulty paying bills (Model 1: 8,009; Model 2: 8,425).

B-9 Sensitivity analysis of adjusted mean variety of fruits or vegetables in older adults in the EPIC-Norfolk study across levels of FH

| | Fruit variety | | | | Vegetable variety | | | |
|---|---|---|---|---|---|---|---|---|
| | Women | | Men | | Women | | Men | |
| | *Model 1* | *Model 2* | *Model 1* | *Model 2* | *Model 1* | *Model 2* | *Model 1* | *Model 2* |
| Enough money for needs | | | | | | | | |
| More than enough | 7.8 (7.6, 7.9) | 7.8 (7.7, 8.0) | 7.0 (6.8, 7.1) | 6.9 (6.8, 7.1) | 16.4 (16.2, 16.7) | 16.6 (16.3, 16.8) | 16.1 (15.9, 16.4) | 16.2 (16.0, 16.5) |
| Just enough | 7.8 (7.7, 7.9) | 7.7 (7.7, 7.8) | 6.8 (6.7, 6.8) | 6.7 (6.7, 6.8) | 16.7 (16.5, 16.8) | 16.6 (16.5, 16.7) | 16.0 (15.9, 16.2) | 15.9 (15.8, 16.1) |
| Less than enough | 7.4 (7.2, 7.6) | 7.4 (7.2, 7.6) | 6.5 (6.3, 6.8) | 6.5 (6.3, 6.7) | 16.4 (16.0, 16.8) | 16.4 (16.1, 16.8) | 15.7 (15.3, 16.1) | 15.6 (15.2, 15.9) |
| Frequency of insufficient money for food/clothing | | | | | | | | |
| Never | 7.8 (7.7, 7.8) | 7.7 (7.6, 7.8) | 6.8 (6.7, 6.9) | 6.7 (6.7, 6.8) | 16.5 (16.3, 16.6) | 16.5 (16.4, 16.7) | 15.9 (15.8, 16.1) | 16.0 (15.8, 16.1) |
| Seldom | 7.9 (7.8, 8.1) | 7.9 (7.7, 8.0) | 6.9 (6.7, 7.0) | 6.9 (6.7, 7.0) | 16.9 (16.7, 17.1) | 16.7 (16.5, 17.0) | 16.2 (15.9, 16.5) | 16.1 (15.9, 16.3) |
| Sometimes | 7.6 (7.4, 7.8) | 7.6 (7.4, 7.8) | 6.8 (6.5, 7.0) | 6.8 (6.6, 7.0) | 16.7 (16.4, 17.0) | 16.6 (16.3, 16.9) | 16.3 (16.0, 16.7) | 16.1 (15.8, 16.4) |
| Often/ Always | 7.1 (6.8, 7.4) | 7.2 (6.9, 7.5) | 6.3 (5.9, 6.7) | 6.3 (6.0, 6.7) | 16.0 (15.5, 16.6) | 16.0 (15.6, 16.5) | 14.8 (14.1, 15.4) | 14.7 (14.2, 15.3) |
| Difficulty paying bills | | | | | | | | |
| None | 7.7 (7.7, 7.8) | 7.7 (7.6, 7.8) | 6.8 (6.7, 6.9) | 6.7 (6.6, 6.8) | 16.5 (16.3, 16.6) | 16.5 (16.3, 16.6) | 15.9 (15.8, 16.1) | 15.9 (15.8, 16.1) |
| Very little | 7.9 (7.8, 8.1) | 7.9 (7.8, 8.0) | 6.8 (6.7, 7.0) | 6.8 (6.7, 7.0) | 17.0 (16.7, 17.2) | 16.8 (16.6, 17.0) | 16.1 (15.9, 16.4) | 16.0 (15.8, 16.3) |
| Slight | 7.7 (7.4, 7.9) | 7.7 (7.4, 7.9) | 6.9 (6.7, 7.2) | 7.0 (6.7, 7.2) | 16.8 (16.4, 17.2) | 16.6 (16.3, 17.0) | 16.4 (15.9, 16.9) | 16.3 (15.9, 16.7) |
| Some | 7.5 (7.3, 7.8) | 7.6 (7.3, 7.8) | 6.6 (6.2, 6.9) | 6.6 (6.3, 6.9) | 16.5 (16.1, 16.9) | 16.6 (16.2, 17.0) | 16.0 (15.5, 16.5) | 15.9 (15.5, 16.4) |
| Great/ Very great | 6.9 (6.3, 7.5) | 6.9 (6.4, 7.4) | 6.6 (5.9, 7.3) | 6.5 (5.9, 7.2) | 15.9 (14.9, 16.8) | 15.8 (15.0, 16.6) | 14.9 (13.7, 16.0) | 14.2 13.2, 15.2) |

Means and CI95. Model 1 adjusted for energy intake (continuous), baseline age (continuous), concurrent marital status (4 categories), education (4 categories), social class (5 categories), home-ownership (3 categories), and three lifestyle variables (total alcohol (continuous); physical activity and energy expenditure (continuous); and smoking status (3 categories)). Model 2 adjusted for energy intake (continuous), baseline age (continuous), concurrent marital status (4 categories), education (4 categories), social class (5 categories), home-ownership (3 categories), and fruit quantity (for fruit variety) or vegetable quantity (for vegetable variety). Numbers were: money for needs (Model 1: 7,997; Model 2: 8,413); insufficient money for food/clothing (Model 1: 8,003; Model 2: 8,417); difficulty paying bills (Model 1: 8,009; Model 2: 8,425).

# Appendix C Supplemental material for Chapter 4

C-1 Characteristics of those who responded or not to social relationship questions in the EPIC-Norfolk cohort & the eligible over-50 sample

C-2 Sensitivity analysis of quantity of intake in gender-specific associations between family contact and variety of fruits or vegetables

C-3 Sensitivity analysis of social class in gender-specific associations between family contact and variety of fruits or vegetables

C-4 Sensitivity analysis of prior poor health in gender-specific associations between family contact and variety of fruits or vegetables

C-5 Sensitivity analysis of other lifestyle factors and confounders in gender-specific associations between family contact and variety of fruits or vegetables

C-6 Association between marital status and variety of fruits or vegetables by living arrangement and by friend contact

C-7 Sensitivity analysis of quantity of intake in the association between marital status and variety of fruits or vegetables by living arrangement and by friend contact

C-8 Sensitivity analysis of social class in the association between marital status and variety of fruits or vegetables by living arrangement and by friend contact

C-9 Association between family contact and variety of fruits or vegetables by living arrangement and by friend contact

C-10 Sensitivity analysis of quantity of intake in the association between family contact and variety of fruits or vegetables by living arrangement and by friend contact

C-11 Sensitivity analysis of social class in the association between family contact and variety of fruits or vegetables by living arrangement and by friend contact

C-12 Association between living arrangement and variety of fruits or vegetables by friend contact

C-13 Sensitivity analysis of quantity of intake in the association between living arrangement and variety of fruits or vegetables by friend contact

C-14 Sensitivity analysis of social class in the association between living arrangement and variety of fruits or vegetables by friend contact

C-1 Characteristics of those who responded or not to social relationship questions in the EPIC-Norfolk cohort & the eligible over-50 sample

| | EPIC cohort (N=25,639) | | Over-50s (N=9,580) | |
|---|---|---|---|---|
| | Responders | Non-responders | Responders | Non-responders |
| *Social exposure – marital status* | *n=12,757* | *n=12,882* | *n=6,257* | *n=3,323* |
| Women | 58% | 56% | 56% | 54% |
| No qualification/O-level | 43% | 46% | 45% | 48% |
| Lower social classes (IV & V) | 16% | 17% | 15% | 16% |
| Moderate/poor health (2HC) | 16% | 17% | 16% | 17% |
| Ever smoker (2HC) | 49% | 52% | 50% | 53% |
| BMI (2HC) | 26.5 (4.0) | 26.8 (3.9) | 26.7 (3.9) | 26.8 (3.8) |
| Fruit variety score | 7.2 (2.4) | 7.2 (2.5) | 7.3 (2.4) | 7.2 (2.5) |
| Vegetable variety score | 16.3 (4.1) | 16.4 (4.2) | 16.1 (4.0) | 16.2 (4.1) |
| *Social exposure – living arrangement* | *n=18,172* | *n=7,467* | *n=8,816* | *n=764* |
| Women | 57% | 56% | 56% | 54% |
| No qualification/O-level | 44% | 47% | 45% | 51% |
| Lower social classes (IV & V) | 16% | 19% | 15% | 17% |
| Moderate/poor health (2HC) | 16% | 19% | 16% | 19% |
| Ever smoker (2HC) | 50% | 54% | 51% | 53% |
| BMI (2HC) | 26.6 (4.0) | 26.7 (3.9) | 26.7 (3.9) | 26.9 (3.8) |
| Fruit variety score | 7.2 (2.5) | 7.1 (2.5) | 7.2 (2.5) | 7.1 (2.4) |
| Vegetable variety score | 16.4 (4.1) | 16.2 (4.3) | 16.2 (4.0) | 16.0 (4.3) |
| *Social exposure – friend contact* | *n=17,327* | *n=8,312* | *n=8,442* | *n=1,138* |
| Women | 58% | 52% | 56% | 51% |
| No qualification/O-level | 43% | 50% | 45% | 54% |
| Lower social classes (IV & V) | 16% | 19% | 15% | 19% |
| Moderate/poor health (2HC) | 16% | 20% | 16% | 20% |
| Ever smoker (2HC) | 50% | 55% | 51% | 55% |
| BMI (2HC) | 26.6 (4.0) | 26.6 (3.9) | 26.7 (3.9) | 26.9 (3.9) |
| Fruit variety score | 7.3 (2.4) | 6.9 (2.5) | 7.3 (2.4) | 6.9 (2.5) |
| Vegetable variety score | 16.4 (4.1) | 15.9 (4.4) | 16.2 (4.0) | 15.6 (4.4) |
| *Social exposure – family contact* | *n=17,261* | *n=8,378* | *n=8,388* | *n=1,192* |
| Women | 58% | 55% | 56% | 54% |
| No qualification/O-level | 44% | 47% | 45% | 50% |
| Lower social classes (IV & V) | 16% | 19% | 15% | 17% |
| Moderate/poor health (2HC) | 16% | 19% | 16% | 20% |
| Ever smoker (2HC) | 50% | 53% | 51% | 54% |
| BMI (2HC) | 26.6 (3.9) | 26.7 (4.2) | 26.7 (3.9) | 26.9 (4.1) |
| Fruit variety score | 7.2 (2.4) | 7.0 (2.5) | 7.3 (2.4) | 7.0 (2.5) |
| Vegetable variety score | 16.4 (4.1) | 16.0 (4.3) | 16.2 (4.0) | 15.7 (4.3) |

C-2 Sensitivity analysis of quantity of intake in gender-specific associations between social relationships and scores for variety of fruit or vegetable

| | Fruit Variety | | Vegetable Variety | |
|---|---|---|---|---|
| | Women | Men | Women | Men |
| Marital status | | | | |
| Partnered | – | – | – | – |
| Single | -0.46 (-0.78, -0.14) | -0.72 (-1.16, -0.27) | -1.48 (-2.01, -0.95) | -2.37 (-3.05, -1.69) |
| Widowed | -0.10 (-0.30, 0.11) | -0.41 (-0.87, 0.05) | -0.60 (-0.94, -0.26) | -1.68 (-2.38, -0.97) |
| Divorced/ Separated | -0.04 (-0.30, 0.22) | -0.39 (-0.84, 0.07) | -0.15 (-0.59, 0.29) | -0.51 (-1.21, 0.19) |
| Living arrangement | | | | |
| Shared | – | – | – | – |
| Alone | -0.26 (-0.40, -0.12) | -0.35 (-0.57, -0.13) | -0.59 (-0.82, -0.35) | -1.11 (-1.45, -0.78) |
| Friend contact | | | | |
| Daily | – | – | – | – |
| Weekly | 0.05 (-0.20, 0.29) | -0.10 (-0.49, 0.28) | 0.11 (-0.30, 0.51) | 0.27 (-0.32, 0.85) |
| Monthly | -0.13 (-0.40, 0.13) | -0.10 (-0.50, 0.30) | -0.02 (-0.45, 0.42) | 0.11 (-0.50, 0.72) |
| Rare/ never | -0.45 (-0.78, -0.12) | -0.83 (-1.26, -0.40) | -0.86 (-1.40, -0.32) | -0.85 (-1.51, -0.19) |
| Family contact | | | | |
| Daily | – | – | – | – |
| Weekly | 0.14 (-0.04, 0.32) | -0.15 (-0.41, 0.12) | 0.76 (0.46, 1.05) | 0.26 (-0.14, 0.67) |
| Monthly | -0.03 (-0.28, 0.21) | -0.38 (-0.69, -0.07) | 0.40 (0.003, 0.80) | 0.03 (-0.44, 0.50) |
| Rare/ never | -0.37 (-0.70, -0.05) | -0.49 (-0.84, -0.14) | -0.26 (-0.80, 0.28) | 0.09 (-0.45, 0.63) |

Gender-specific beta coefficients (CI95) obtained by linear regression models adjusting for total energy intake, age, education and quantity of fruits (for fruit variety) or vegetables (for vegetable variety). References were partnered (married/living as married); shared-living; or, daily contact. Numbers analysed were: marital status (Women: 3,523; Men: 2,729); living arrangement (Women: 4,892; Men: 3,918); friend contact (Women: 4,729; Men: 3,708); family contact (Women: 4,661; Men: 3,721).

C-3 Sensitivity analysis of social class in gender-specific associations between social relationships and scores for variety of fruit or vegetable

| | Fruit Variety | | Vegetable Variety | |
|---|---|---|---|---|
| | Women | Men | Women | Men |
| Marital status | | | | |
| Partnered | – | – | – | – |
| Single | -0.44 (-0.79, -0.08) | -0.88 (-1.37, -0.39) | -1.67 (-2.29, -1.05)[a] | -3.01 (-3.78, -2.24)[a] |
| Widowed | -0.01 (-0.23, 0.21) | -0.48 (-1.00, 0.03) | -0.68 (-1.07, -0.29)[b] | -2.12 (-2.92, -1.32)[b] |
| Divorced/ Separated | 0.07 (-0.22, 0.36) | -0.30 (-0.82, 0.21) | -0.08 (-0.59, 0.42) | -0.66 (-1.47, 0.15) |
| Living arrangement | | | | |
| Shared | – | – | – | – |
| Alone | -0.13 (-0.28, 0.03) | --0.32 (-0.57, -0.08) | -0.52 (-0.79, -0.25)[c] | -1.43 (-1.81, -1.05)[c] |

| | Fruit Variety | | Vegetable Variety | |
|---|---|---|---|---|
| | Women | Men | Women | Men |
| Friend contact | | | | |
| Daily | – | – | – | – |
| Weekly | -0.11 (-0.37, 0.16) | -0.42 (-0.86, 0.009) | -0.11 (-0.57, 0.36) | -0.16 (-0.84, 0.52) |
| Monthly | -0.35 (-0.63, -0.06) | -0.48 (-0.93, -0.03) | -0.36 (-0.86, 0.14) | -0.41 (-1.12, 0.29) |
| Rare/ never | -0.76 (-1.11, -0.40) | -1.07 (-1.55, -0.59) | -1.04 (-1.67, -0.441) | -1.32 (-2.08, -0.57) |
| Family contact | | | | |
| Daily | – | – | – | – |
| Weekly | 0.05 (-0.14, 0.25) | -0.24 (-0.54, 0.05) | 0.66 (0.32, 1.00) | 0.06 (-0.40, 0.52) |
| Monthly | -0.14 (-0.40, 0.12) | -0.44 (-0.78, -0.10) | 0.17 (-0.29, 0.62) | -0.11 (-0.65, 0.42) |
| Rare/ never | -0.50 (-0.86, -0.15) | -0.50 (-0.89, -0.11) | -0.36 (-0.99, 0.26) | -0.25 (-0.86, 0.37) |

Gender-specific beta coefficients (CI95) obtained by linear regression models adjusting for total energy intake, age, education, and social class. References were partnered (married/living as married); shared-living; or, daily contact. Numbers analysed were: marital status (Women: n=3,459; Men: n=2,692); living arrangement (Women: n=4,798; Men: n=3,864); contact with any friend (Women: n=4,642; Men: n=3,655); and contact with immediate family not living with participant (Women: n=4,580; Men: n=3,670). Significant gender difference in vegetable variety for: [a]single (p=0.007); [b]widowed (p=0.002) and [c]lone-living (p=0.000).

## C–4 Sensitivity analysis of prior poor health in gender–specific associations between family contact and variety of fruits or vegetables

| | Fruit Variety | | Vegetable Variety | |
|---|---|---|---|---|
| | Women (n=4,609) | Men (n=3,670) | Women (n=4,609) | Men (n=3,670) |
| Family contact | | | | |
| Daily | – | – | – | – |
| Weekly | 0.001 (-0.19, 0.20) | -0.25 (-0.55, 0.05) | 0.54 (0.21, 0.88) | 0.05 (-0.42, 0.51) |
| Monthly | -0.16 (-0.41, 0.10) | -0.44 (-0.78, -0.09) | 0.04 (-0.41, 0.49) | -0.17 (-0.71, 0.37) |
| Rare/ never | -0.61 (-0.96, -0.26) | -0.47 (-0.86, -0.08) | -0.59 (-1.20, 0.03) | -0.21 (-0.83, 0.40) |

Gender-specific beta coefficients (CI95) obtained by linear regression models adjusting for total energy intake, age, education, and prior poor health (self-rated general health status, high blood, cancer, and stroke; all self-reported at cohort entry). Reference was daily contact.

## C–5 Sensitivity analysis of other lifestyle factors and confounders in gender–specific associations between social relationships and scores for variety of fruit or vegetable

| | Fruit Variety | | Vegetable Variety | |
|---|---|---|---|---|
| | Women | Men | Women | Men |
| Marital status | | | | |
| Partnered | – | – | – | – |
| Single | -0.50 (-0.85, -0.15) | -0.79 (-1.27, -0.30) | -1.87 (-2.47, -1.26) | -2.88 (-3.64, -2.11) |
| Widowed | -0.07 (-0.30, 0.15) | -0.46 (-0.97, 0.06) | -0.85 (-1.24, -0.46) | -2.21 (-3.02, -1.39) |
| Divorced/ Separated | -0.03 (-0.32, 0.26) | -0.41 (-0.91, 0.09) | -0.20 (-0.71, 0.30) | -0.82 (-1.61, -0.03) |

| | Fruit Variety | | Vegetable Variety | |
|---|---|---|---|---|
| | Women | Men | Women | Men |
| Living arrangement | | | | |
| Shared | – | – | – | – |
| Alone | -0.22 (-0.38, -0.06) | -0.32 (-0.57, -0.07) | -0.68 (-0.95, -0.40) | -1.48 (-1.87, -1.09) |
| Friend contact | | | | |
| Daily | – | – | – | – |
| Weekly | -0.07 (-0.34, 0.19) | -0.44 (-0.87, -0.01) | 0.05 (-0.42, 0.52) | -0.05 (-0.73, 0.63) |
| Monthly | -0.31 (-0.60, -0.02) | -0.54 (-0.99, -0.09) | -0.14 (-0.64, 0.37) | -0.22 (-0.93, 0.48) |
| Rare/ never | -0.69 (-1.05, -0.32) | -1.15 (-1.64, -0.67) | -0.85 (-1.49, -0.22) | -1.14 (-1.90, -0.38) |
| Family contact | | | | |
| Daily | – | – | – | – |
| Weekly | 0.003 (-0.20, 0.20) | -0.26 (-0.56, 0.04) | 0.57 (0.23, 0.92) | -0.02 (-0.49, 0.45) |
| Monthly | -0.11 (-0.38, 0.15) | -0.51 (-0.86, -0.17) | 0.06 (-0.40, 0.53) | -0.26 (-0.81, 0.28) |
| Rare/ never | -0.61 (-0.97, -0.25) | -0.52 (-0.92, -0.12) | -0.53 (-1.15, 0.10) | -0.20 (-0.82, 0.43) |

Gender-specific beta coefficients (CI95) obtained by linear regression models adjusting for total energy intake, age, education, BMI, smoking status, self-reported health status, physical activity and energy expenditure (PAEE score), and total alcohol intake (units/week). References were partnered (married/living as married); shared-living; or, daily contact. Numbers analysed were: marital status (Women: 3,302; Men: 2,593); living arrangement (Women: 4,575; Men: 3,716); friend contact (Women: 4,420; Men: 3,520); and family contact (Women: 4,358; Men: 3,535).

## C–6 Association between marital status and variety of fruits or vegetables by living arrangement and by friend contact

| | Fruit variety | | Vegetable variety | |
|---|---|---|---|---|
| | Co-living | Lone-living | Co-living | Lone-living |
| Marital Status | | | | |
| Partnered | – | – | – | – |
| Single | -0.63 (-1.15, -0.12) | -0.83 (-1.33, -0.33) | -2.39 (-3.24, -1.53) | -2.47 (-3.30, -1.64) |
| Widowed | -0.08 (-0.59, 0.42) | -0.38 (-0.81, 0.04) | -0.40 (-1.23, 0.44) | -1.28 (-1.98, -0.57) |
| Divorced/ Separated | -0.19 (-0.67, 0.29) | -0.29 (-0.76, 0.18) | -0.66 (-1.46, 0.13) | -0.28 (-1.06, 0.50) |
| | Frequent friend contact | Infrequent friend contact | Frequent friend contact | Infrequent friend contact |
| Marital Status | | | | |
| Partnered | – | – | – | – |
| Single | -0.51 (-0.83, -0.19) | -0.89 (-1.66, -0.11) | -2.17 (-2.70, -1.64) | -3.28 (-4.57, -2.00) |
| Widowed | -0.05 (-0.28, 0.18)[a] | -0.71 (-1.28, -0.14)[a] | -0.87 (-1.25, -0.50)[b] | -2.02 (-2.96, -1.07)[b] |
| Divorced/ Separated | -0.02 (-0.30, 0.27) | -0.42 (-1.03, 0.20) | -0.18 (-0.65, 0.30) | -0.90 (-1.92, 0.12) |

Beta-coefficients (CI95) adjusted for total energy intake, age, gender and education. Numbers analysed were: living arrangement (5,875) and friend contact (5,636). Significant interaction between friend contact and widowed: [a]fruit variety (p=0.034); [b]vegetable variety (p=0.026).

C-7 Sensitivity analysis of quantity of intake in the association between marital status and variety of fruits or vegetables by living arrangement and by friend contact

| | Fruit variety | | Vegetable variety | |
|---|---|---|---|---|
| | Co-living | Lone-living | Co-living | Lone-living |
| Marital Status | | | | |
| Partnered | – | – | – | – |
| Single | -0.59 (-1.07, -0.11) | -0.82 (-1.28, -0.36) | -1.75 (-2.50, -0.99) | -1.83 (-2.57, -1.09) |
| Widowed | 0.01 (-0.46, 0.47) | -0.44 (-0.84, -0.05) | -0.22 (-0.96, 0.52) | -0.81 (-1.43, -0.19) |
| Divorced/ Separated | -0.14 (-0.58, 0.30) | -0.37 (-0.81, 0.06) | -0.53 (-1.23, 0.18) | 0.01 (-0.68, 0.70) |
| | Frequent friend contact | Infrequent friend contact | Frequent friend contact | Infrequent friend contact |
| Marital Status | | | | |
| Partnered | – | – | – | – |
| Single | -0.45 (-0.75, -0.15) | -0.96 (-1.68, -0.25) | -1.68 (-2.15, -1.21) | -2.66 (-3.80, -1.53) |
| Widowed | -0.08 (-0.29, 0.13) | -0.52 (-1.05, 0.01) | -0.62 (-0.96, -0.29)[a] | -1.53 (-2.37, -0.69)[a] |
| Divorced/ Separated | -0.06 (-0.33, 0.20) | -0.45 (-1.02, 0.12) | -0.10 (-0.53, 0.32) | -0.42 (-1.33, 0.48) |

Beta-coefficients (CI95) adjusted for total energy intake, age, gender, education and quantity of fruits (for fruit variety) or vegetables (for vegetable variety). Numbers analysed were: living arrangement (5,875); friend contact (5,636). [a]Significant interaction between friend contact and widowed (p=0.045).

C-8 Sensitivity analysis of social class in the association between marital status and variety of fruits or vegetables by living arrangement and by friend contact

| | Fruit variety | | Vegetable variety | |
|---|---|---|---|---|
| | Co-living | Lone-living | Co-living | Lone-living |
| Marital Status | | | | |
| Partnered | – | – | – | – |
| Single | -0.70 (-1.23, -0.18) | -0.85 (-1.36, -0.34) | -2.32 (-3.19, -1.45) | -2.34 (-3.19, -1.50) |
| Widowed | -0.03 (-0.54, 0.48) | -0.32 (-0.75, 0.11) | -0.30 (-1.14, 0.55) | -1.12 (-1.84, -0.41) |
| Divorced/ Separated | -0.11 (-0.59, 0.38) | -0.22 (-0.70, 0.25) | -0.58 (-1.38, 0.23) | -0.18 (-0.97, 0.61) |
| | Frequent friend contact | Infrequent friend contact | Frequent friend contact | Infrequent friend contact |
| Marital Status | | | | |
| Partnered | – | – | – | – |
| Single | -0.57 (-0.89, -0.24) | -0.82 (-1.62, -0.02) | -2.06 (-2.60, -1.52) | -3.13 (-4.45, -1.81) |
| Widowed | -0.002 (-0.23, 0.23)[a] | -0.69 (-1.27, -0.12)[a] | -0.73 (-1.11, -0.34)[b] | -1.93 (-2.89, -0.98)[b] |
| Divorced/ Separated | 0.03 (-0.26, 0.32) | -0.24 (-0.86, 0.38) | -0.14 (-0.63, 0.35) | -0.64 (-1.67, 0.39) |

Beta-coefficients (CI95) adjusted for total energy intake, age, gender, education and social class. Numbers analysed were: living arrangement (5,785); friend contact (5,548). Significant interaction between friend contact and widowed: [a]fruit variety (p=0.027); [b]vegetable variety (p=0.020).

C-9 Association between family contact and variety of fruits or vegetables by living arrangement and by friend contact

| | Fruit variety | | Vegetable variety | |
|---|---|---|---|---|
| | Co-living | Lone-living | Co-living | Lone-living |
| Family contact | | | | |
| Daily | – | – | – | – |
| Weekly | -0.05 (-0.23, 0.13) | -0.35 (-0.79, 0.09) | 0.37 (0.07, 0.66) | 0.38 (-0.34, 1.11) |
| Monthly | -0.27 (-0.50, -0.05) | -0.42 (-0.92, 0.08) | 0.002 (-0.37, 0.38) | 0.28 (-0.54, 1.10) |
| Rare/ never | -0.48 (-0.76, -0.19) | -0.62 (-1.20, -0.04) | -0.13 (-0.60, 0.34) | -0.48 (-1.43, 0.47) |
| | Frequent friend contact | Infrequent friend contact | Frequent friend contact | Infrequent friend contact |
| Family contact | | | | |
| Daily | – | – | – | – |
| Weekly | -0.08 (-0.25, 0.10) | -0.16 (-0.61, 0.30) | 0.46 (0.16, 0.75) | -0.12 (-0.87, 0.63) |
| Monthly | -0.25 (-0.48, -0.01) | -0.22 (-0.72, 0.28) | 0.14 (-0.24, 0.52) | -0.45 (-1.28, 0.38) |
| Rare/ never | -0.44 (-0.74, -0.14) | -0.45 (-1.01, 0.11) | 0.01 (-0.49, 0.51)[a] | -1.01 (-1.93, -0.08)[a] |

Beta-coefficients (CI95) adjusted for total energy intake, age, gender and education. Numbers analysed were living arrangement (8,344); friend contact (8,047). [a]Significant interaction between friend contact and no family contact (p=0.056).

C-10 Sensitivity analysis of quantity of intake in the association between family contact and variety of fruits or vegetables by living arrangement and by friend contact

| | Fruit variety | | Vegetable variety | |
|---|---|---|---|---|
| | Co-living | Lone-living | Co-living | Lone-living |
| Family contact | | | | |
| Daily | – | – | – | – |
| Weekly | 0.04 (-0.13, 0.20) | 0.04 (-0.37, 0.44) | 0.58 (0.32, 0.84) | 0.63 (-0.01, 1.27) |
| Monthly | -0.18 (-0.39, 0.03) | -0.03 (-0.49, 0.43) | 0.30 (-0.03, 0.63) | 0.56 (-0.16, 1.28) |
| Rare/ never | -0.40 (-0.66, -0.14) | -0.17 (-0.70, 0.36) | 0.18 (-0.24, 0.59) | -0.004 (-0.84, 0.84) |
| | Frequent friend contact | Infrequent friend contact | Frequent friend contact | Infrequent friend contact |
| Family contact | | | | |
| Daily | – | – | – | – |
| Weekly | 0.06 (-0.11, 0.22) | -0.08 (-0.49, 0.34) | 0.65 (0.39, 0.91) | 0.20 (-0.46, 0.86) |
| Monthly | -0.12 (-0.33, 0.09) | -0.18 (-0.64, 0.29) | 0.45 (0.11, 0.79) | -0.13 (-0.86, 0.61) |
| Rare/ never | -0.29 (-0.57, -0.01) | -0.41 (-0.93, 0.10) | 0.41 (-0.03, 0.86)[a] | -0.57 (-1.39, 0.24)[a] |

Beta-coefficients (CI95) adjusted for total energy intake, age, gender, education and quantity of fruits (for fruit variety) or vegetables (for vegetable variety). Numbers analysed were: living arrangement (8,344); friend contact (8,047). [a]Significant interaction between friend contact and no family contact (p=0.036).

C-11 Sensitivity analysis of social class in the association between family contact and variety of fruits or vegetables by living arrangement and by friend contact

| | Fruit variety | | Vegetable variety | |
|---|---|---|---|---|
| | Co-living | Lone-living | Co-living | Lone-living |
| Family contact | | | | |
| Daily | – | – | – | – |
| Weekly | -0.02 (-0.20, 0.16) | -0.32 (-0.75, 0.12) | 0.44 (0.15, 0.74) | 0.44 (-0.29, 1.16) |
| Monthly | -0.24 (-0.47, -0.02) | -0.35 (-0.85, 0.14) | 0.10 (-0.28, 0.48) | 0.42 (-0.40, 1.25) |
| Rare/ never | -0.42 (-0.70, -0.13) | -0.62 (-1.21, -0.04) | 0.001 (-0.48, 0.48) | -0.42 (-1.39, 0.55) |
| | Frequent friend contact | Infrequent friend contact | Frequent friend contact | Infrequent friend contact |
| Family contact | | | | |
| Daily | – | – | – | – |
| Weekly | -0.04 (-0.22, 0.14) | -0.18 (-0.64, 0.28) | 0.55 (0.25, 0.85) | -0.10 (-0.86, 0.67) |
| Monthly | -0.19 (-0.43, 0.04) | -0.28 (-0.79, 0.22) | 0.29 (-0.10, 0.68) | -0.41 (-1.25, 0.44) |
| Rare/ never | -0.40 (-0.70, -0.09) | -0.46 (-1.02, 0.10) | 0.14 (-0.37, 0.65)[a] | -0.80 (-1.74, 0.13)[a] |

Beta-coefficients (CI95) adjusted for total energy intake, age, gender, education and social class. Numbers analysed were: living arrangement (8,214); friend contact (7,922). [a]Significant interaction between friend contact and no family contact (p=0.082).

C-12 Association between living arrangement and variety of fruits or vegetables by friend contact

| | Fruit variety | | Vegetable variety | |
|---|---|---|---|---|
| | Frequent friend contact | Infrequent friend contact | Frequent friend contact | Infrequent friend contact |
| Living arrangement | | | | |
| Shared | – | – | – | – |
| Alone | -0.20 (-0.35, -0.06) | -0.48 (-0.81, -0.15) | -0.80 (-1.04, -0.56)[a] | -1.62 (-2.17, -1.07)[a] |

Beta-coefficients (CI95) adjusted for total energy intake, age, gender and education (n=8,403).
[a]Significant interaction between friend contact and lone-living (p=0.007).

C-13 Sensitivity analysis of quantity of intake in the association between living arrangement and variety of fruits or vegetables by friend contact

| | Fruit variety | | Vegetable variety | |
|---|---|---|---|---|
| | Frequent friend contact | Infrequent friend contact | Frequent friend contact | Infrequent friend contact |
| Living arrangement | | | | |
| Shared | – | – | – | – |
| Alone | -0.29 (-0.42, -0.15) | -0.38 (-0.69, -0.07) | -0.67 (-0.88, -0.46)[a] | -1.22 (-1.70, -0.73)[a] |

Beta-coefficients (CI95) adjusted for total energy intake, age, gender, education and quantity of fruits (for fruit variety) or vegetables (for vegetable variety) (n=8,403). [a]Significant interaction between friend contact and lone-living (p=0.041).

C-14 Sensitivity analysis of social class in the association between living arrangement and variety of fruits or vegetables by friend contact

| | Fruit variety | | Vegetable variety | |
|---|---|---|---|---|
| | Frequent friend contact | Infrequent friend contact | Frequent friend contact | Infrequent friend contact |
| Living arrangement | | | | |
| Shared | – | – | – | – |
| Alone | -0.17 (-0.31, -0.02) | -0.41 (-0.75, -0.08) | -0.71 (-0.95, -0.47)[a] | -1.47 (-2.03, -0.92)[a] |

Beta-coefficients (CI95) adjusted for total energy intake, age, gender, education and social class (n=8,265). [a]Significant interaction between friend contact and lone-living (p=0.013).

# Appendix D Supplemental material for Chapter 5

D-1 Characteristics of older adults in the EPIC-Norfolk study for dichotomised economic exposures

D-2 Concurrent socio-demographics of older adults in the EPIC-Norfolk study across combinations of economic disadvantage and non-married status

D-3 Associations between economic conditions and variety of fruits or vegetables in older adults in the EPIC-Norfolk study

D-4 Associations between social relationships and variety of fruits or vegetables in older adults in the EPIC-Norfolk study

D-1 Characteristics of older adults in the EPIC-Norfolk study for dichotomised economic exposures

| | Women | Not married | Lone-living | Infrequent friend contact | Poor/ moderate health | Ever smoker | Irregular car use | Mean (SD) BMI | Mean (SD) fruit variety (0-11) | Mean (SD) vegetable variety (0-16) |
|---|---|---|---|---|---|---|---|---|---|---|
| Social class (n=9,407) | | | | | | | | | | |
| High (n=5,980) | 56% | 19% | 18% | 16% | 14% | 49% | 79% | 26.5 (3.8) | 7.5 (2.4) | 16.7 (3.9) |
| Low (n=3,427) | 54% | 18% | 16% | 20% | 21% | 55% | 75% | 27.2 (4.1) | 6.9 (2.5) | 15.5 (4.1) |
| Education (n=9,574) | | | | | | | | | | |
| High (n=5,200) | 63% | 19% | 17% | 16% | 14% | 51% | 79% | 26.5 (3.8) | 7.5 (2.4) | 16.8 (3.9) |
| Low (n=4,374) | 49% | 21% | 19% | 19% | 20% | 52% | 76% | 27.0 (4.0) | 7.0 (2.5) | 15.6 (4.0) |
| Wealth (n=8,829) | | | | | | | | | | |
| Home-owner (n=8,20) | 55% | 17% | 16% | 17% | 16% | 51% | 80% | 26.6 (3.9) | 7.3 (2.4) | 16.4 (4.0) |
| Renter (n=809) | 61% | 43% | 37% | 18% | 26% | 54% | 59% | 27.7 (4.3) | 6.7 (2.7) | 14.8 (4.2) |
| Has more than enough money for needs (n=8,747) | | | | | | | | | | |
| Yes (n=1,680) | 53% | 15% | 15% | 14% | 10% | 51% | 82% | 26.2 (3.7) | 7.6 (2.4) | 16.8 (3.9) |
| No (n=7,067) | 56% | 21% | 18% | 18% | 18% | 52% | 77% | 26.9 (3.9) | 7.2 (2.5) | 16.1 (4.0) |
| Sufficient money to afford clothing/food (n=8,753) | | | | | | | | | | |
| Yes (n=7,317) | 55% | 18% | 16% | 17% | 15% | 51% | 79% | 26.6 (3.8) | 7.3 (2.4) | 16.4 (4.0) |
| No (n=1,436) | 59% | 29% | 25% | 19% | 24% | 55% | 72% | 27.4 (4.4) | 7.0 (2.6) | 15.8 (4.2) |
| Able to pay bills (n=8,762) | | | | | | | | | | |
| Yes (n=8,038) | 55% | 18% | 17% | 17% | 15% | 51% | 78% | 26.7 (3.8) | 7.3 (2.4) | 16.3 (4.0) |
| No (n=724) | 60% | 36% | 27% | 21% | 30% | 57% | 74% | 27.8 (4.6) | 6.9 (2.6) | 15.7 (4.3) |

Measurement time-points were: sex, education and occupational class (1993-1997); home-ownership, regular car use, and all social relationship and FH measures (1996-2000); self-rated general health, smoking status, marital status and dietary intake (1998-2002).

D-2 Concurrent socio-demographics of older adults in the EPIC-Norfolk study across combinations of economic disadvantage and non-married status

| | Mean (SD) age | Women | Poor/ moderate health | Ever smoker | Irregular car use | Mean (SD) BMI |
|---|---|---|---|---|---|---|
| Social class and marital status (n=6,151) | | | | | | |
| High class, married (n=3,156) | 62 (7) | 51% | 13% | 49% | 81% | 27 (4) |
| High class, non-married (n=764) | 64 (8) | 79% | 18% | 47% | 64% | 26 (4) |
| Low class, married (n=1,825) | 61 (7) | 53% | 19% | 54% | 76% | 27 (4) |
| Low class, non-married (n=406) | 65 (7) | 71% | 25% | 56% | 52% | 28 (5) |
| Education and marital status (n=6,252) | | | | | | |
| High education, married (n=2,820) | 61 (7) | 44% | 13% | 50% | 80% | 27 (4) |
| High education, non-married (n=642) | 63 (8) | 74% | 17% | 49% | 66% | 26 (5) |
| Low education, married (n=2,216) | 62 (7) | 61% | 18% | 51% | 78% | 27 (4) |
| Low education, non-married (n=574) | 65 (7) | 79% | 25% | 51% | 53% | 27 (5) |
| Home-ownership and marital status (n=5,810) | | | | | | |
| Owner-occupier, married (n=4,425) | 62 (7) | 52% | 14% | 50% | 80% | 27 (4) |
| Owner-occupier, non-married (n=924) | 64 (8) | 77% | 19% | 49% | 65% | 27 (5) |
| Renter, married (n=267) | 64 (7) | 54% | 26% | 58% | 60% | 28 (4) |
| Renter, non-married (n=194) | 65 (8) | 72% | 32% | 58% | 42% | 28 (5) |
| Money for needs and marital status (n=5,830) | | | | | | |
| More than enough, married (n=999) | 61 (7) | 52% | 9% | 46% | 83% | 26 (4) |
| More than enough, non-married (n=179) | 63 (8) | 70% | 14% | 43% | 70% | 26 (5) |
| Not enough, married (n=3,693) | 62 (7) | 51% | 16% | 52% | 78% | 27 (4) |
| Not enough, non-married (n=959) | 64 (8) | 77% | 21% | 52% | 59% | 27 (5) |
| Insufficient money for food/clothing and marital status (n=5,836) | | | | | | |
| Sufficient money for food, married (n=4,007) | 62 (7) | 51% | 14% | 50% | 80% | 27 (4) |
| Sufficient money for food, non-married (n=862) | 64 (8) | 75% | 17% | 49% | 63% | 27 (5) |
| Insufficient money for food, married (n=690) | 61 (7) | 52% | 22% | 54% | 73% | 27 (4) |
| Insufficient money for food, non-married (n=277) | 63 (8) | 78% | 31% | 55% | 56% | 27 (5) |
| Difficulty paying bills and marital status (n=5,839) | | | | | | |
| Able to pay bills, married (n=4,388) | 62 (7) | 52% | 14% | 50% | 79% | 27 (4) |
| Able to pay bills, non-married (n=967) | 64 (7) | 75% | 17% | 49% | 61% | 27 (4) |
| Difficulty paying bills, married (n=309) | 61 (7) | 48% | 26% | 58% | 77% | 28 (5) |
| Difficulty paying bills, non-married (n=175) | 62 (8) | 80% | 40% | 57% | 58% | 28 (5) |

D-3 Associations between economic conditions and variety of fruits or vegetables in older adults in the EPIC-Norfolk study

| | Fruit Variety | | | | Vegetable Variety | | | |
|---|---|---|---|---|---|---|---|---|
| | Women | | Men | | Women | | Men | |
| | *Model 1* | *Model 2* | *Model 1* | *Model 2* | *Model 1* | *Model 2* | *Model 1* | *Model 2* |
| High social class | | | | | | | | |
| Yes | reference | reference | reference | reference | reference | reference | reference | reference |
| No | -0.43 (-0.56, -0.30) | -0.50 (-0.67, -0.33) | -0.71 (-0.86, -0.56) | -0.57 (-0.76, -0.38) | -1.15 (-1.37, -0.93) | -1.30 (-1.58, -1.02) | -1.59 (-1.84, -1.35) | -1.49 (-1.82, -1.17) |
| High education | | | | | | | | |
| Yes | reference | reference | reference | reference | reference | reference | reference | reference |
| No | -0.61 (-0.73, -0.48) | -0.61 (-0.77, -0.45) | -0.52 (-0.67, -0.38) | -0.36 (-0.55, -0.17) | -1.39 (-1.60, -1.18) | -1.61 (-1.87, -1.34) | -1.17 (-1.41, -0.93) | -1.05 (-1.37, -0.73) |
| Home-owner | | | | | | | | |
| Yes | reference | reference | reference | reference | reference | reference | reference | reference |
| No | -0.71 (-0.94, -0.47) | -0.58 (-0.88, -0.29) | -0.83 (-1.12, -0.54) | -0.77 (-1.14, -0.40) | -1.48 (-1.88, -1.09) | -1.47 (-1.97, -0.98) | -1.72 (-2.20, -1.23) | -1.53 (-2.15, -0.90) |
| More than enough money for needs | | | | | | | | |
| Yes | reference | reference | reference | reference | reference | reference | reference | reference |
| No | -0.33 (-0.50, -0.16) | -0.30 (-0.50, -0.10) | -0.46 (-0.65, -0.28) | -0.35 (-0.58, -0.13) | -0.52 (-0.81, -0.24) | -0.52 (-0.86, -0.18) | -0.81 (-1.12, -0.50) | -0.92 (-1.29, -0.54) |
| Has sufficient money to afford food/clothing | | | | | | | | |
| Yes | reference | reference | reference | reference | reference | reference | reference | reference |
| No | -0.45 (-0.62, -0.27) | -0.40 (-0.61, -0.19) | -0.33 (-0.54, -0.13) | -0.09 (-0.35, 0.17) | -0.52 (-0.81, -0.23) | -0.32 (-0.68, 0.04) | -0.69 (-1.04, -0.34) | -0.69 (-1.13, -0.26) |
| Able to meet payment of bills | | | | | | | | |
| Yes | reference | reference | reference | reference | reference | reference | reference | reference |
| No | -0.54 (-0.77, -0.31) | -0.50 (-0.79, -0.21) | -0.43 (-0.71, -0.15) | -0.11 (-0.46, 0.24) | -0.72 (-1.10, -0.33) | -0.42 (-0.91, 0.07) | -0.82 (-1.28, -0.35) | -0.56 (-0.15, 0.04) |

Gender-specific beta coefficients (CI95) obtained by linear regression models using an interaction term and adjusting for age and energy intake (Model 1), and additionally for all three social relationships (Model 2). Numbers were: social class (Model 1: 9,407; Model 2: 5,522); education (Model 1: 9,574; Model 2: 5,608); home-ownership (Model 1: 8,701; Model 2: 5,531); money for needs (Model 1: 8,747; Model 2: 5,572); insufficient money for food/clothing (Model 1: 8,753; Model 2: 5,579); difficulty paying bills (Model 1: 8,762; Model 2: 5,582). .

D-4 Associations between social relationships and variety of fruits or vegetables in older adults in the EPIC-Norfolk study

| | Fruit Variety | | | | Vegetable Variety | | | |
|---|---|---|---|---|---|---|---|---|
| | Women | | Men | | Women | | Men | |
| | *Model 1* | *Model 2* | *Model 1* | *Model 2* | *Model 1* | *Model 2* | *Model 1* | *Model 2* |
| Married | | | | | | | | |
| Yes | reference | reference | reference | reference | reference | reference | reference | reference |
| No | -0.08 (-0.25, 0.10) | -0.09 (-0.28, 0.10) | -0.62 (-0.90, -0.34) | -0.37 (-0.67, -0.07) | -0.76 (-1.06, -0.46) | -0.75 (-1.06, -0.44) | -2.07 (-2.55, -1.60) | -1.79 (-2.29, -1.30) |
| Co-living | | | | | | | | |
| Yes | reference | reference | reference | reference | reference | reference | reference | reference |
| No | -0.16 (-0.32, -0.0004) | -0.16 (-0.33, 0.004) | -0.35 (-0.58, -0.12) | -0.24 (-0.47, -0.003) | -0.57 (-0.84, -0.31) | -0.60 (-0.87, -0.33) | -1.51 (-1.89, -1.12) | -1.32 (-1.71, -0.94) |
| Frequent friend contact | | | | | | | | |
| Yes | reference | reference | reference | reference | reference | reference | reference | reference |
| No | -0.54 (-0.73, -0.34) | -0.42 (-0.61, -0.22) | -0.52 (-0.70, -0.34) | -0.49 (-0.67, -0.30) | -0.81 (-1.13, -0.49) | -0.53 (-0.85, -0.20) | -0.83 (-1.14, -0.53) | -0.68 (-0.98, -0.38) |

Gender-specific beta coefficients (CI95) obtained by linear regression models using an interaction term and adjusting for age and energy intake (Model 1) and additionally for all six economic exposures (Model 2). Numbers were: married (Model 1: 6,257; Model 2: 5,628); co-living (Model 1: 8,816; Model 2: 8,414); and frequent friend contact (Model 1: 8,442; Model 2: 8,086).

# Appendix E Supplemental material for Chapter 7

E-1 Sensitivity analysis of other lifestyle factors in the association of SES and general and central obesity in older adults in the EPIC-Norfolk study

E-2 Sensitivity analysis of other lifestyle factors in the association of FH and odds of general obesity in older adults in the EPIC-Norfolk study

E-3 Sensitivity analysis of other lifestyle factors in the association of FH and odds of central obesity in older adults in the EPIC-Norfolk study

E-1 Sensitivity analysis of other lifestyle factors in the association of SES and general and central obesity in older adults in the EPIC-Norfolk study

| | General obesity | | Central obesity | |
|---|---|---|---|---|
| | Women | Men | Women | Men |
| Social Class | *(n=4,870)* | *(n=4,006)* | *(n=4,875)* | *(n=4,010)* |
| Professional | 1.00 | 1.00 | 1.00 | 1.00 |
| Managerial and Technical | 1.16 (0.83, 1.61) | 1.27 (0.86, 1.86) | 0.95 (0.72, 1.24) | 1.00 (0.76, 1.33) |
| Skilled non-manual | 1.09 (0.77, 1.55) | 1.63 (1.07, 2.49) | 0.88 (0.66, 1.17) | 1.15 (0.84, 1.59) |
| Skilled manual | 1.41 (1.00, 2.00) | 1.61 (1.07, 2.40) | 1.04 (0.78, 1.39) | 1.09 (0.81, 1.47) |
| Partly skilled | 1.76 (1.22, 2.53) | 1.42 (0.92, 2.19) | 1.19 (0.87, 1.61) | 1.17 (0.84, 1.61) |
| Unskilled | 2.09 (1.32, 3.32) | 1.36 (1.29, 4.33) | 1.55 (1.03, 2.33) | 1.36 (0.81, 2.28) |
| Education | *(n=4,968)* | *(n=4,057)* | *(n=4,973)* | *(n=4,061)* |
| Degree | 1.00 | 1.00 | 1.00 | 1.00 |
| A-level | 1.05 (0.81, 1.36) | 1.51 (1.12, 2.03) | 1.07 (0.86, 1.34) | 1.19 (0.95, 1.49) |
| O-level | 1.13 (0.83, 1.56) | 1.14 (0.75, 1.73) | 0.96 (0.73, 1.27) | 1.22 (0.90, 1.67) |
| No qualification | 1.42 (1.10, 1.84) | 1.88 (1.37, 2.56) | 1.31 (1.05, 1.64) | 1.51 (1.19, 1.91) |
| Home-ownership | *(n=4,522)* | *(n=3,689)* | *(n=4,527)* | *(n=3,693)* |
| Owner occupier | 1.00 | 1.00 | 1.00 | 1.00 |
| Renting, private | 1.35 (0.88, 2.09) | 1.43 (0.83, 2.45) | 1.33 (0.90, 1.96) | 1.18 (0.74, 1.89) |
| Renting, public | 1.42 (1.05, 1.90) | 2.01 (1.37, 2.95) | 1.68 (1.29, 2.19) | 1.78 (1.26, 2.50) |

Gender-specific odds ratios (CI95) obtained by multivariable logistic regression analysis adjusting for age, marital status, smoking status, total energy intake, physical activity and energy expenditure, and total alcohol intake.

E-2 Sensitivity analysis of other lifestyle factors in the association of FH and odds of general obesity in older adults in the EPIC-Norfolk study

| | Women | | | | Men | | | |
|---|---|---|---|---|---|---|---|---|
| | *Model A* | *Model B: A + education* | *Model C: B + social class* | *Model D: C + home-ownership* | *Model A* | *Model B: A + education* | *Model C: B + social class* | *Model D: C + home-ownership* |
| Enough money for needs | | | | | | | | |
| More than enough | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Just enough | 1.44 (1.16, 1.78) | 1.36 (1.09, 1.69) | 1.33 (1.07, 1.66) | 1.33 (1.06, 1.66) | 1.04 (0.81, 1.33) | 0.98 (0.76, 1.26) | 0.94 (.73, 1.21) | 0.92 (0.71, 1.19) |
| Less than enough | 2.39 (1.77, 3.22) | 2.21 (1.63, 3.00) | 2.10 (1.54, 2.87) | 1.98 (1.44, 2.72) | 2.04 (1.46, 2.84) | 1.88 (1.35, 2.63) | 1.77 (1.26, 2.49) | 1.72 (1.21, 2.44) |
| Frequency of insufficient money for food/clothing | | | | | | | | |
| Never | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Seldom | 1.35 (1.13, 1.62) | 1.32 (1.10, 1.59) | 1.31 (1.09, 1.58) | 1.30 (1.08, 1.56) | 1.29 (1.03, 1.62) | 1.27 (1.01, 1.59) | 1.25 (0.99, 1.57) | 1.26 (1.00, 1.59) |
| Sometimes | 1.55 (1.24, 1.93) | 1.50 (1.20, 1.86) | 1.48 (1.18, 1.85) | 1.41 (1.12, 1.77) | 1.36 (1.01, 1.82) | 1.31 (0.98, 1.76) | 1.30 (0.96, 1.74) | 1.23 (0.91, 1.67) |
| Often/ Always | 1.69 (1.21, 2.37) | 1.60 (1.14, 2.25) | 1.56 (1.11, 2.19) | 1.48 (1.04, 2.10) | 2.25 (1.50, 3.37) | 2.18 (1.45, 3.28) | 2.09 (1.37, 3.18) | 2.07 (1.35, 3.17) |
| Difficulty paying bills | | | | | | | | |
| None | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Very little | 1.35 (1.12, 1.62) | 1.33 (1.11, 1.60) | 1.30 (1.08, 1.57) | 1.31 (1.08, 1.57) | 1.03 (0.82, 1.29) | 1.02 (0.81, 1.28) | 1.02 (0.81, 1.29) | 1.00 (0.79, 1.26) |
| Slight | 1.75 (1.33, 2.30) | 1.74 (1.32, 2.29) | 1.74 (1.32, 2.29) | 1.67 (1.26, 2.21) | 1.05 (0.72, 1.52) | 1.04 (0.71, 1.51) | 1.04 (0.71, 1.51) | 1.03 (0.71, 1.51) |
| Some | 2.02 (1.55, 2.64) | 1.95 (1.49, 2.55) | 1.87 (1.43, 2.45) | 1.82 (1.38, 2.40) | 1.74 (1.23, 2.46) | 1.71 (1.21, 2.42) | 1.64 (1.16, 2.34) | 1.57 (1.09, 2.27) |
| Great/ Very great | 2.46 (1.44, 4.21) | 2.35 (1.37, 4.02) | 2.37 (1.38, 4.07) | 2.18 (1.24, 3.83) | 3.41 (1.79, 6.47) | 3.35 (1.76, 6.37) | 3.37 (1.76, 6.44) | 3.37 (1.74, 6.55) |

Gender-specific odds ratios (CI95) obtained by multivariable logistic regression analysis adjusting for age, marital status, smoking status, total energy intake, physical activity and energy expenditure, and total alcohol intake. Model D numbers of women and men were, respectively: money for needs (4,380; 3,606); insufficient money for food/clothing (4,387; 3,605); difficulty paying bills (4,388; 3,610).

E-3 Sensitivity analysis of other lifestyle factors in the association of FH and odds of general obesity in older adults in the EPIC-Norfolk study

| | Women | | | | Men | | | |
|---|---|---|---|---|---|---|---|---|
| | *Model A* | *Model B: A + education* | *Model C: B + social class* | *Model D: C + home-ownership* | *Model A* | *Model B: A + education* | *Model C: B + social class* | *Model D: C + home-ownership* |
| Enough money for needs | | | | | | | | |
| More than enough | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Just enough | 1.46 (2.21, 1.75) | 1.41 (1.17, 1.70) | 1.42 (1.18, 1.72) | 1.43 (1.18, 1.73) | 1.17 (0.96, 1.42) | 1.12 (0.91, 1.36) | 1.13 (0.92, 1.38) | 1.10 (0.90, 1.35) |
| Less than enough | 2.53 (1.94, 3.31) | 2.42 (1.85, 3.18) | 2.41 (1.83, 3.18) | 2.24 (1.69, 2.98) | 1.80 (1.35, 2.39) | 1.70 (1.27, 2.26) | 1.67 (1.24, 2.24) | 1.64 (1.21, 2.21) |
| Frequency of insufficient money for food/clothing | | | | | | | | |
| Never | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Seldom | 1.35 (1.15, 1.59) | 1.33 (1.13, 1.57) | 1.32 (1.12, 1.56) | 1.32 (1.12, 1.55) | 1.31 (1.09, 1.57) | 1.29 (1.07, 1.55) | 1.29 (1.07, 1.56) | 1.29 (1.07, 1.56) |
| Sometimes | 1.48 (1.21, 1.80) | 1.45 (1.19, 1.77) | 1.44 (1.18, 1.76) | 1.38 (1.12, 1.69) | 1.49 (1.17, 1.88) | 1.45 (1.14, 1.84) | 1.46 (1.15, 1.86) | 1.43 (1.12, 1.83) |
| Often/ Always | 1.96 (1.45, 2.66) | 1.90 (1.40, 2.57) | 1.92 (1.41, 2.60) | 1.80 (1.31, 2.46) | 1.50 (1.03, 2.18) | 1.46 (1.00, 2.13) | 1.42 (0.96, 2.09) | 1.43 (0.96, 2.13) |
| Difficulty paying bills | | | | | | | | |
| None | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Very little | 1.38 (1.18, 1.62) | 1.37 (1.17, 1.61) | 1.34 (1.14, 1.58) | 1.35 (1.15, 1.60) | 1.15 (0.96, 1.38) | 1.14 (0.96, 1.37) | 1.16 (0.96, 1.39) | 1.14 (0.94, 1.37) |
| Slight | 1.48 (1.15, 1.91) | 1.47 (1.15, 1.90) | 1.49 (1.15, 1.92) | 1.42 (1.09, 1.84) | 1.36 (1.02, 1.82) | 1.35 (1.01, 1.81) | 1.35 (1.01, 1.81) | 1.37 (1.02, 1.84) |
| Some | 1.86 (1.45, 2.38) | 1.82 (1.42, 2.33) | 1.80 (1.40, 2.30) | 1.76 (1.37, 2.27) | 1.59 (1.18, 2.15) | 1.57 (1.16, 2.12) | 1.54 (1.13, 2.09) | 1.46 (1.06, 2.01) |
| Great/ Very great | 3.24 (1.97, 5.33) | 3.14 (1.91, 5.18) | 3.11 (1.87, 5.17) | 2.98 (1.77, 5.02) | 1.55 (0.81, 2.95) | 1.52 (0.80, 2.90) | 1.56 (0.81, 2.98) | 1.58 (0.81, 3.06) |

Gender-specific odds ratios (CI95) obtained by multivariable logistic regression analysis adjusting for age, marital status, smoking status, total energy intake, physical activity and energy expenditure, and total alcohol intake. Model D numbers of women and men were, respectively: money for needs (4,385; 3,610); insufficient money for food/clothing (4,392; 3,609); difficulty paying bills (4,393; 3,614).

# Appendix F Supplemental material for Chapter 8

F-1 Baseline socio-demographic characteristics of Whitehall II cohort participants who reported presence or absence of FH at baseline and follow-up

F-2 Sensitivity analysis of excluding baseline weight or including additional confounders in the independent associations of cumulative FH with adjusted mean weight change in middle-aged adults in the Whitehall II study

F-3 Robust variance estimates for the independent associations of cumulative FH with adjusted mean weight change in middle-aged adults in the Whitehall II study

F-4 Sensitivity analysis of excluding baseline weight or including additional confounders in the independent associations of cumulative FH with odds of excess weight gain in middle-aged adults in the Whitehall II study

F-5 Robust variance estimates for the independent associations of cumulative FH with odds of excess weight gain in middle-aged adults in the Whitehall II study

F-6 Sensitivity analysis of including baseline height in associations between cumulative FH and odds of excess weight gain in middle-aged adults in the Whitehall II study

F-7 Secondary analysis of four levels of cumulative FH associated with odds of excess weight in middle-aged adults in the Whitehall II study

F-8 Secondary analysis of a stringent threshold for cumulative FH associated with odds of excess weight gain in middle-aged adults in the Whitehall II study

F-1 Baseline socio-demographic characteristics of Whitehall II cohort participants who reported presence or absence of FH at baseline and cumulative over follow-up

| | Cohort at baseline | | Cohort followed up | |
|---|---|---|---|---|
| | Hardship[a] | No hardship[a] | Hardship[b] | No hardship[b] |
| *FH exposure –insufficient money for food/clothing* | *n=1,339* | *n=5,090* | *n=2,860* | *n=2,965* |
| Age, mean (SD) | 44 (6) | 45 (6) | 44 (6) | 45 (6) |
| Women | 32% | 31% | 32% | 28% |
| Not married | 26% | 24% | 26% | 23% |
| Lowest education (<=16 y) | 38% | 32% | 37% | 29% |
| Lowest class (clerical/ office support) | 30% | 18% | 29% | 13% |
| Renter | 15% | 9% | 15% | 7% |
| Long-standing illness | 35% | 30% | 34% | 30% |
| Depressed | 18% | 12% | 17% | 11% |
| Ever smoker | 55% | 49% | 55% | 46% |
| Not physically active | 84% | 81% | 82% | 81% |
| Weight (kg), mean (SD) | 74 (13) | 73 (12) | 73 (12) | 73 (11) |
| Total alcohol[c], mean (SD) | 10.4 (14) | 12 (15) | 11 (15) | 13 (14) |
| *FH exposure –difficulty paying bills* | *n=1,346* | *n=5,085* | *n=2,392* | *n=3,179* |
| Age, mean (SD) | 44 (6) | 45 (6) | 44 (6) | 45 (6) |
| Women | 29% | 31% | 31% | 29% |
| Not married | 24% | 25% | 25% | 23% |
| Lowest education (<=16 y) | 34% | 32% | 35% | 30% |
| Lowest class (clerical/office support) | 25% | 19% | 27% | 15% |
| Renter | 14% | 9% | 15% | 7% |
| Long-standing illness | 35% | 30% | 35% | 30% |
| Depression | 18% | 12% | 18% | 11% |
| Ever smoker | 56% | 48% | 55% | 46% |
| Not physically active | 82% | 82% | 81% | 81% |
| Weight (kg), mean (SD) | 75 (13) | 73 (12) | 74 (13) | 73 (12) |
| Total alcohol[c], mean (SD) | 12 (15) | 12 (14) | 12 (15) | 12 (14) |

[a]Reported hardship included responses 'sometimes', 'often', and 'always', or 'some', 'great', and 'very great' to baseline FH questions (1985-88). [b]Cumulative hardship constructed from FH data over follow-up using the same response cut-points and comprising a reference group (no FH at any time-point), occasional hardship (FH at any time-point) and persistent hardship (FH at ≥2 time-points). [c]Total alcohol intake (units/week) from FFQ was first available at mid-point.

F-2 Sensitivity analysis of excluding baseline weight or including additional confounders in the independent associations of cumulative FH with adjusted mean weight change in middle-aged adults in the Whitehall II study

| | Women | |
|---|---|---|
| | *Model 1: Excluding baseline weight* | *Model 2: Including additional confounders* |
| History of insufficient money for food/clothing | | |
| None | 4.57 (4.12, 5.02) | 4.60 (4.15, 5.06) |
| Occasional | 5.05 (4.18, 5.91) | 5.04 (4.18, 5.90) |
| Persistent | 6.22 (5.42, 7.01) | 6.26 (5.46, 7.05) |
| History of great difficulty paying bills | | |
| None | 4.65 (4.22, 5.08) | 4.67 (4.24, 5.11) |
| Occasional | 5.62 (4.69, 6.56) | 5.60 (4.66, 6.53) |
| Persistent | 5.82 (4.92, 6.71) | 5.90 (5.00, 6.80) |
| | Men | |
| History of insufficient money for food/clothing | | |
| None | 4.20 (3.92, 4.49) | 4.21 (3.93, 4.50) |
| Occasional | 4.15 (3.62, 4.69) | 4.14 (3.61, 4.68) |
| Persistent | 4.62 (4.07, 5.17) | 4.63 (4.08, 5.19) |
| History of great difficulty paying bills | | |
| None | 4.18 (3.91, 4.46) | 4.21 (3.93, 4.49) |
| Occasional | 4.70 (4.14, 5.26) | 4.73 (4.17, 5.30) |
| Persistent | 4.25 (3.66, 4.84) | 4.16 (3.57, 4.76) |

Gender-specific mean (CI95) weight change (kg) obtained by multivariable linear regression analysis adjusting for follow-up years, ethnicity, and midpoint age, current smoker and married, but not for baseline weight (Model 1), or adjusting for all covariates, SES and also for midpoint general health, depression, anxiety, MVPA and total energy and alcohol intakes (Model 2). Numbers were: insufficient money for food/clothing (Model 1: 3,701; Model 2: 3,671); difficulty paying bills (Model 1: 3,671; Model 2: 3,639).

F-3 Robust variance estimates for the independent associations of cumulative FH with adjusted mean weight change in middle-aged adults in the Whitehall II study

| | Women | |
|---|---|---|
| | *Model A* | *Model B: + SES* |
| History of insufficient money for food/clothing | | |
| None | 4.67 (4.15, 5.19) | 4.58 (4.06, 5.10) |
| Occasional | 5.12 (4.30, 5.94) | 5.07 (4.18, 5.97) |
| Persistent | 5.85 (4.99, 6.72) | 6.17 (5.19, 7.14) |
| History of great difficulty paying bills | | |
| None | 4.71 (4.23, 5.19) | 4.65 (4.17, 5.14) |
| Occasional | 5.20 (4.26, 6.13) | 5.64 (4.49, 6.78) |
| Persistent | 5.81 (4.83, 6.79) | 5.79 (4.71, 6.86) |
| | Men | |
| History of insufficient money for food/clothing | | |
| None | 4.33 (4.07, 4.60) | 4.21 (3.95, 4.47) |
| Occasional | 4.25 (3.82, 4.68) | 4.15 (3.67, 4.63) |
| Persistent | 4.69 (4.17, 5.21) | 4.59 (4.02, 5.15) |
| History of great difficulty paying bills | | |
| None | 4.27 (4.02, 4.52) | 4.20 (3.94, 4.45) |
| Occasional | 4.60 (4.12, 5.08) | 4.68 (4.14, 5.21) |
| Persistent | 4.33 (3.78, 4.89) | 4.23 (3.65, 4.81) |

Robust variance estimates for gender-specific mean (CI95) weight change (kg) obtained by STATA command vce(robust) in multivariable linear regression analysis adjusting for follow-up years, ethnicity, and midpoint age, current smoker and married (Model A), and additionally for SES (Model B). Numbers were: insufficient money for food/clothing (Model A: 4,025; Model B: 3,701); difficulty paying bills (Model A: 3,923; Model B: 3,671).

F-4 Sensitivity analysis of excluding baseline weight or including additional confounders in the independent associations of cumulative FH with odds of excess weight gain in middle-aged adults in the Whitehall II study

| | Women | |
|---|---|---|
| | *Model 1: Excluding baseline weight* | *Model 2: Including additional confounders* |
| History of insufficient money to afford adequate food/clothing | | |
| None | 1.00 | 1.00 |
| Occasional | 1.01 (0.72, 1.43) | 0.99 (0.70, 1.39) |
| Persistent | 1.52 (1.10, 2.10) | 1.46 (1.05, 2.04) |
| History of difficulty paying bills | | |
| None | 1.00 | 1.00 |
| Occasional | 1.28 (0.89, 1.83) | 1.24 (0.86, 1.78) |
| Persistent | 1.45 (1.02, 2.05) | 1.42 (0.99, 2.02) |
| | Men | |
| | *Model 1: Excluding baseline weight* | *Model 2: Including additional confounders* |
| History of insufficient money to afford adequate food/clothing | | |
| None | 1.00 | 1.00 |
| Occasional | 1.06 (0.85, 1.31) | 1.01 (0.81, 1.25) |
| Persistent | 1.18 (0.94, 1.47) | 1.14 (0.91, 1.43) |
| History of difficulty paying bills | | |
| None | 1.00 | 1.00 |
| Occasional | 1.13 (0.91, 1.41) | 1.08 (0.86, 1.35) |
| Persistent | 1.12 (0.89, 1.41) | 1.04 (0.82, 1.32) |

Gender-specific odds ratios (CI95) of gaining ≥5kg obtained by multivariable linear regression analysis adjusting for follow-up years, ethnicity, and midpoint age, current smoker and married, but not for baseline weight (Model 1), or adjusting for all covariates, SES and also for midpoint general health, depression, anxiety, MVPA and total energy and alcohol intakes (Model 2). Numbers analysed were: insufficient money (Model 1: 3701; Model 2: 3,671); difficulty paying bills (Model 1: 3,671; Model 2: 3,639).

F-5 Robust variance estimates for the independent associations of cumulative FH with odds of odds of excess weight gain in middle-aged adults in the Whitehall II study

| | Women | |
|---|---|---|
| | *Model A* | *Model B: A + SES* |
| History of insufficient money for food/clothing | | |
| None | 1.00 | 1.00 |
| Occasional | 0.95 (0.69, 1.31) | 1.01 (0.72, 1.42) |
| Persistent | 1.42 (1.05, 1.94) | 1.45 (1.04, 2.02) |
| History of great difficulty paying bills | | |
| None | 1.00 | 1.00 |
| Occasional | 1.12 (0.80, 1.56) | 1.26 (0.87, 1.84) |
| Persistent | 1.42 (1.02, 1.98) | 1.39 (0.98, 1.97) |
| | Men | |
| History of insufficient money for food/clothing | | |
| None | 1.00 | 1.00 |
| Occasional | 1.06 (0.87, 1.29) | 1.03 (0.83, 1.28) |
| Persistent | 1.15 (0.94, 1.41) | 1.13 (0.91, 1.41) |
| History of great difficulty paying bills | | |
| None | 1.00 | 1.00 |
| Occasional | 1.06 (0.87, 1.30) | 1.09 (0.88, 1.36) |
| Persistent | 1.11 (0.90, 1.38) | 1.08 (0.86, 1.36) |

Robust variance estimates for gender-specific odds ratios (CI95) of gaining ≥5kg obtained by STATA command vce(robust) in multivariable logistic regression analysis adjusting for baseline weight, follow-up years, ethnicity, and mid-point age, current smoker and married (Model A), and additionally for SES (Model B). Numbers were: insufficient money for food/clothing (Model A: 4,025; Model B: 3,701); difficulty paying bills (Model A: 3,923; Model B: 3,671).

F-6 Sensitivity analysis of including baseline height in associations between cumulative FH and odds of excess weight gain in middle-aged adults in the Whitehall II study

| | | |
|---|---|---|
| | Women | |
| | *Model A* | *Model B: A + SES* |
| History of insufficient money to afford adequate food/clothing | | |
| None | 1.00 | 1.00 |
| Occasional | 0.95 (0.69, 1.30) | 1.01 (0.72, 1.42) |
| Persistent | 1.41 (1.04, 1.90) | 1.44 (1.04, 1.99) |
| History of difficulty paying bills | | |
| None | 1.00 | 1.00 |
| Occasional | 1.11 (0.80, 1.52) | 1.25 (0.87, 1.80) |
| Persistent | 1.40 (1.01, 1.95) | 1.37 (0.96, 1.94) |
| | Men | |
| History of insufficient money to afford adequate food/clothing | | |
| None | 1.00 | 1.00 |
| Occasional | 1.05 (0.87, 1.28) | 1.03 (0.83, 1.28) |
| Persistent | 1.14 (0.93, 1.40) | 1.13 (0.90, 1.41) |
| History of difficulty paying bills | | |
| None | 1.00 | 1.00 |
| Occasional | 1.05 (0.86, 1.29) | 1.09 (0.87, 1.36) |
| Persistent | 1.11 (0.89, 1.37) | 1.08 (0.86, 1.36) |

Gender-specific odds ratios (CI95) of gaining ≥5kg obtained by multivariable logistic regression analysis adjusting for baseline height and weight, follow-up years, ethnicity, and mid-point age, current smoker, and married (Model A), and additionally for SES (education, occupational status, home-ownership) (Model B). Numbers analysed were: insufficient money (Model A: 4,024; Model B: 3,700); difficulty paying bills (Model A: 3,922; Model B: 3,670).

F-7 Secondary analysis of four levels of cumulative FH associated with odds of excess weight in middle-aged adults in the Whitehall II study

| | Women | | Men | |
|---|---|---|---|---|
| | OR (CI95) | n | OR (CI95) | n |
| History of insufficient money for food/clothing | | | | |
| None (no FH at any time-point) | 1.00 | 841 | 1.00 | 2,124 |
| Occasional (FH at any time-point) | 0.95 (0.70, 1.31) | 433 | 1.06 (0.87, 1.29) | 1,014 |
| Regular (FH at any 2 time-points) | 1.40 (0.95, 2.05) | 271 | 0.97 (0.75, 1.25) | 550 |
| Persistent (FH at ≥3 time-points) | 1.46 (0.98, 2.19) | 221 | 1.45 (1.09, 1.92) | 371 |
| History of difficulty paying bills | | | | |
| None (no FH at any time-point) | 1.00 | 925 | 1.00 | 2,254 |
| Occasional (FH at any time-point) | 1.12 (0.81, 1.54) | 385 | 1.06 (0.86, 1.30) | 869 |
| Regular (FH at any 2 time-points) | 1.23 (0.81, 1.88) | 197 | 0.84 (0.64, 1.10) | 466 |
| Persistent (FH at ≥3 time-points) | 1.68 (1.07, 2.64) | 164 | 1.59 (1.18, 2.16) | 310 |

Gender-specific odds ratios (CI95) obtained by multivariable logistic regression analysis using a sex interaction term and adjusting for baseline weight, follow-up years, ethnicity, and mid-point age, current smoker, and married.

F-8 Secondary analysis of a stringent threshold for cumulative FH associated with odds of excess weight gain in middle-aged adults in the Whitehall II study

| | Women | | Men | |
|---|---|---|---|---|
| | OR (CI95) | n | OR (CI95) | n |
| History of insufficient money for food/clothing | | | | |
| None (no FH at any time-point) | 1.00 | 1,135 | 1.00 | 2,783 |
| Occasional (FH at any time-point) | 1.67 (1.14, 2.46) | 233 | 1.04 (0.80, 1.34) | 492 |
| Persistent (FH at ≥2 time-points) | 1.27 (0.69, 2.33) | 98 | 1.25 (0.87, 1.78) | 231 |
| History of difficulty paying bills | | | | |
| None (no FH at any time-point) | 1.00 | 1,218 | 1.00 | 3,020 |
| Occasional (FH at any time-point) | 1.52 (0.88, 2.65) | 128 | 1.16 (0.80, 1.69) | 236 |
| Persistent (FH at ≥2 time-points) | 1.05 (0.46, 2.43) | 47 | 1.24 (0.70, 2.18) | 96 |

Gender-specific odds ratios (CI95) obtained by multivariable logistic regression analysis using a sex interaction term and adjusting for baseline weight, follow-up years, ethnicity, and mid-point age, current smoker, and married. Stringent threshold based on FH responses 'often' and 'always', or 'great' and 'very great'.

F-9 Characteristics of older adults in Whitehall II study across levels of self-reported financial hardship

| | Women | Non-white | Not married | Lower education[a] | Lower social class[b] | Renter[c] | Poor/ fair health | Ever smoker | General obesity | Central obesity |
|---|---|---|---|---|---|---|---|---|---|---|
| Frequency of insufficient money (n=2,423) | | | | | | | | | | |
| Never (n=1,390) | 29% | 7% | 20% | 37% | 18% | 8% | 8% | 51% | 8% | 9% |
| Seldom (n=660) | 36% | 13% | 20% | 42% | 28% | 12% | 11% | 54% | 12% | 12% |
| Sometimes (n=263) | 38% | 24% | 26% | 46% | 38% | 17% | 16% | 54% | 16% | 14% |
| Often/ Always (n=110) | 45% | 21% | 35% | 51% | 46% | 27% | 19% | 65% | 16% | 17% |
| Difficulty paying bills (n=2,423) | | | | | | | | | | |
| Very little (n=1,660) | 32% | 9% | 20% | 39% | 21% | 9% | 8% | 51% | 9% | 9% |
| Slight (n=421) | 31% | 11% | 21% | 41% | 27% | 11% | 13% | 55% | 12% | 12% |
| Some (n=294) | 36% | 20% | 28% | 46% | 36% | 20% | 18% | 56% | 14% | 14% |
| Great/ Very great (n=48) | 44% | 31% | 27% | 33% | 46% | 17% | 13% | 46% | 21% | 25% |

Measurement time-points were: sex, age, education, class, accommodation, ethnicity (1985-1988); financial hardship measures (1989-90); self-rated general health, smoking status, marital status and obesity (1991-94). [a]Up to age 16; [b]Clerical/office support employment grade. [c]Accommodation type: council housing; private and furnished; private and unfurnished.

F-10 Odds ratio of general obesity in older adults in the Whitehall II study across levels of FH

| | Women | | | |
|---|---|---|---|---|
| | *Model A* | *Model B: A + education* | *Model C: B + social class* | *Model D: C + home-ownership* |
| Frequency of insufficient money for food/clothing | | | | |
| Never | 1.00 | 1.00 | 1.00 | 1.00 |
| Seldom | 1.16 (0.81, 1.66) | 1.27 (0.82, 1.97) | 1.26 (0.81, 1.95) | 1.27 (0.82, 1.96) |
| Sometimes | 1.74 (1.10, 2.75) | 2.00 (1.16, 3.43) | 1.96 (1.14, 3.37) | 1.87 (1.08, 3.23) |
| Often/ Always | 1.79 (0.97, 3.31) | 2.06 (1.03, 4.14) | 2.02 (1.00, 4.07) | 1.99 (0.98, 4.01) |
| Difficulty paying bills | | | | |
| Very little | 1.00 | 1.00 | 1.00 | 1.00 |
| Slight | 1.49 (0.996, 2.22) | 1.40 (0.86, 2.29) | 1.38 (0.84, 2.26) | 1.37 (0.83, 2.24) |
| Some | 1.60 (1.03, 2.48) | 1.70 (1.02, 2.84) | 1.67 (1.00, 2.79) | 1.59 (0.94, 2.66) |
| Great/ Very great | 1.95 (0.74, 5.13) | 2.19 (0.81, 5.92) | 2.19 (0.81, 5.91) | 2.17 (0.80, 5.86) |
| | | | Men | |
| Frequency of insufficient money for food/clothing | | | | |
| Never | 1.00 | 1.00 | 1.00 | 1.00 |
| Seldom | 1.48 (1.01, 2.17) | 1.60 (1.04, 2.47) | 1.58 (1.02, 2.44) | 1.58 (1.02, 2.46) |
| Sometimes | 1.65 (0.96, 2.81) | 1.99 (1.13, 3.52) | 1.94 (1.09, 3.45) | 1.95 (1.10, 3.46) |
| Often/ Always | 1.74 (0.81, 3.77) | 1.47 (0.56, 3.85) | 1.42 (0.54, 3.74) | 1.41 (0.54, 3.71) |
| Difficulty paying bills | | | | |
| Very little | 1.00 | 1.00 | 1.00 | 1.00 |
| Slight | 1.08 (0.70, 1.68) | 1.30 (0.80, 2.10) | 1.27 (0.78, 2.06) | 1.26 (0.78, 2.05) |
| Some | 0.97 (0.56, 1.69) | 1.16 (0.65, 2.09) | 1.13 (0.63, 2.03) | 1.14 (0.63, 2.06) |
| Great/ Very great | 2.00 (0.76, 5.26) | 2.42 (0.81, 7.23) | 2.27 (0.75, 6.83) | 2.25 (0.75, 6.78) |

Gender-specific odds ratios (CI95) obtained by multivariable logistic regression adjusting for age, marital status, smoking status, and ethnicity (Model A). Numbers for both exposures were: 3,258 (Model A) and 2,428 (Model D).

F-11 Odds ratio of central obesity in older adults in the Whitehall II study across levels of FH

| | Women | | | |
|---|---|---|---|---|
| | *Model A* | *Model B: A + education* | *Model C: B + social class* | *Model D: C + home-ownership* |
| Frequency of insufficient money for food/clothing | | | | |
| Never | 1.00 | 1.00 | 1.00 | 1.00 |
| Seldom | 1.25 (0.86, 1.80) | 1.37 (0.88, 2.13) | 1.35 (0.87, 2.10) | 1.32 (0.85, 2.07) |
| Sometimes | 1.45 (0.88, 2.37) | 1.61 (0.90, 2.85) | 1.56 (0.87, 2.77) | 1.49 (0.83, 2.67) |
| Often/ Always | 1.88 (1.10, 3.50) | 2.11 (1.05, 4.25) | 2.04 (1.01, 4.12) | 2.06 (1.02, 4.18) |
| Difficulty paying bills | | | | |
| Very little | 1.00 | 1.00 | 1.00 | 1.00 |
| Slight | 1.59 (1.06, 2.40) | 1.52 (0.93, 2.49) | 1.50 (0.91, 2.46) | 1.51 (0.92, 2.49) |
| Some | 1.76 (1.12, 2.76) | 1.66 (0.98, 2.81) | 1.63 (0.96, 2.76) | 1.57 (0.92, 2.69) |
| Great/ Very great | 2.23 (0.85, 5.84) | 2.39 (0.89, 6.42) | 2.37 (0.88, 6.38) | 2.43 (0.90, 6.55) |
| | | | Men | |
| Frequency of insufficient money for food/clothing | | | | |
| Never | 1.00 | 1.00 | 1.00 | 1.00 |
| Seldom | 1.45 (1.02, 2.07) | 1.31 (0.87, 1.97) | 1.27 (0.84, 1.93) | 1.28 (0.85, 1.94) |
| Sometimes | 1.25 (0.73, 2.13) | 1.51 (0.86, 2.63) | 1.45 (0.82, 2.54) | 1.45 (0.83, 2.55) |
| Often/ Always | 1.98 (1.01, 3.89) | 1.33 (0.55, 3.22) | 1.25 (0.51, 3.04) | 1.24 (0.51, 3.03) |
| Difficulty paying bills | | | | |
| Very little | 1.00 | 1.00 | 1.00 | 1.00 |
| Slight | 1.18 (0.78, 1.77) | 1.25 (0.79, 1.99) | 1.22 (0.76, 1.94) | 1.21 (0.76, 1.92) |
| Some | 1.31 (0.81, 2.11) | 1.42 (0.84, 2.39) | 1.37 (0.81, 2.32) | 1.40 (0.83, 2.37) |
| Great/ Very great | 3.21 (1.43, 7.23) | 3.52 (1.37, 9.02) | 3.27 (1.27, 8.47) | 3.27 (1.26, 8.47) |

Gender-specific odds ratios (CI95) obtained by multivariable logistic regression adjusting for age, marital status, smoking status, and ethnicity (Model A). Numbers for both exposures were: 3,220 (Model A) and 2,427 (Model D).