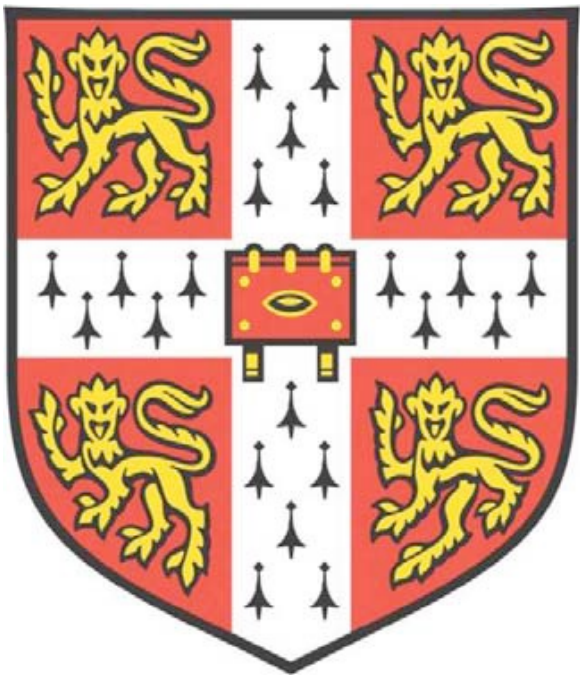
The persistence of poor diet and diet inequalities



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Declaration

This dissertation is the result of my own work under the supervision of Dr Jean Adams and advice of Professor Martin White. I have not submitted this work, in whole or part, for any other degree at the University of Cambridge or elsewhere. This dissertation does not include work done in collaboration except where declared in the 'contributions and dissemination' section and specifically indicated in the text.

In accordance with the Degree Committee of the Faculty of Clinical Medicine and Veterinary Medicine guidelines, this dissertation does not exceed 60,000 words.

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Summary

The persistence of poor diet and diet inequalities

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Diet is determined by socioeconomic factors (e.g. education, occupation, and income) and personal characteristics (e.g. ethnicity, gender, and age). Diet inequalities, whereby diet quality differs systematically across population subgroups, are well-documented. Reducing inequalities has long been prioritised by governmental bodies, yet inequalities persist and effective solutions remain elusive. My thesis aims to further understanding of diet inequalities, particularly focusing on two under-studied groups: food insecure adults and ethnic minority adults. An analysis of UK national nutrition surveys showed substantial social inequalities in diet that largely persisted from 1986 to 2012, though adherence to dietary recommendations improved over time for most population subgroups. Alongside persisting inequalities, food bank usage has risen in the UK. In an online survey, 24% of UK adults reported food insecurity (inability, or perceived inability, to afford a sufficient and nutritious diet). Food insecurity was more prevalent among certain population subgroups, and was associated with poorer diet and health. A thematic analysis of national newspapers revealed public support for the government to address the perceived root causes of food insecurity, through improving welfare support and employment policies. However, existing interventions rely heavily on charitable provision of food for individuals. Analysis of a multi-ethnic sample of Amsterdam residents illustrated that diet quality was not always associated with socioeconomic position in all ethnic groups. Together, these studies show that socioeconomic inequalities in diet persist, but are not inevitable, and demonstrate an intersection between personal characteristics and socioeconomic circumstances in their influence on diet. Socioeconomic disadvantage does not explain all diet inequalities. Community support may be protective against poor diet. Changes to the food and economic systems are likely to be necessary to improve population diet and reduce diet inequalities. Governmental action to make these structural changes is supported by the general public in the case of food insecurity.

Contributions and dissemination

Chapters 2-5 are based on research that I led, resulting in papers written in collaboration with multiple authors. The contents of these papers are presented with minimal changes. Consequently, there will be some overlap in the contents of these chapters. For each study in Chapters 2-5, I solely performed all statistical analyses with advice from my supervisor and co-authors. I also conceived each study's objectives, interpreted the findings, and led the writing of all manuscripts.

Chapter 2 is published as: Yau A, Adams J, Monsivais P. (2019) Time trends in adherence to UK dietary recommendations and associated sociodemographic inequalities, 1986-2012: a repeated cross-sectional analysis. *Eur J Clin Nutr* 73, 997-1005. This publication was selected as EJCN Editors' Choice in July 2019. This work was presented at the Society for Social Medicine Annual Scientific Meeting, Manchester in September 2017. AY and PM conceived the idea for the study and formulated the research question. The study analysis was designed by AY, PM, and JA. AY led on the data analysis, supported by JA and PM. All authors contributed to the interpretation of the data. AY drafted the initial manuscript, conducted the literature search, and produced figures. Data were from the National Diet and Nutrition Surveys collected by NatCen Social Research and Medical Research Council Elsie Widdowson Laboratory (formerly MRC Human Nutrition Research) in the United Kingdom.

Chapter 3 is published in *Public Health Nutrition* as: Yau, A, White M, Hammond D, White C, Adams J. (2020) Sociodemographic characteristics, diet, and health among food insecure UK adults: cross-sectional analysis of the International Food Policy Study. doi: 10.1017/S1368980020000087. This work was presented at the Public Health Science Conference, Belfast in November 2018 and at the International Society of Behavioural Nutrition and Physical Activity (ISBNPA) Annual Meeting, Prague in June 2019. AY, MW, and JA conceived the idea for the study and formulated the research question. CW and DH collected and managed the data. The study analysis was designed by AY, MW, and JA. AY led on the data analysis, supported by MW, JA, CW, and DH. All authors contributed to the interpretation of the data. AY drafted the initial manuscript and conducted the literature search. Data from the International Food Policy Study were collected by researchers at the University of Waterloo, Canada.

Chapter 4 is in preparation for submission to *Social Science and Medicine* as: Yau A, Singh-Lalli H, Forde H, Keeble M, White M, Adams J. News media coverage of food insecurity in the UK, 2014-2019: a thematic analysis. AY, MW, and JA conceived the idea for the study and formulated the research question. AY conducted searches in Factiva to retrieve news articles and screened all articles against inclusion criteria. Duplicate screening of articles was conducted by HSL (45%), HF (23%), MK (23%), and JA (10%). AY led on the data analysis, supported by MW and JA. All authors contributed to the

interpretation of the data. AY drafted the initial manuscript, conducted the literature search, and produced figures.

Chapter 5 is published as: Yau A, Adams J, White M, Nicolaou M. (2020) Differences in diet quality and socioeconomic patterning of diet quality across ethnic groups: cross-sectional data from the Healthy Living in an Urban Setting (HELIUS) study. *Eur J Clin Nutr* 74: 387-396. This work was presented at the ISBNPA Annual Meeting, Prague in June 2019. The abstract was nominated for the ISBNPA student prize in the Socioeconomic Inequalities category. AY, JA, MW, and MN conceived the idea for the study and formulated the research question. The study analysis was designed by AY, JA, and MN. AY led on the data analysis, supported by JA, MW, and MN. All authors contributed to the interpretation of the data. AY drafted the initial paper, conducted the literature search, and produced figures. Data from the HELIUS Dietary Patterns Study were collected by researchers at the Amsterdam Medical Center, University of Amsterdam, the Netherlands.

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Contents

List of Tables

List of Figures

List of Boxes

List of Abbreviations

ABC	Audit Bureau of Circulations
AFI	Adult food insecurity
AFSSM	Adult Food Security Survey Module
BMI	Body mass index
BRFSS	Behavioural Risk Factor Surveillance System
CFSSM	Child Food Security Survey Module
CI(s)	Confidence interval(s)
DALY(s)	Disability-adjusted life year(s)
DNSBA	Dietary and Nutritional Survey of British Adults
DHD15-Index	Dutch Healthy Diet Index 2015
FFQ(s)	Food frequency questionnaire(s)
FI	Food insecure
ft	Foot (length)
FV	Fruit and vegetables
GCSE	General Certificate of Secondary Education
HELIUS	Healthy Life in an Urban Setting
HFFSM	Household Food Security Survey Module
kcal	Kilocalorie
kg	Kilogram
lb	Pound (mass)
m	Metres
NVQ	National Vocational Qualification
IFPS	International Food Policy Study
IMD	Index of Multiple Deprivation
IQR	Interquartile range
LQ(s)	Lower quartile(s)
NDNS	National Diet and Nutrition Survey
NS-SEC	National Statistics - Socioeconomic Classification
OECD	Organisation for Economic Cooperation and Development

OR(s)	Odds ratio(s)
RGSC	Registrar General Social Class
RPM	Red and processed meat
SEP	Socioeconomic position
SIC	Standard Industrial Classification
SACN	Scientific Advisory Committee on Nutrition
SOC	Social Occupational Classification
SSB(s)	Sugar-sweetened beverage(s)
UI(s)	Uncertainty interval(s)
UK	United Kingdom
UN	United Nations
UQ(s)	Upper quartile(s)
US	United States
USDA	United States Department of Agriculture
WHO	World Health Organisation
I	RGSC classification I - professional
II	RGSC classification II – managerial/technical
IIINM	RGSC classification IIINM – skilled non-manual
IIIM	RGSC classification IIIM – skilled manual
IV	RGSC classification IV – partly skilled
V	RGSC classification V – unskilled
β	Beta-coefficient
£	Pound sterling

1 INTRODUCTION AND BACKGROUND

1.1 Introduction

Poor diet is a major contributor to poor health,[1] and dietary risk is not evenly distributed within populations.[2,3] Using data from two Western European countries, the United Kingdom (UK) and the Netherlands, I sought to understand how dietary risk is distributed within populations, taking into account personal and socioeconomic characteristics. This work particularly focuses on two population subgroups: individuals from an ethnic minority background and individuals who were food insecure. As well as being under-studied in dietary public health research, these groups may have poorer access to material resources and may be socially disadvantaged because of discrimination and stigmatisation.[4–6] Both the lack of material and social resources are key in the theories proposed to explain health inequalities,[7] so it is important to address knowledge gaps related to diet and health inequalities within these two groups.

Health inequalities have detrimental health and social effects for individuals, but also for population health as a whole. For this reason, reducing health inequalities within countries emerged as a policy priority internationally with the World Health Organisation's declaration of Alma-Ata in 1978,[8] and has subsequently been reflected in numerous policy documents, including the United Nations' Sustainable Development Goals for 2030.[9] Yet health inequalities continue to be observed in many countries and many areas of health.[10] Although eliminating social inequalities in health completely may not be possible, substantial reductions in health inequalities can be achieved.[11] Thus, reducing health inequalities remains a global public health priority.[12–14] The UK has produced numerous policy documents that cite the need to reduce health inequalities since the Black report written in 1980.[12–14] In England, socioeconomic inequalities in life expectancy have been documented,[14,15] alongside socioeconomic inequalities in the prevalence of obesity,[16] and diet-related chronic diseases such as diabetes,[17] and cardiovascular diseases.[18] Health inequalities have also been reported by ethnicity, gender, and age, among other personal characteristics.[13,19]

The observations in this dissertation aim to provide insight into which mechanisms could be important to address in order to reduce diet and health inequalities between population subgroups. This introductory chapter first provides key background information related to population health and health inequalities, which is necessary to the understanding of social inequalities in diet. Next, the chapter outlines the current evidence on social inequalities in diet, identifies gaps in the literature, and outlines the aims of my dissertation.

1.2 What are health inequalities?

1.2.1 Definition

To understand the problem of persisting health inequalities, it is important to first understand what they are. Health inequalities are defined as:

> *"[u]nfair and avoidable differences in people's health across social groups and between different population groups...unfair because these health inequalities do not occur randomly or by chance, but are socially determined by circumstances largely beyond an individual's control. These circumstances disadvantage some people and limit their chance to live a longer, healthier life. Health inequalities are avoidable because they are rooted in political and social decisions."*[20]

Here I should point out the distinction between differences and inequalities. Some differences in health are not inequalities, because they are neither avoidable nor unfair. For example, women have a greater risk of breast cancer than men due to having more breast tissue and exposure to the hormone oestrogen.[21] This is a sex difference in health, but is not an inequality. On the other hand, many socially determined differences in health are avoidable and unfair, and therefore are the inequalities that policies should seek to reduce. Examples of avoidable risks are those related to behaviours such as diet, smoking, and physical activity.[22] Unfair risks are those that disproportionately affect certain social groups within society. For example, it is unfair if poor diet quality arises in low-income groups because they cannot afford to consume a healthy diet.

Outside of the UK, some researchers term health differences (as described above) as health inequalities, and health inequalities (as defined above) as health inequities.[7] Within this dissertation, I will be using the terminology that is more common in the UK, where health inequalities are perceived as avoidable and unjust,[14] and thus a public health and policy priority to reduce. I will therefore not use the term 'health inequity' to avoid confusion.

1.2.2 Population subgroups

Whilst healthy life expectancy has risen in the past decades globally,[23] striking differences remain between population subgroups.[24] Differences in health have been described using frameworks such as PROGESS-Plus (see **Box 1.1**), a set of personal characteristics that could contribute to social and health disadvantages.[25] This list is not exhaustive, but does illustrate that distribution of health within populations is multidimensional.[25] Health inequalities could result from differential exposure to risk factors for poor health or differential effects of risk factors on health between population subgroups.[26]

Box 1.1. List of PROGRESS-Plus characteristics

Place of residence
Race, ethnicity, culture, language
Occupation
Gender, sex
Religion
Education
Socioeconomic status
Social capital
Plus: personal characteristics associated with discrimination (e.g. age, disability), features of relationships (e.g. excluded from school), time-dependent relationships (temporary disadvantage e.g. leaving the hospital)

1.2.3 Persistence of health inequalities

Health inequalities have been documented in Europe for centuries,[27,28] and persist despite public health efforts to reduce them. Inequalities are observed in most health outcomes and risk factors, and the life expectancy gap between the most and least deprived groups has widened in several countries.[29–31] In the UK, health inequalities have featured regularly in health reports since the Black report published in 1980, which argued that a broad anti-poverty strategy was needed to address the social inequalities observed in health.[12] Despite declining prevalence of some diseases (such as cardiovascular disease) in the overall population, inequalities across population subgroups remain.[32] Socioeconomic inequalities in the prevalence of obesity and numerous diet-related chronic diseases continue to be observed.[14,33] For some measures of health, socioeconomic inequalities have not only remained but widened since they were first discussed as part of the public health agenda.[34] The socioeconomic gap in life expectancy in the UK has increased from 9.0 years in 2001 to 9.7 years in 2016 in men, and 6.1 years in 2001 to 7.9 years in 2016 in women.[35] For other measures of health, such as deaths from cardiovascular diseases, socioeconomic inequalities have reduced over time, but remain high.[35] In 2017, mortality rates from cardiovascular diseases were 3.7 times higher for men and 4.5 times higher for women living in the most deprived areas of England and Wales, compared to those living in the least deprived areas.[36] A recent study of health inequalities in England estimated that one in three premature deaths could be avoided if the whole population had the mortality rate of the least deprived decile, thus attributing a third of premature deaths to socioeconomic inequality.[15] Explanations for these persisting, and in some cases widening, within-country inequalities in health are considered in Section 1.5.1.

1.3 The role of diet in poor health

1.3.1 Dietary risk

Dietary risk is the leading cause of disability-adjusted life years (DALYs) lost globally,[37] with 11 million (95% uncertainty interval [UI] 10-12) deaths and 255 million (95% UI 234-274) DALYs lost attributed to poor diet globally in 2017.[1] This translates to 22% of deaths and 15% of DALYs lost being due to suboptimal diet.[1] In Western Europe, dietary risk accounts for 15% of deaths and 9% of DALYs lost.[1] In 2016, suboptimal diet accounted for the largest percentage of deaths globally in men, 19% (95% UI 16.3-21.8), and the second largest percentage in women, 18.6% (95% UI 15.7-21.7).[38] In comparison, smoking was the second and sixth leading cause of death among men and women, accounting for 16.3% (95% UI 14.6-17.9) and 5.8% (95% UI 5.0-6.7) of deaths, respectively.[38] Suboptimal diet was the second leading risk factor for DALYs lost in men and women, 10.6% (95% UI 9.1-12.2) and 8.4% (95% UI 7.0-9.9), respectively.[38] Smoking was the leading risk factor for DALYs lost in men and the 9th leading risk factor in women, accounting for 9.5% (95% UI 8.5-10.7) and 2.9% (95% UI 2.5-2.9), respectively.[38] The overconsumption of energy, leading to obesity (body mass index [BMI] ≥30kg/m^2), is an important dietary risk. In the UK, the majority of adults (64%) were overweight (BMI ≥25kg/m^2) or obese in 2017.[39] Obesity reduces life expectancy by 3 years, whilst severe obesity reduces life expectancy by up to 10 years.[40] Obesity is a major risk factor for some of the most common diet-related chronic diseases, including type 2 diabetes, cardiovascular diseases, and some cancers.[41] Obesity can also affect more than physical heath, with obese adults less likely to be in employment than non-obese adults and often subject to discrimination and stigmatisation, which have negative consequences for self-esteem and mental health.[40]

1.3.2 Dietary guidelines

Dietary guidelines exist at national and international levels with the aim of reducing diet-related chronic disease and poor health.[42,43] Guidelines are primarily based on nutritional epidemiological studies, but can take into account achievability.[44–46] Whilst dietary guidelines vary between countries, they are nutritionally similar across European countries.[47] It is common for guidelines to recommend increasing the consumption of fruits, vegetables, whole grains, nuts and seeds, fibre, and fish, whilst decreasing consumption of red and processed meats, salt, sugar, and saturated fats.[48] Reducing total energy intake is also recommended in light of the increasing prevalence of obesity globally.[49] Further, there is growing evidence supporting the reduced consumption of ultra-processed foods,[50,51] which now dominate the global food system and contribute to a substantial proportion of calories purchased, especially in high-income countries.[52] Ultra-processed foods (such as biscuits, sugary drinks, and crisps) tend to be energy-dense and low in micronutrients.[53] In general, recommendations are poorly met in most countries.[3,48] Whilst there has been a global increase in the consumption of healthy

foods, there has also been an increase in the consumption of unhealthy foods, the latter being worse in high-income countries.[3] Chapter 2 will explore trends in adherence to some national dietary recommendations among UK adults.

Dietary guidelines provide individuals, communities, and governments with targets, and also provide benchmarks to monitor population diet quality against. However, dietary guidelines do not typically accommodate differences in food preferences, for example in ethnic minority groups, or consider the different nutritional needs of population subgroups, such as pregnant women or older adults.[47] Chapter 5 will investigate ethnic differences in diet quality through assessing adherence to dietary recommendations. Dietary recommendations also do not consider that the pricing of foods might discourage or prevent people from meeting the recommendations.[54] Chapters 3 and 4 will explore food insecurity, the inability or perceived inability to afford a sufficient and nutritious diet, in the UK.

1.4 Diet inequalities

1.4.1 Diet inequalities contribute to health inequalities

Socioeconomic variations in diet are estimated to mediate up to 25% of the association seen between socioeconomic position and all-cause mortality.[2] This suggests that whilst many factors contribute to health inequalities, diet does play an important role.[55] The UK government shows desire to improve population health and reduce health inequalities.[56] Improving diet and reducing diet inequalities simultaneously could be important in achieving these goals. Diet quality differs by various sociodemographic and economic characteristics. This dissertation focuses on dietary differences by socioeconomic position, ethnicity, gender, and age. Below I outline the existing scientific literature on these inequalities.

1.4.2 Socioeconomic inequalities in diet and related health outcomes

The association between low socioeconomic position and poor health and health-related behaviours (including diet) are some of the most consistent findings reported in epidemiological research.[2] Many studies have reported a gradient, whereby individuals of lower socioeconomic position have poorer diet quality than individuals of higher socioeconomic position. Such gradients are seen across various dietary outcomes,[57] including intake of fruit and vegetables,[58,59] salt,[60,61] and red and processed meat.[62] The consumption of energy-dense foods is also higher among lower socioeconomic groups compared to higher socioeconomic groups.[63] These foods are usually highly processed, nutrient-poor, and cheap.[52]

Dietary differences between socioeconomic groups contribute to the socioeconomic inequalities observed for various diet-related health outcomes.[64] A meta-analysis indicated that low socioeconomic position increased the risk of type 2 diabetes by 45%

and 31% in high-income countries, as measured by educational level and occupational level, respectively.[65] Low educational level has also been associated with higher risk of cardiovascular disease in European countries, which was cumulative over the life course.[66] In high-income countries, lower socioeconomic position is associated with higher BMI.[67] Weight gain is also more likely in socioeconomically disadvantaged groups in high-income countries,[68] indicating that the effect is cumulative over the life course.

Research suggests that socioeconomic differences in diet are partly explained by diet costs,[69,70] and that financial constraints could be linked to the higher prevalence of obesity in low socioeconomic groups, compared to high socioeconomic groups, in high-income countries.[71] Higher diet cost has been found to be associated with higher diet quality in the UK and the Netherlands.[72,73] Conversely, energy-dense yet nutrient-poor foods are cheap, readily available, and convenient, due to profitability of these highly processed food products for the food industry, which supplies the majority of food in high-income countries.[52,53] One study also found that, in the UK, prices of less healthy foods are lower than prices of healthier foods.[74] This price gap has also increased over time.[74] Thus, lower socioeconomic position may result in poor diet quality and higher caloric intake. The diet quality of low-income groups will be discussed throughout this dissertation, with a particular focus on food insecure individuals in Chapters 3 and 4.

1.4.3 Ethnic inequalities in diet and related health outcomes

Ethnic minority groups living in Europe often have higher prevalence of diet-related chronic diseases, including type 2 diabetes and cardiovascular diseases, compared to the ethnic majority of the host country.[75–77] Ethnic differences in health could be partly due to ethnic differences in diet,[78] as dietary patterns, behaviours, preferences, and norms differ by ethnicity.[79,80] Research also indicates differences in diet quality between ethnic groups residing in Western countries.[19,81,82] The dietary differences observed may be influenced by cultural factors such as food beliefs, religion, and cultural patterns and customs, as well as availability of different types of food in the local environment.[83–85] The differences may also reflect differences in health status and age distribution of participants between ethnic groups.[85]

Dietary patterns may be subject to further change as an ethnic group becomes established in their host country, and begin to adopt traits of the majority population, a process known as "acculturation",[83] including dietary habits through "dietary acculturation".[86] However, the literature on the effect of acculturation on diet is inconclusive.[80,87–90] This is further discussed in Section 1.8.4, and ethnic differences in diet quality are discussed in Chapter 5.

1.4.4 Gender inequalities in diet and related health outcomes

Diet and health differences can be seen between men and women. Prevalence of diet-related chronic diseases, such as coronary heart disease and stroke, are higher in men

than in women.[91] Food choice has also been found to differ by gender, and adherence to dietary recommendations is generally better in women compared to men.[3,92,93] The social norms and expectations surrounding food may be an explanation for dietary differences between men and women, partly due to historically gendered marketing.[94] Some foods (such as steak) are typically perceived as masculine within society, whilst other foods (such as salads) are typically perceived as feminine.[95,96] Women are also more likely to be responsible for food shopping and food preparation compared to men,[97] and may therefore have more opportunities to gain nutrition knowledge and food preparation skills that make it easier to achieve a healthy diet. Barriers to healthy eating reported by men and women are somewhat different. In one study, more men reported "fondness of good food" as a barrier than women, whilst women reported "price" as a barrier more often than men.[97] Gender inequalities in diet are further discussed in Chapters 2 and 5.

1.4.5 Age inequalities in diet and related health outcomes

Health-related behaviours change throughout the life course.[98] Food choices have been found to change with life transitions, and can be thought of as developing over the life course based on people's life circumstances, past experiences with food, and social and historical context.[99] Correspondingly, diet quality was found to deteriorate with leaving home and leaving education in early adulthood, and improved again by the age of 30 years.[100] Differences in diet quality and dietary behaviours could be explained by differences in barriers (or perceived barriers) to and enablers of healthy eating. Research found age differences in the reporting of time, lack of willpower, limited options, and daily habit as barriers to healthy eating.[101] An alternative explanation to age differences in diet quality is that it is a cohort effect, and that older adults have better diet quality than younger adults, because they have retained diets from a time period where diets were healthier. Using cross-sectional surveys that span a 26-year period, I discuss how age differences in diet quality cannot be completely explained through a cohort effect (see Chapter 2).

1.4.6 Influence of interacting social characteristics

1.4.6.1 Influence of interacting social characteristics on diet

Factors affecting diet and health do not work in isolation, but interact. For example, gender differences in meat consumption are observed, where men tend to consume more meat than women, but the magnitude has been found to differ by ethnicity.[95,102] Cultural framing of meat consumption has been used to explain why gender differences in meat consumption vary across ethnic groups.[103] It is argued that ethnic groups that have stronger cultural framing of meat consumption as masculine have greater gender differences in meat intake.[95] That is, men typically eat more meat than women, and ethnic backgrounds where meat consumption is considered masculine augment this

effect. This suggests that the cultural and gendered expectations surrounding meat consumption are compounded.

1.4.6.2 Intersectionality framework

Intersectionality is a theoretical framework that can be used to conceptualise this interaction. Intersectionality recognises that upstream social determinants interact and that social identity is not one characteristic, but a combination of many.[104,105] The resulting social dynamics and power relations within society feed into a system of privilege versus oppression.[106] This is a useful framework to consider for my research, which aims to explore inequalities in diet across various population subgroups and serves to remind us that it is not one social characteristic that defines a person, but multiple characteristics that may have competing, or multiplicative, effects on diet quality.

The concept of intersectionality originated in black feminist literature and has since been adopted in sociology and more recently in public health.[104,106,107] Social groups may differ in their exposure to risks, or in the resources enabling them to cope with these risks.[26] The public health literature tends to focus on socioeconomic inequalities in health, whilst the intersectionality literature focuses on the intersection between ethnicity and gender, in line with its origins.[105] In its application to health inequalities, it is important for the intersectionality framework to consider other intersecting social identities, especially socioeconomic position, which is repeatedly reported as a driver of health.[2,108] The oppression of some population subgroups and privilege of other subgroups offers an explanation for differences in diet and health between these groups, and emphasises that social disadvantages can be compounding in effect. Intersectionality has been used, for example, to explain the differential prevalence of obesity by ethnicity, gender, and socioeconomic position. One study reported that weight gain was the greatest in low-income, black women compared to other income, ethnicity and, gender combinations in the US.[109] The difference between social groups was also more pronounced in younger adults, highlighting the complexity of these interacting characteristics.[109] Another study proposed that social differences in the prevalence of obesity were due to differences in internalisation of weight stigma and coping with stigma across different social groups.[110]

1.4.7 Food insecurity

Food insecurity is pertinent to the study of diet inequalities, because food insecure individuals experience social and/or economic disadvantages that could lead to insufficient diets. Food insecurity at the individual or household level focuses on food access, as opposed to food availability at the national level.[111] There is no universally accepted definition of food insecurity, but it is commonly defined as when the following definition of food security is not met: *"all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs*

and food preferences for an active and healthy life".[112] Another common definition of food insecurity is *"the inability to consume an adequate quality or sufficient quantity of food in socially acceptable ways, or the uncertainty that one will be able to do so"*.[113] These definitions go beyond recognising food insecurity as an insufficient quantity of food, and consider the impact on nutrition, social interactions, and stress levels.

Increased prevalence of food insecurity at the household and individual level has been reported in North America since the 1960s.[114] Food insecurity is associated with poor physical and mental health outcomes,[115,116] and is a social and public health problem. The North American literature indicates that food insecurity is linked to social policies and various economic, physical, political, and sociocultural factors.[117] Reductions in food insecurity can be seen with improved welfare support,[118] increased employment rates, and higher incomes.[119] More recently, there has been concern that a similar rise in individual-level food insecurity is occurring in Europe.[120] However, food insecurity research in Europe is limited. I discuss the current evidence in Section 1.8.3.

1.5 Researching inequalities

1.5.1 Theories of health inequalities

Several theories have been used to conceptualise and explain social inequalities in health. Here, I describe some key theories that can be applied to diet and health inequalities. Firstly, I consider the explanations of health inequalities proposed in the Black report, which catalysed policy thinking on health inequalities in the UK and elsewhere.[12] I then consider other commonly proposed mechanisms used to explain health inequalities related to: social standing, and unified explanations that bring multiple explanations together using the ideas of salutogenesis and capital.

1.5.1.1 Black report explanations of health inequalities

The Black report was a UK government report on health inequalities published in 1980.[12] It was controversial at the time, but crucial in putting health inequalities on the public health agenda.[12] This report proposed four explanations of health inequalities: artefact, selection (natural or social), cultural/behavioural, and materialist or structuralist.[12]

The artefact explanation proposed no causal relationship between socioeconomic position and health, rather that the associations observed were statistical artefacts due to measurement. As socioeconomic inequalities in various health outcomes have been repeatedly found in different populations, using different measures, over different time periods, this is unlikely to explain much of the health inequalities observed.[121]

The selection explanation hypothesises that those with better health acquire higher socioeconomic position, whereas individuals with poorer health will experience a 'social slide'.[121] The Black report argues that this may explain some of the association, but that

the effect is predominantly in the other direction, based on longitudinal studies.[12] More recently, the selection theory has been used to explain the greater socioeconomic inequalities in health seen in 'meritocratic' Scandinavian countries compared to Southern European countries. It is argued that in the former, 'more able' individuals move into higher socioeconomic groups through social mobility, whilst 'less able' individuals experience a socioeconomic slide.[121] This results in those with the lower risk of ill health in higher socioeconomic groups. In contrast, less meritocratic societies will have ill health spread across the socioeconomic spectrum.

The cultural/behavioural explanation assumes individual choice and autonomy, and look to knowledge as an explanation of behavioural differences.[12] However, this explanation does not explain how differences in behaviour between social groups arise.[121] It is also argued that if culture were to be a valid fundamental explanation of health inequalities, the differences in power, income, and social circumstances between social groups would have to be explained away as incidental findings, which is "highly implausible".[121]

The materialist explanation proposes that poverty and material deprivation drive health inequalities.[12] The Black report itself gave most weight to the materialist explanation, arguing it to explain more of the inequalities observed than the other proposed explanations, and attributing health inequalities to the socioeconomic environment and social structure.[12] This is supported by research showing diminishing health inequalities with improved social support and welfare,[20,31] and conversely, widening health inequalities with periods of high unemployment and social turbulence.[122]

1.5.1.2 Social standing as an explanation of health inequalities

Aside from the explanations proposed in the Black report, the influence of low social standing on health is commonly explained through a psychosocial pathway, whereby sustained feelings of inferiority manifest as chronic stress in low socioeconomic groups living in socially unequal societies.[123] It has been hypothesised that beyond a certain threshold of national income, within-country health inequalities are driven by income inequality within the population as a result of higher levels of chronic stress, low self-esteem, lack of social cohesion, and lack of trust within these unequal societies.[124] This may lead to a lack of control over one's destiny, and lead to socioeconomic inequalities in health.[125] Lack of control can exist at different levels, which may reinforce each other. Control may differ between population subgroups at a micro-level (e.g. social position affecting resources such as money, power, information, and prestige), meso-level (community influence on material and social conditions), or macro-level (cultural attitude to population subgroups or socio-political environment).[125] Stigma as a result of discrimination and marginalisation of disadvantaged groups might explain poorer health among these groups.[126]

As there is a socioeconomic gradient seen for most health outcomes, the spectrum of social standing may be a good explanation of health inequalities. In general, countries with greater income inequality do have greater health inequality.[124] However, that is not to say that countries with the smallest income gap have the smallest health gap. For example, some Southern European countries have less health inequality, despite greater income inequality, than Scandinavian countries,[123] as discussed in the health selection explanation in the Black report. This could be to do with the differential welfare systems, some of which could be better at protecting people from low income, or buffering against the negative effects of low income on health.[123,127]

1.5.1.3 Unified explanations of health inequalities

Lack of material resources, health selection, differential behaviour, low social standing, and high income inequality may all partly explain social inequalities in health. These categories are not mutually exclusive,[128] and a more holistic approach to explaining health inequality may be more appropriate.

1.5.1.3.1 Capital explanation of health inequalities

Social standing has been conceptualised as the possession of three forms of capital (or resources): social, cultural, and economic.[129] Economic capital is similar to the materialist explanation within the Black report, but the capital explanation adds in the role of social and cultural capital. Social capital is the resources that are accessed through social networks, and consists of three components: moral obligations and norms, social values (especially trust), and social networks (especially voluntary associations).[130,131] Cultural capital refers to educational attainment, and encompasses people's values, skills, knowledge, and tastes.[129] These forms of capital interact and feed into each other, and together influence behavioural norms and knowledge, and ultimately behaviour itself.[132] For example, economic capital may determine whether a health behaviour, such as consuming a healthy diet, is possible. But sufficient income alone is not enough, as money does not directly improve health – it only improves health if it is used towards improving health.[133] Cultural capital may influence the value attached to health and healthy eating, and knowledge about healthy food options, and therefore whether the available financial resources are used for health-enhancing behaviours. The people around you may also support healthy behaviours (social capital). The depletion of one or more forms of capital may deplete the resources required for health, in individuals or groups of individuals, and the differential access to such resources may explain inequalities in health.[131]

1.5.1.3.2 Salutogenic explanation of health inequalities

The salutogenic theory of health inequality brings together different strands of explanations using the idea of 'margin of resources'.[134] This model explains social inequalities in health through the differential capacity, of individuals and groups of individuals, to realise health promoting behaviours.[122] This theory describes health as

created through an active process that is energy-consuming.[134] Good health can only be achieved if the margin of resources, which is dependent on the resources available relative to needs, allows.[134] Thus, poor health may result in individual or groups unable to create health due to a deficit of resources as a result of life stressors.[134]

1.5.1.4 Summary

In summary, there are various explanations for health inequalities, with some bringing together different social, economic, and structural factors. These may all contribute to the 'margins of resources' or 'capital' individuals, or groups of individuals, have to create and maintain health.[134] Whilst material resources are essential for health, other resources (social, cultural, and personal) also help to create and maintain health.[130,135] Structural explanations describe the environment that individuals have to navigate to achieve health, and may be seen as the fundamental root cause of inequality, whereas the other explanations could be seen as the mechanisms linking structural determinants to health outcomes.[121] Although typically used to explain socioeconomic differences, these categories could apply to differences by other personal characteristics, such as gender, age, and ethnicity. Some explanations may be more suitable for some groups under some circumstances. Whilst discussing these possible explanations, the Black report also highlighted that inequalities arise from *"cumulative dispositions and experience of the lifetime, and of multiple causation".*[12] Together, this means that when considering health inequalities, we should acknowledge the potential role of having, or not having, multiple types of resources over the life course, which may influence health behaviours and outcomes.

1.5.1.5 Explanations for diet inequalities

The theories used to explain health inequalities can be applied to diet inequalities. Low material resources could lead to an inability to purchase adequate amounts of food, which is part of the definition of food insecurity (as discussed in Section 1.4.7). Low material resources could also increase the influence food pricing has on food purchasing. In the current food environment, where the food industry produces an abundance of cheap, energy-dense and nutrient-poor food,[52,53] people on a low income may over-consume calories, but under-consume key nutrients. These foods are more concentrated in more deprived areas compared to less deprived areas, which may further exacerbate socioeconomic inequality in diet.[136]

Chronic stress, which has been associated with low social standing, may change dietary behaviours as stress is thought to be associated with greater preference for highly palatable, energy-dense foods.[137,138] Everyday stress may also lead people to choose convenient foods.[137]

Wide income inequalities within societies may also create a social environment where the possession of certain items, such as expensive cars or luxury cosmetic goods, maintains

or improves an individual's social status.[139] The need for these aspirational purchases may divert resources towards such items, over a nutritious diet. The absence of such 'luxury' items has been linked to poor health, theorised to be a marker of lack of social participation.[140] Diet could also be a way of expressing social status and distinguishing oneself from other social groups,[129,141] reinforcing differential cultural food norms between social groups.

1.5.2 Categorising social groups

The stratification of population subgroups is socially constructed, but necessary to the study of inequalities.[25] In this dissertation, I categorise populations into social groups in order to explore inequalities in diet by socioeconomic position, ethnicity, gender/sex, age, and food security status. In the following sections, I will discuss measures that can be used to assess socioeconomic position, ethnicity, and food insecurity, and their strengths and limitations in relation to my research aims. All measures of sex/gender and age were self-reported in my data, as is the case in most studies, so I will not outline different measures that can be used to measure these characteristics. However, I will discuss the use of the terms sex and gender within this dissertation.

1.5.2.1 Measuring socioeconomic position

Socioeconomic position is defined as *"social and economic factors that influence what positions individuals and groups hold within the structure of society"*.[133] It is thought of as an *"aggregate concept that includes both resource-based and prestige-based measures"*.[108] In this dissertation, I will use the term socioeconomic position over socioeconomic status as suggested by Kreiger, Williams, and Moss.[108] The theory behind the term socioeconomic status was criticised for blurring *"distinctions between two different aspects of socioeconomic position: (a) actual resources, and (b) status, meaning prestige- or rank-related characteristics"*.[108] Socioeconomic position can be measured at an individual, household, community, or area level. Common individual-level measures of socioeconomic position include occupational level, educational level, and income level. A commonly used area-level measure in England is the Index of Multiple Deprivation. There are advantages and disadvantages associated with each measure, which are briefly considered below, and the best suited measure will be dependent on the research question.[133]

1.5.2.1.1 Occupation

Historically, occupational class has been a preferred marker of socioeconomic position in the UK, thought to represent social status or prestige within society, as well as being a marker of income and access to material resources.[12,133] Therefore, this has been the most commonly available marker of socioeconomic position over time in the UK.[142] However, the types of occupations have changed over time, with fewer people undertaking manual jobs and newer categories of jobs being developed, such as those

within the information technology sector.[143] For this reason, the Standard Occupational Classification used to categorise occupations in the UK requires updating, and was last revised in the year 2010.[144] For an individual, occupational level may change throughout adulthood. Therefore, it may be useful for tracking changes in financial and social circumstances for an individual over time. However, the fluidity of this marker may also make it difficult to measure. Moreover, occupational level may not be a good indicator of socioeconomic position for groups who are neither in work nor looking for work, such as students or homemakers.

1.5.2.1.2 Education

Educational measures of socioeconomic position capture knowledge and skills-related assets.[142] Educational attainment reflects childhood and early adulthood circumstances and opportunity, which may in turn influence adulthood circumstances.[133] Highest level of educational attainment is a fairly stable marker of socioeconomic position in adulthood, as formal education is usually completed by early adulthood.[28] Educational level is easy to measure, usually has high response rate, and can be used in non-working populations.[133] However, more opportunities for education over time, especially in some population subgroups such as women, means that educational level may have different meanings for different birth cohorts.[133] For centuries, women were not admitted into UK universities, and more men than women attended higher education until the 1990s.[145] By 1992, there was no gender gap in higher education participation in the UK, and now, females are more likely to attend higher education than males.[146,147] Therefore, whilst low level of education could have been the norm in the past, it could reflect social disadvantage in a younger cohort.

1.5.2.1.3 Income

Of the measures discussed, income level is the most direct measure of access to material resources. Like occupational level, income level can fluctuate and is likely to reflect current life circumstances. Household-level income, rather than individual-level income, is commonly used as it is thought to more accurately reflect access to material resources, especially in unemployed groups, such as students or homemakers. When using household income level, household composition needs to be considered to account for differences in financial resource requirements.[148] This is known as equivalised household income. This means that both household income and household composition data are needed to calculate this measure of socioeconomic position. However, household composition and household income are not always available. Moreover, income is often considered sensitive information, and participants may not be willing to disclose their income,[149] leading to missing data or misreporting. A further consideration is that poor health may lead to lower income, so the relationship between income and health likely operates in both directions. However, reverse causality, where health affects income, is

thought to have a much smaller effect compared to the effect of income on health, but could be significant in some population subgroups.[150]

1.5.2.1.4 Material assets

Material assets, such as housing, cars, and other investments, can be used as a measure of socioeconomic position, and can be a source of economic security as well as status.[108] Assets capture the accumulation of resources, which will be dependent on social circumstances throughout the life course and can be passed through generations.[133]

1.5.2.1.5 Area-level measures of socioeconomic position

Socioeconomic position can be measured at the area level, capturing the effect of area socioeconomic circumstances on health above and beyond individual-level socioeconomic position.[142] Index of Multiple Deprivation (IMD) is the official measure of relative area-level deprivation in England.[151] IMD splits England into over 32,000 areas and calculates deprivation based on the area's income, employment, health deprivation and disability, education and skills training, crime, barriers to housing and services, and local environment.[151] IMD can be used to assess absolute and relative deprivation compared to other English areas.[151] These data have been collected by the Ministry of Housing, Communities and Local Government and its predecessors since the 1970s,[151] and can have important implications for local policy. Area-level measures of socioeconomic position can be used as a proxy for individual-level socioeconomic position.[152] However, variation in socioeconomic position within an area may be lost in these aggregate data.[142] Furthermore, we must consider the "ecological fallacy" problem, which is a bias that can arise from (incorrectly) applying findings from aggregate data to individuals.[153]

1.5.2.1.6 Using and interpreting measures of socioeconomic position

In this dissertation, I report a variety of individual-level measures of socioeconomic position. Where multiple individual-level measures were available, I compared the effect of each on the outcome, as socioeconomic factors often act independently of each other.[154,155] I do not report any area-level measures as my work focuses on personal characteristics and their effect in combination with socioeconomic position on diet quality. Using area-level measures of socioeconomic position, where individual-level measures are of interest, would likely underestimate the associations with health due to the error associated with assigning the same score to all individuals from the same area.[142] Alternatively, using area-level measures as a proxy for individual-level socioeconomic position could overestimate the effect, as it combines the individual and area effects,[142] which may have independent effects on health.[156]

Different measures of socioeconomic position could have different meanings for individuals, as the presence of one resource may compensate for the lack of another. For example, material assets may improve an individual's ability to cope with unexpected emergencies, such as unemployment and loss of income.[108] Similarly, high educational

attainment may be somewhat protective against poor health when access to material resources are limited, for example, because education improves skills that help individuals to use resources efficiently.[157] The interaction between different resources is considered in some composite measures of socioeconomic position, such as wealth, which measures income and material assets. Wealth is used over income to measure socioeconomic position in some instances because it is assumed to be a better indicator of socioeconomic position.[158] Subjective measures of income adequacy rather than objective measures of wealth are also commonly used. This may better reflect economic ability to meet one's needs and individual experience, but the relationship between objective and subjective indicators of wealth has been found to differ depending on attitudes to money.[159]

When interpreting associations with markers of socioeconomic position, we should also consider that some markers may have different meanings for different population subgroups. For example, although measures of socioeconomic position are commonly correlated with each other to some degree,[142] higher educational attainment may not correlate with high earning potential or high social standing in some groups.[28] Therefore, it could be helpful to include more than one measure of socioeconomic position and base analyses on theory. Nonetheless, the use of one measure over another may simply relate to the availability of data.

1.5.2.2 Measuring ethnicity

Ethnicity can be defined as the *"social group a person belongs to, and either identifies with or is identified with by others, as a result of a mix of cultural and other factors including language, diet, religion, ancestry, and physical features traditionally associated with race"*.[160] Measures of ethnicity can be objective or subjective. The most common objective measure used is country of birth/migration generation. This typically considers the birthplace of the person and their parents (and in some cases their grandparents). If the person migrated themselves, they are considered as the first migration generation. If it was their parents who migrated, they would be considered as the second migration generation, and so on.[161] Country of birth is stable over time, but uni-dimensional as it only considers country of birth/migration generation.[162] On the other hand, self-identification with an ethnic group is multi-dimensional and subjective, and may encompass multiple aspects of ethnicity.[161] Ethnicity is commonly self-reported within questionnaires with mutually exclusive categories provided, asking the participant to choose the answer that is most suitable.[161] Self-identification may offer a better reflection of identity, over the use of country of birth/migration generation. However, high correlation has been found between self-identification and objective country of birth measures.[162] In older studies, ethnicity was sometimes identified by an interviewer. This is likely to have resulted in error. Ethnicity was selected by an interviewer in the earliest

survey used in Chapter 2, and self-reported by participants in the later surveys. Ethnicity was assessed through country of birth/migration generation in Chapter 5.

1.5.2.3 Measuring food insecurity

Many measures of food insecurity have been proposed to assess food insecurity at the national, household, or individual level.[163] These measures may consider food availability, access, utilisation, stability over time, or a combination of these domains.[164] Due to my interest in inequalities within populations, I will not discuss national measures of food insecurity, but I will outline common household and individual level measures. I consider the strengths and weaknesses of these measures, especially related to their validity and reliability. However, it is important to point out that assessing validity and reliability of food insecurity measures is difficult as the phenomena is not directly observable and there is no gold standard measure.[163]

The most common tool used to measure food insecurity is the Household Food Security Survey Module (HFSSM) developed by the United States Department of Agriculture (USDA) in 1997, and later revised in 2000.[165] The HFSSM is a 18-question tool that has been used worldwide to assess household-level food security, based on subjective experience.[111,164] Questions relate to anxiety about, perception of, and intake of food within the household in the past 12 months. There are three summary scales: HFSSM (18-questions), adult food security survey module (AFSSM, 10 questions), and child food security survey module (CFSSM, 8-questions). The Food Insecurity Experience Scale is an individual-level measure of food insecurity that is based on the HFSSM.[166] This measure consists of eight questions and measures access to food, especially economic access. This tool has also been used in numerous countries.[166] The AFSSM is the measure used in the study described in Chapter 3, as this measure that has been used most extensively in high-income countries,[114] with evidence suggesting high internal validity, construct validity, and high test-retest reliability, supporting its validity and accuracy in measuring food insecurity.[167] The full HFSSM tool was not able to be used due to the high proportion of missing data for the child food security questions within the dataset.

The Radimer/Cornell Scale is an individual-level measure of food insecurity that was developed in the 1990s through in-depth interviews with mothers who had experienced hunger. This scale comprises 12 items that ask about sufficiency of food intake, going without food, problems with household food supply, quality of diets, feeling about the situation, and coping.[166] A single-item measure based on the Radimer/Cornell Scale is sometimes added to population health surveys.[166] This measure does not adequately capture the full experience of food insecurity, but may provide a quick and easy proxy measure that can be used across large samples.

Dietary Diversity Scores assess food access by counting the number of food groups consumed at a given reference period.[111] This is a simple measure and dietary diversity does reflect nutrient adequacy.[163] The scale was validated against 24-hour nutrient intake data across multiple countries.[163] However, there is a lack of formal theory that links the number of food groups consumed to the level of food insecurity, making interpretation and comparison across contexts difficult.[168] Therefore, diet diversity may reflect energy and nutrient intake, but is not a comprehensive measure of food insecurity.

The above measures do not provide an exhaustive list of food insecurity measures.[111,114,163,166,167] Variants of these measures have also been developed, and many of the existing food insecurity measures having been developed through adapting another.[167] Thus, many of them have similar features, and focus on financial constraints and access to sufficient amounts of food.[167,169]

1.5.2.4 Measuring sex and gender

Sex is the biological categorisation of male and female (or intersex) based on anatomy and chromosomes, whilst gender is the socially-constructed concept of man and woman (or other gender identities) based on behaviours and attributes.[170] In questionnaires, participants may be asked to report either or both. At the population level, sex and gender are highly correlated. In the context of health inequalities, it is likely that differences between men and women are based on gender, rather than sex. That is that, unfair and avoidable differences will not be biological in nature. As illustrated in Section 1.2.1, sex differences in health do exist, but are not considered inequalities. Inequalities that exist between men and women are likely social. In Chapters 2 and 5, sex, but not gender, data were available. In Chapter 3, both sex and gender data were available. As 99% of participants in Chapter 3 were cis-gender (participants identified as male and as a man, or as female and as a woman), I used sex as a proxy for gender for consistency with the other chapters.

1.6 Importance of reducing diet inequalities

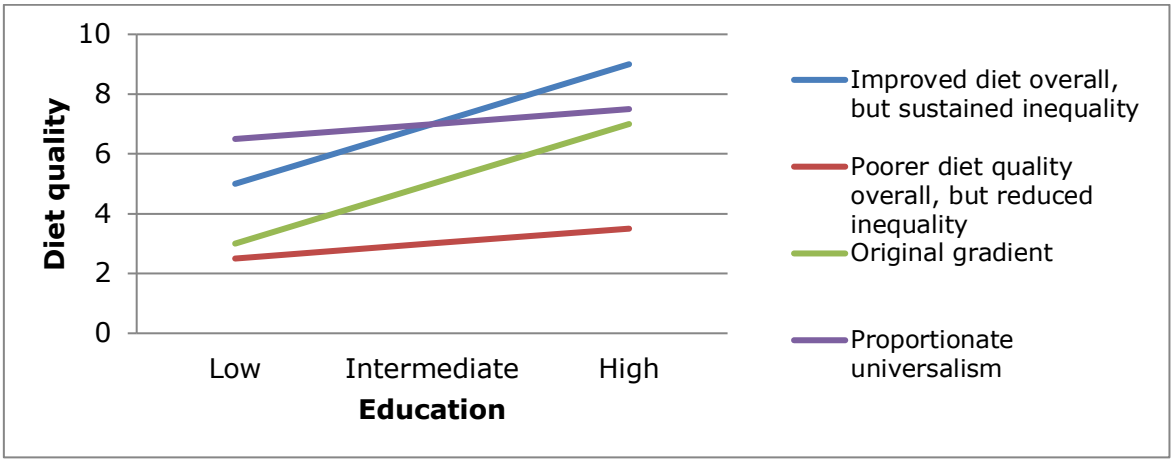
Inequalities by definition are unfair and avoidable. Reducing diet inequalities would be reducing inequality in a modifiable behaviour that contributes substantially to health, improving the health and wellbeing of those who are unnecessarily disadvantaged. Beyond the rationale of justice, morality, and equality of opportunity, reducing health inequalities, by improving the health of disadvantaged groups most at risk of poor health, would be a cost-effective way to improve the health and wellbeing of populations as a whole.[11,171] Reducing health inequalities would have economic benefits through a more productive workforce and lower costs from disease treatment and hospitalisation.[14,172] Reducing inequalities, including those related to diet, could also have societal benefits.[171] Studies have shown that more equal societies are happier and

healthier.[124] This may relate to the high stress, low trust, and low social cohesion created by a pronounced difference in social standing between people within a society.[138]

1.7 Ways to address diet inequalities

Interventions have the potential to reduce social inequalities in diet. Policies that aim to improve population diet and reduce diet inequalities simultaneously must consider who should be targeted and how. Firstly, it is important to consider the impact of interventions on various population subgroups, so as not to exacerbate inequalities when designing and implementing interventions.[22,173] It is proposed that population interventions should act across the whole population, with the scale and intensity of the intervention matching the level of disadvantage.[14] This concept is termed "proportionate universalism" and aims to reduce the steepness of inequality gradients.[14] **Fig 1.1** illustrates the hypothetical potential effects of interventions in relation to educational inequalities in diet. If we take the green line to be the original gradient, where overall diet quality is poor and the educational gradient is fairly steep, we could: improve diet quality in all education groups by the same amount without reducing the gap between groups (blue line), improve diet quality in all groups but most in the group that started with the lowest diet quality (purple line), or there could be a reduction in inequality, but because all education groups have worse diet quality than before (red line). The most desired outcome would be where diet quality is improved for the whole population and improved the most in those who were initially most disadvantaged (proportionate universalism, purple line).

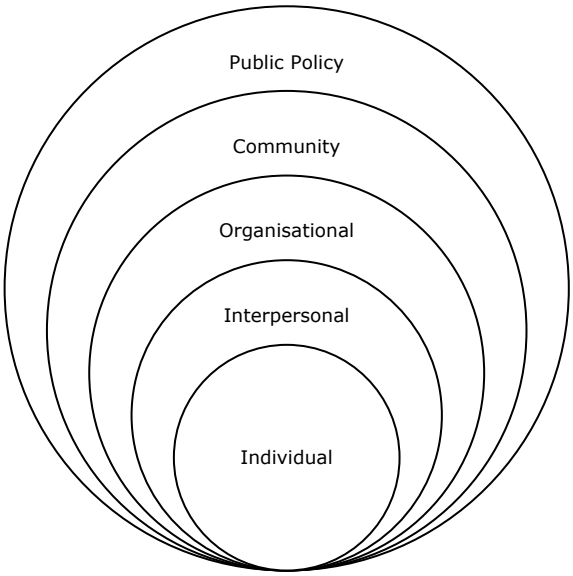
Figure 1.1. Illustration of potential intervention effects on diet quality and educational inequality in diet quality



Interventions must also address the mechanisms behind health inequalities. As discussed in Section 1.5.1, inequalities may be driven by a lack of material, social, or cultural resources, which in turn may lead to certain unhealthy behaviours or cultural norms. Policies could change behaviour at the individual level, for example by providing cookery

classes to increase knowledge and confidence in food preparation, or community level, for example by teaching children about nutrition in schools. Alternatively, policies could make structural changes that support individual behaviour change, for example by offering more healthy choices at food retailers, or structural changes that require no individual behaviour change, for example by incentivising industry to reformulate products to be healthier.[174] The social ecological model offers an approach to thinking about diet inequalities that acknowledges the interaction between factors at the individual, interpersonal, institutional, community, and policy levels (see **Figure 1.2**).[175] The model assumes that positive changes at one level will complement and reinforce changes at another.[175]

Figure 1.2. Social ecological model illustrating the levels of intervention



Dietary interventions that intervene structurally are considered to be upstream interventions, whilst those that target individual behaviour are thought of as downstream interventions. A systematic review reported that upstream interventions, such as those that change the price of foods, appeared to decrease socioeconomic inequalities in diet, whilst downstream interventions, such as dietary counselling, tended to increase inequalities.[176] Upstream interventions that require little individual behaviour change and individual effort or resources (agency) are likely to be more effective, more equitable, and provide sustained benefits.[174] Furthermore, meaningful reductions in health inequalities are not possible without policies to address structural changes, as these are the root causes of health inequality.[121]

1.8 Overview of dissertation

Based on the literature discussed in Sections 1.1 to 1.7, this dissertation aims to fill in several gaps in the scientific literature related to social inequalities in diet.

1.8.1 A focus on Western Europe

Inequalities in diet and health are seen across the globe.[177] The Sustainable Development Goals to end hunger and poverty, and to reduce health inequalities remain global priorities and should be at the heart of policies across all nations.[9] In high-income countries, we have seen an increase in diet and health inequalities.[14,178–180] In this dissertation I chose to focus on Western Europe, using data from the UK and the Netherlands. Both countries have strong records of tracking nutritional intake of the population and epidemiological research, so robust data were available from these locations to answer my research questions. The UK and the Netherlands are fairly ethnically diverse populations, making research into ethnic minority groups both important and feasible. According to the 2011 UK census, 14% of the UK population was from a non-white ethnic minority group.[181] In 2019, 24% of the Dutch population was from a migration background.[182] The UK is also an example of a high-income country that has seen a dramatic increase in the number of people accessing emergency food,[183] indicating a growing problem with individual-level food insecurity, with little UK-based evidence on the topic.

1.8.2 Trends in diet and diet inequalities

Since The Health and Social Care Act 2012, Public Health England, local authorities, and the National Health Service (i.e. governmental bodies involved with public health) have been legally accountable for reducing health inequalities within their work in England.[184] The English government introduced a strategy that aimed to reduce health inequalities by 10% in 10 years in 1997.[31] This strategy reallocated public health funding to the neediest areas, sought to improve evaluation of interventions, and aimed to tackle multiple underlying social determinants of health that contribute to health inequalities, including healthcare provision, nutrition, health promotion in schools, the build environment, and tobacco control.[185] This strategy was reported to be successful in reducing socioeconomic inequalities in life expectancy, but the removal of this programme in 2010 led to a widening of the health gap again.[31] In 2011, life expectancy reduced for the most deprived groups.[35] In 2015-17, the life expectancy was 9.3 years greater in men and 7.5 years greater in women living in the least deprived 10% of areas in England compared to those living in the most deprived 10% of areas, a widening of the life expectancy gap compared to 2012-14.[35,186] The English strategy to reduce health inequalities was not found to be effective in improving self-assessed health, or reducing the proportion reporting long-standing health problems, smoking, or obesity.[187]

Social inequalities in diet may be associated with social inequalities in health. It is important to monitor the magnitude of the associations to inform policies on health inequalities and dietary guidance. UK evidence will also contribute to the growing international literature on diet inequalities, helping us to understand the consistency of

associations. In Chapter 2 of this dissertation, I test whether similar trends in diet inequalities can be seen over the history of the UK's national nutrition surveillance. The first UK survey of nutritional intake in the general population was conducted in 1986-87 (the Dietary and Nutritional Survey of British Adults – DNSBA), and a similar survey (the National Diet and Nutrition Survey – NDNS) is still conducted today. I used these data to track diet quality over time and explore whether social inequalities in diet existed across all the surveys. Similar studies conducted in the United States (US) and the Netherlands report persisting, and even widening diet inequalities.[178–180] This topic has not previously been studied in the UK. The UK has substantial income inequality and health inequality, with one of the widest health gaps between the most and least deprived people of the OECD (Organisation for Economic Cooperation and Development) countries.[172]

1.8.3 Food insecurity

Research has linked food insecurity with socially and economically disadvantaged groups, and with poor diet and health outcomes in Northern America, as detailed in Section 1.4.7. Far less research has been conducted in European countries, although high prevalence of food insecurity has been reported.[120,188] Whilst we can draw from the international literature, some differences might be expected due to differences in the economic situation, demographics, and food environment. For example, different sociodemographic characteristics were found to be associated with food insecurity in the UK compared to Australia, which points to the need for local evidence.[189]

The UK has high levels of poverty and wealth inequality for its national income level compared to other European countries, and is thought to have higher food insecurity prevalence compared to other European countries.[190] However, the UK is lacking robust data describing and documenting food insecurity. Food bank usage is often used as a proxy measure of food insecurity due to the lack of alternative measures in the UK. Food bank usage has increased by 73% in the last 5 years (from 2013/14 to 2018/19).[183] Food bank use is most commonly reported to be due to delays or changes to benefit payments (32%), low income (20%), or unemployment (11%).[191] Whilst in the long-term, we need longitudinal studies of food insecure individuals and consistent monitoring of food insecurity prevalence, in the interim, it would be helpful to research food insecurity in the UK with the available resources. The International Food Policy Study (IFPS) is an online survey that includes a nationwide sample of UK adults, and contains information from which food security status can be determined, using questions adapted from the USDA's AFSSM.[192] In Chapter 3, I present work that estimated the prevalence of food insecurity among UK adults in 2017 and investigated the association between food insecurity and sociodemographic characteristics, diet, and health.

Further to quantifying associations with food insecurity, I explored news media representation of food insecurity. Food insecure individuals and food bank users have described their experience as stigmatising, shameful, and embarrassing.[193,194] Public attitudes could perpetuate this, and the news media also plays an important role in shaping, responding to, and portraying public discourse.[195] Public knowledge and attitude towards food insecurity may give some indication as to what policy responses would be acceptable. Previous work points to a lack of voice for those who are food insecure within the news media, and little mention of children and families in the discussion of food insecurity.[196,197] There was also a reported lack of critical analysis regarding the need for food banks in news articles, which could be feeding into the normalisation of food insecurity.[196] UK research into the news media representation of food insecurity does not include news articles published beyond 2015.[196,197] An updated picture in light of the continued high prevalence of food insecurity would be valuable to the UK literature. This analysis may also have important implications for other contexts, shedding light on how public opinion and government action coincide. A thematic analysis of news media coverage on food insecurity in the UK is presented in Chapter 4.

1.8.4 Diet quality in ethnic minority groups

With increasing numbers of ethnic minority groups residing in Western countries, there has been growing interest in the relationship between ethnicity and health.[19,198] Evidence on ethnic differences in diet quality is limited in Western Europe, as ethnic minorities are under-represented in dietary studies.[199] This may be due to various factors, such as lack of engagement or language barriers.[78] Assessment of dietary intake in ethnic minority groups may also be limited by the tools that are available.[200] For example, a food frequency questionnaire (FFQ) tailored to the majority population may be less accurate in assessing the diet quality of ethnic minority individuals if their diet consists of foods that are different from those typical of the majority population.[201] This coupled with the higher prevalence of diet-related diseases observed in some ethnic minority groups means that ethnic minority groups have different habitual diets, poorer health outcomes, and are under-studied, and thus warrant further research.

Ethnic differences in diet are sometimes explained through differences in socioeconomic position, but it is not clear whether ethnic differences are mediated through socioeconomic differences, or whether the two factors interact to influence diet and health.[202,203] Understanding the relationship between socioeconomic position and ethnicity could help us to develop culturally-sensitive interventions that are more effective for those at higher risk of poor diet,[75] and help to reduce ethnic and socioeconomic inequalities in diet.

1.8.5 Dissertation themes and structure

The work presented in this dissertation centres on three themes: sociodemographic differences in meeting dietary recommendations, individual-level food insecurity, and the relationship between ethnicity, socioeconomic position, and diet quality. Specific aims of each study are presented within the chapters themselves.

Surveillance of diet, and associated inequalities, as well as social attitudes to diet inequalities, may help to inform policies that aim to reduce such inequalities. My focus is on filling in knowledge gaps using the best available observational data. I used large datasets from the UK and the Netherlands to answer my research questions. I used quantitative research methods to look at associations between personal characteristics and diet quality. Chapter 2 uses national nutritional surveillance data from the UK spanning a 26-year period (1986-2012). Chapter 3 uses online survey data from 2017 with information on sociodemographic characteristics, food security, diet, and health. Chapter 5 explores diet inequalities in ethnic minority groups using a large multi-ethnic dataset from the Netherlands, which contains data on dietary intake, socioeconomic position, and various measures of culture collected in 2011-15. I used qualitative research methods to investigate news media representation of food insecurity in the UK in 2016-19 (Chapter 4).

In total, this dissertation comprises six chapters. Following this first introductory chapter, Chapters 2 to 5 describe empirical research conducted in order to answer my research questions. Chapter 6 summarises the findings of my work and critically discusses their interpretation, common themes, and implications for policy.

2 TRENDS IN UK DIET AND DIET INEQUALITIES

2.1 Abstract

Background/objectives Little is known about time trends in diet quality and associated inequalities in the United Kingdom (UK). This study aimed to examine trends in adherence to four UK dietary recommendations, overall, and among sociodemographic subgroups, from 1986 to 2012.

Subjects/methods We conducted a repeated cross-sectional analysis using data from three UK diet surveys: Dietary and Nutritional Survey of British Adults 1986-87 (*n*=2018), National Diet and Nutrition Survey (NDNS) 2000-01 (*n*=1683), and NDNS Rolling Programme 2008-12 (*n*=1632). We measured adherence to dietary recommendations for fruit and vegetables, salt, oily fish, and red and processed meat, estimated using food diary record data, as well as total energy intake from food sources. We compared adherence to dietary recommendations and energy intake across surveys and by four sociodemographic characteristics: sex, age, socioeconomic position, and ethnicity.

Results Overall, population adherence to dietary recommendations was low to moderate, but improved over time. There were inequalities in adherence to all recommendations at all timepoints according to one or more sociodemographic characteristic. When inequalities were present, women, older adults, those with non-manual occupations, and non-white individuals were more likely to adhere to dietary recommendations. Whilst some dietary inequalities declined, most persisted across the three surveys. Total energy intake from food declined over time.

Conclusions The persistence of most inequalities highlights the need for further interventions to reduce dietary inequalities, as well as to improve overall population diet. The greatest simultaneous improvement in population adherence and reduction of inequalities was observed for salt, which may reflect the success of the UK Salt Reduction Programme. Similarly comprehensive programmes should be encouraged for other dietary components.

2.2 Introduction

Dietary factors account for nearly one in five deaths and are the second leading risk factor for global disability.[38] In England, consumption of unhealthy diets is the biggest behavioural risk factor for morbidity and mortality, accounting for 10.8% of Disability-Adjusted Life Years lost in 2013.[204] Current nutrition surveillance data from the United Kingdom (UK) suggest that dietary recommendations are largely not met by the population.[205] It has been estimated that if the UK population met current dietary recommendations, approximately 33,000 deaths per year could be prevented, 15,000 and 7500 of which would be a result of meeting the fruit and vegetable recommendation and salt recommendation, respectively.[206] Health benefits would also be seen by complying with recommendations for oily fish and red and processed meat: higher fish intake, especially oily fish, is associated with lower incident rates of cardiovascular disease,[207] and lower red and processed meat consumption with reduced mortality from cardiovascular disease and cancer.[208]

Obesity increases the risk of numerous chronic diseases.[41] In England, obesity prevalence in adults has risen from 15% in 1993 to 29% in 2017.[209] A further 36% of adults in England were overweight in 2017.[209] The rise in obesity prevalence may be because of an increase in the consumption of energy-dense foods and/or a decrease in physical activity over time, as a result of societal and environmental changes and a lack of policies to support healthy diets and physical activity.[41]

Alongside suboptimal population diet quality and overconsumption of energy, dietary risk factors are not distributed equally across population subgroups leading to dietary inequalities. Whilst inequalities in diet have been documented cross-sectionally for over 80 years,[210] little is known about the evolution of dietary inequalities seen today. Studies conducted in the United States and the Netherlands found persisting or widening inequalities in diet quality by education, income, ethnicity, age, and sex.[178–180,211,212] In the UK, most research has focused specifically on socioeconomic inequalities and a small number of food groups, reporting persisting gaps in fruit and vegetable intake and intake of high fat and high sugar foods.[213–216] Thus, little is known about other sociodemographic inequalities in the consumption of a wider range of food groups. In this study, we aimed to examine trends in adherence to four dietary recommendations and total energy intake in the UK from 1986 to 2012, overall, and among sociodemographic subgroups.

2.3 Methods

2.3.1 Data sources

We used data from three national diet surveys to conduct a repeated cross-sectional analysis: Dietary and Nutritional Survey of British Adults (DNSBA) 1986-87,[217] National Diet and Nutrition Survey (NDNS) 2000-01,[218] and NDNS Rolling Programme (2008-

12).[219] A rolling programme was introduced in 2008 to replace the one-off surveys previously conducted. In order to achieve a sample size comparable to previous surveys, we used data from the first four years of the Rolling Programme. All surveys used multistage random sampling and recruited a cross-section of the UK adult population. Response rates for the surveys have been reported as 70%, 47%, and 58% for DNSBA 1986-87, NDNS 2000-01, and NDNS 2008-12, respectively. Full details on the survey methods and response rates are described elsewhere: DNSBA 1986-87,[217] NDNS 2000-01,[220] and NDNS Rolling Programme (2008-12).[205]

For DNSBA, ethics approval was obtained from the British Medical Association. For NDNS, ethics approval was obtained from the Oxfordshire A Research Ethics Committee. Written informed consent was obtained from all participants.

2.3.2 Inclusion and exclusion criteria

Respondents aged 19-64 years with sufficient dietary data (7 days of food diary records for DNSBA 1986-87 and NDNS 2000-01, and 3 or 4 days of food diary records for NDNS Rolling Programme 2008-12) were included. A small number of respondents were excluded due to insufficient information for assignment of socioeconomic position (SEP) (*n*=29, 41, and 23 in 1986-87, 2000-01, and 2008-12, respectively).

2.3.3 Sociodemographic characteristics

We examined adherence to dietary recommendations by four sociodemographic characteristics: sex (men and women), age (19-40 and 41-64 years), SEP (non-manual and manual occupations), and ethnicity (white and non-white). SEP was based on the occupation of the household reference person/head of house. In DNSBA 1986-87 and NDNS 2000-01, occupational social class was classified using the Registrar General's Social Class (RGSC). The National Statistics Socioeconomic Classification (NS-SEC) replaced RGSC as the UK government's preferred measure of occupation social class in 2001, and this was used in the NDNS Rolling Programme. For comparability, we derived the household reference person's RGSC for respondents in the Rolling Programme using the Standard Occupational Classification 2000 and employment status.[221] Where this was not possible from the information available, we estimated RGSC from the NS-SEC category (for details see **Supplementary Figure A1**).[222] Respondents were stratified into two categories for analysis: non-manual occupations (I Professional; II Managerial/Technical; IIINM Skilled Non-Manual) and manual occupations (IIIM Skilled Manual; IV Partly Skilled; V Unskilled).

2.3.4 Measuring adherence to dietary recommendations

Dietary data were collected using food diary records, weighed 7-day diaries in the first two surveys and unweighed 4-day diaries in NDNS 2008-12. We used average person-level daily intake estimates to measure adherence to the current UK recommendations for four key dietary components related to chronic diseases: fruit and vegetables (≥400

g/day), oily fish (≥140 g/week), salt (≤6 g/day), and red and processed meat (≤80 g/day). The daily average was multiplied by seven for the oily fish recommendation, which is expressed per week. We also used average person-level daily intake estimates of total energy intake from food sources to assess daily energy intake (kcal/day).

2.3.5 Statistical methods

Adjusted logistic regression models were used to estimate the odds ratios (ORs), with 95% confidence intervals (CIs), for meeting the dietary recommendations by sex, age, SEP, ethnicity, and timepoint, with each analysis mutually adjusted for the other variables. We examined interaction terms between the four sociodemographic characteristics and timepoint to determine whether the differences in adherence between sociodemographic subgroups changed over time. We used likelihood-ratio tests to compare models with and without interaction terms (sociodemographic characteristic x timepoint) in order to test the significance of each interaction. We also used an adjusted multiple logistic regression model to estimate the relative risk of achieving any number of these recommendations across the surveys. To examine differences in total daily energy intake from food sources, we compared adjusted medians (lower quartiles, upper quartiles) across timepoints and between sociodemographic subgroups. The medians were adjusted for sex, age, SEP, and ethnicity. Wald tests were used to test the differences. Significance levels were set at a two-tailed *P*-value ≤0.05 for all tests. All statistical analyses were performed using Stata/SE 13.

2.3.6 Sensitivity analyses

Whilst all three surveys aimed to achieve population representative samples, variations in response across population subgroups can lead to non-response bias. Survey weights were provided in the second and third surveys to reduce the effects of this. In sensitivity analyses, we ran models using survey weights in the second and third surveys. This did not alter our conclusions (see **Supplementary Table A1-A2**). Hence, for consistency, we present all our results without survey weights.

2.4 Results

2.4.1 Population characteristics

Overall, 5333 individuals were included in the analyses. The proportion of respondents who were women, aged 41-64 years, in non-manual households, or non-white increased over time (see **Table 2.1**).

Table 2.1. Descriptive characteristics of study population

Characteristic	1986-1987 (*n*=2018)	2000-2001 (*n*=1683)	2008-2012 (*n*=1632)	Total (*n*=5333)
Sex, *n* (%)				
Men	991 (49.1)	753 (44.7)	705 (43.2)	2449 (45.9)
Women	1027 (50.9)	930 (55.3)	927 (56.8)	2884 (54.1)
Age, *n* (%)				
19-40	1055 (52.3)	794 (47.2)	720 (44.1)	2569 (48.2)
41-64	963 (47.7)	889 (52.8)	912 (55.9)	2764 (51.8)
SEP*, *n* (%)				
Non-manual	973 (48.2)	970 (57.6)	987 (60.5)	2930 (54.9)
Manual	1045 (51.8)	713 (42.4)	645 (39.5)	2403 (45.1)
Ethnicity, *n* (%)				
White	1940 (96.1)	1593 (94.7)	1473 (90.3)	5006 (93.9)
Non-white	78 (3.9)	90 (5.4)	159 (9.7)	327 (6.1)

Non-manual= professional (I), managerial/technical (II), and skilled non-manual (IIINM).
Manual= skilled manual (IIIM), partly skilled (IV), and unskilled (V).
*Socioeconomic position (based on RGSC classification)

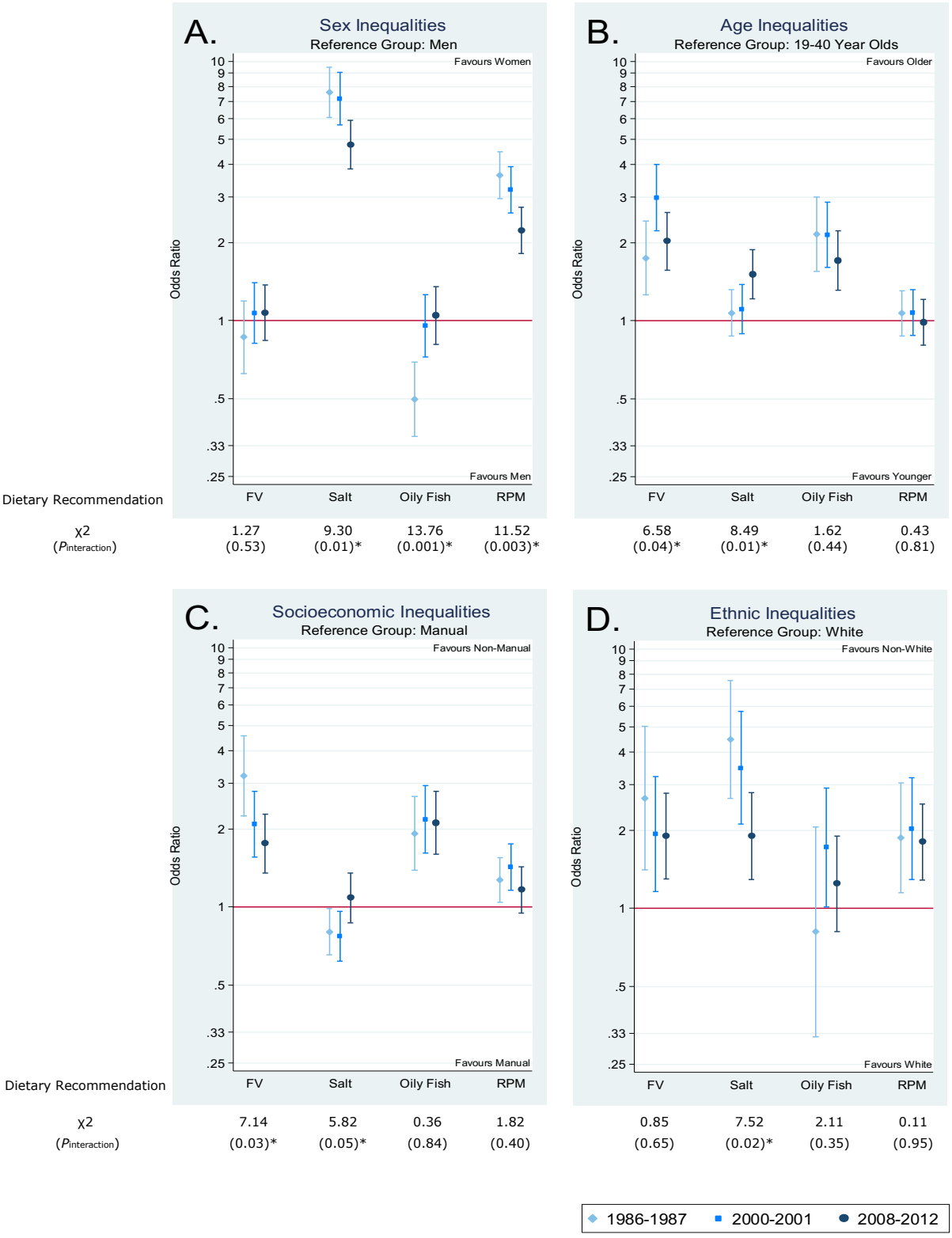
2.4.2 Adherence to dietary recommendations

Table 2.2 shows the proportion of respondents meeting each dietary recommendation over time and the adjusted odds ratio for achieving each recommendation compared to the previous survey. In 2008-12, over 60% of respondents achieved the salt recommendation, under half achieved the red and processed meat recommendation, and around 20% achieved the recommendations for fruit and vegetables or oily fish. The odds of meeting each recommendation increased over time, except for red and processed meat between 2000-01 and 2008-12, where there was no significant change. The greatest change in adherence was seen for the salt recommendation between 2000-01 and 2008-12: OR 2.63 (95% CI 2.26, 3.08). **Table 2.2** also shows the proportion of respondents meeting any number of these recommendations, and the relative risk ratio for doing so between surveys. The proportion of respondents adhering to multiple dietary recommendations was low, but increased over time.

Table 2.2. Changes in adherence to dietary recommendations over time

	1986-1987 (*n*=2018)	**2000-2001** (*n*=1683)	**2008-2012** (*n*=1632)	**2000-01 vs 1986-87**	**2008-12 vs 2000-01**
Adherence to individual dietary recommendations, *n* (%)				**OR (95% CI) of meeting recommendation**	
Fruit and vegetables	168 (8.3)	271 (16.1)	341 (20.9)	1.97 (1.60, 2.42)	1.32 (1.10, 1.58)
Salt	690 (34.2)	682 (40.5)	1002 (61.4)	1.27 (1.09, 1.47)	2.63 (2.26, 3.08)
Oily fish	171 (8.5)	250 (14.9)	303 (18.6)	1.78 (1.45, 2.20)	1.28 (1.06, 1.54)
RPM	602 (29.8)	739 (43.9)	689 (42.2)	1.77 (1.54, 2.04)	0.88 (0.76, 1.02)
Number of dietary recommendations adherent to, *n* (%)				**RRR (95% CI) of meeting recommendations**	
0	892 (44.2)	511 (30.4)	318 (19.5)	0.69 (0.59 to 0.82)	0.62 (0.51 to 0.75)
1	682 (33.8)	565 (33.6)	562 (32.2)	REF	REF
2	388 (19.2)	469 (27.9)	469 (27.9)	1.46 (1.22, 1.74)	1.13 (0.95, 1.35)
3	51 (2.5)	113 (6.7)	185 (11.3)	2.55 (1.79, 3.62)	1.60 (1.23, 2.09)
4	5 (0.23)	25 (1.5)	42 (2.6)	5.66 (2.15, 14.91)	1.72 (1.03, 2.88)

Figure 2.1. Adjusted odds ratios (95% CIs) for adhering to dietary recommendations by sociodemographic characteristics, 1986-2012



Dietary Recommendation	FV	Salt	Oily Fish	RPM
χ2 ($P_{interaction}$)	1.27 (0.53)	9.30 (0.01)*	13.76 (0.001)*	11.52 (0.003)*
χ2 ($P_{interaction}$)	6.58 (0.04)*	8.49 (0.01)*	1.62 (0.44)	0.43 (0.81)
χ2 ($P_{interaction}$)	7.14 (0.03)*	5.82 (0.05)*	0.36 (0.84)	1.82 (0.40)
χ2 ($P_{interaction}$)	0.85 (0.65)	7.52 (0.02)*	2.11 (0.35)	0.11 (0.95)

A. Sex inequalities. B. Age inequalities. C. Socioeconomic inequalities. D. Ethnic inequalities. All odds ratios (95% CIs) are mutually adjusted for the other sociodemographic characteristics studied.
FV, fruit and vegetables. RPM, red and processed meat.
*Statistically significant likehood-ratio test (P≤0.05)

2.4.3 Sociodemographic inequalities in meeting dietary recommendations

Fig 2.1 shows the adjusted odds ratios (95% CI) for meeting the four dietary recommendations by sociodemographic characteristic. We also present the results of likelihood-ratio tests used to test for interactions between the sociodemographic characteristics and timepoint, and thus changes in sociodemographic inequalities over time.

2.4.3.1 Sex inequality in meeting dietary recommendations

There was no sex inequality in achieving the fruit and vegetable recommendation at any time. However, women were more likely than men to adhere to the salt and red and processed meat recommendations at all timepoints. The magnitude of these inequalities reduced over time (P=0.01 and 0.003, respectively). Men were more likely to adhere to the oily fish recommendation than women in 1986-87, but this inequality was not observed in later surveys (P=0.001). Further details are shown in **Supplementary Table A3**.

2.4.3.2 Age inequality in meeting dietary recommendations

Age inequality in adherence to the fruit and vegetable recommendation was observed in all three surveys, with older adults more likely to adhere than younger adults. The magnitude of this inequality fluctuated over time: getting wider in 2000-01, then narrower in 2008-12 (P=0.04). Age inequality in meeting the salt recommendation emerged between the second two surveys, favouring the older group (P=0.01). The older group was more likely to meet the oily fish recommendation than the younger group. This relationship persisted without significant change across the three surveys (P=0.44). There was no age inequality in adherence to the red and processed meat recommendation at any point. Further details are presented in **Supplementary Table A4**.

2.4.3.3 Socioeconomic inequality in meeting dietary recommendations

Socioeconomic inequality in meeting the fruit and vegetable recommendation persisted, favouring the higher socioeconomic group, but declined in magnitude over time (P=0.03). There was marginal socioeconomic inequality in meeting the salt recommendation in the first two surveys, which favoured the manual group. This difference did not persist to the last survey (P=0.05). Socioeconomic inequality in adherence to the oily fish recommendation, favouring the higher socioeconomic group, was observed at all three timepoints without evidence of significant change (P=0.84). There was marginal-to-no evidence of socioeconomic inequality in adherence to the red and processed meat recommendation at all timepoints. More information is presented in **Supplementary Table A5**.

2.4.3.4 Ethnic inequality in meeting dietary recommendations

Non-white participants had higher odds of meeting all dietary recommendations than white participants, except for oily fish. These inequalities persisted across all three surveys, with only ethnic inequality in adherence to the salt recommendation reducing (*P*=0.02). More information is available in **Supplementary Table A6**.

2.4.4 Total energy intake from food sources

Estimated total daily energy intake from food sources (excluding alcohol) decreased over time in all population subgroups except among non-white participants, where no difference was detected (see **Table 2.3**).

Table 2.3. Median (lower quartile, upper quartile) total daily food energy intake (kcal/day) over time and by sociodemographic characteristics

Sociodemographic characteristic	**1986-1987** (*n*=2018)	**2000-2001** (*n*=1683)	**2008-2012** (*n*=1632)	**Pearson's F Statistic** (*P*-value)
Overall, median (LQ, UQ)	1917 (1532, 2319)	1785 (1397, 2131)	1726 (1348, 2050)	53.72 (<0.0001)
Sex, median (LQ, UQ)				
Men	2275 (1883, 2606)	2086 (1710, 2424)	1973 (1605, 2359)	49.82 (<0.0001)
Women	1646 (1343, 1912)	1530 (1288, 1802)	1504 (1233, 1786)	23.22 (<0.0001)
Age, median (LQ, UQ)				
19-40	1933 (1582, 2450)	1778 (1467, 2093)	1756 (1456, 2102)	28.39 (<0.0001)
41-64	1908 (1590, 2223)	1779 (1490, 2086)	1695 (1378, 2025)	28.80 (<0.0001)
SEP*, median (LQ, UQ)				
Non-manual	1953 (1626, 2227)	1808 (1532, 2073)	1720 (1454, 2044)	45.49 (<0.0001)
Manual	1901 (1552, 2239)	1748 (1418, 2105)	1732 (1369, 2073)	20.08 (<0.0001)
Ethnicity, median (LQ, UQ)				
White	1924 (1606, 2244)	1791 (1488, 2091)	1723 (1413, 2058)	56.40 (<0.0001)
Non-white	1793 (1390, 2097)	1667 (1341, 2047)	1703 (1394, 1999)	0.85 (0.43)

Medians (lower quartiles, upper quartiles) adjusted for sex, age, SEP, and ethnicity.
Non-manual= professional (I), managerial/technical (II), and skilled non-manual (IIINM).
Manual= skilled manual (IIIM), partly skilled (IV), and unskilled (V).
*Socioeconomic position (based on RGSC classification)

2.5 Discussion

This is one of the first studies to investigate trends in dietary inequalities by multiple sociodemographic characteristics. Furthermore, this is the first study to do so by looking at adherence to multiple dietary recommendations in the UK. We found that most dietary inequalities identified in 1986-87 persisted in 2008-12. Whilst some inequalities reduced in magnitude over the study period, only sex inequality in meeting the oily fish recommendation was extinguished. Overall, adherence to dietary recommendations was low to moderate, but improved over time. The proportion of respondents meeting multiple recommendations also increased with time.

2.5.1 Strengths and limitations of this study

We used data from three national diet surveys with similar methodologies, allowing comparison over a 26-year period. Throughout, food diaries were used to collect dietary data – one of the most accurate methods of dietary assessment at the population level.[223] However, like all self-reported methods of dietary assessment, diaries may be subject to social desirability bias. The switch from 7-day weighed diaries to 4-day unweighed diaries in 2008-12 may have also introduced time-varying bias. We combined four years of data from the NDNS Rolling Programme in our last timepoint to achieve a sufficient sample size for subgroup analyses. Although more recent years of data from the Rolling Programme are now available, we excluded these in order to minimise any within-timepoint variations.

Across the three surveys, non-disaggregated data were used to obtain dietary intake estimates. Mixed dishes were coded by their meat/fish component. For example, 400 g of lamb stew, consisting of 300 g of lamb and 100 g of vegetables, would be coded as a lamb dish, and all 400 g would contribute to the estimated intake of red and processed meat, but not fruit and vegetable intake. Consequently, we likely overestimated oily fish and red and processed meat intake, and underestimated fruit and vegetable intake in all surveys. More accurate estimates where mixed dishes are disaggregated into their ingredients were available for the NDNS Rolling Programme,[224] but not for earlier surveys. To assess the implications for our study, we compared adherence to dietary recommendations using estimated intake of these food groups from disaggregated and non-disaggregated data in the NDNS Rolling Programme (see **Supplementary Table A7**). Overall adherence was 10% higher for fruit and vegetables, 2% lower for oily fish, and 20% higher for red and processed meat, when using disaggregated estimates compared to non-disaggregated estimates. The inequalities observed were similar for the fruit and vegetable and oily fish recommendations for both methods of intake estimation. However, sex and socioeconomic inequalities in adherence to the red and processed meat recommendation were magnified when based on disaggregated estimates. An increased reliance on ready meals could mean that consumption of mixed dishes has increased over time,[225] affecting the accuracy of non-disaggregated estimates more in later surveys compared to earlier surveys. We were unable to test the effect of disaggregation over time in our study, but if true, the general trend of modest improvement we observed in overall adherence is likely underestimated, whilst the reduction in sex inequality we reported for adherence to the red and processed meat recommendation may be overestimated.

In all three surveys, salt intake was consistently estimated using a nutrient databank. This was first developed for DNSBA 1986-87, and subsequently updated for NDNS.[226] These estimates do not include discretionary salt added at the table or during cooking. We did not use the more accurate estimates from urinary sodium due to the small

sample sizes. In NDNS 2000-01, dietary estimates of salt intake were 20% lower than urinary estimates,[218] but underestimation was consistent across population subgroups.[227]

We assessed adherence to four dietary recommendations, which are important to population health, prominent in public messaging, and have quantifiable recommendations in the UK.[42] This provides good insight into diet quality using measurable benchmarks, but does not provide a comprehensive measure of diet quality. We excluded some dietary recommendations, such as sugar and fibre, due to limited data availability or a lack of comparability across the surveys. Other food groups of public health concern, such as sugary drinks, were excluded as there are currently no clear UK recommendations.

Survey weights were not available for DNSBA 1986-87. However, applying survey weights for NDNS 2000-01 and NDNS 2008-12 did not alter our conclusions (see **Supplementary Table A1-A2**). As such, it is likely that our results are generalisable to the UK as a whole. Moreover, our analyses focus on relative inequalities, which can be observed regardless of whether subgroups are population representative.

2.5.2 Comparison of results to other studies

Similarly persistent or widening sociodemographic inequalities in diet and modest improvements in overall population diet quality were observed in the United States and the Netherlands.[178–180,211,212] Our study was mostly consistent with other UK studies, which generally found persisting, if reducing, age and socioeconomic inequalities over time.[215,228] However, one study found socioeconomic inequality in salt intake in the NDNS Rolling Programme (2008-11), which was inconsistent with our findings.[60] This difference could be because we used averages across the four years instead of looking at trends across each year. Additionally, we used RGSC to measure SEP, rather than NS-SEC.

2.5.3 Interpretation of findings and implications for policy

It is clear that interventions that simultaneously reduce dietary inequalities and improve overall adherence to dietary recommendations are needed. Diet quality reflects the accessibility, availability and cost of food, as well one's food preferences, nutritional knowledge, and sociocultural norms.[85,229] These are all likely to play a role in the overall poor adherence to dietary recommendations we found. The differential effects of many of these factors across population subgroups may also be responsible for the inequalities we documented.[230] Identifying the most important determinants of both diet overall and inequalities in diet, and how to address them, is important for minimising diet-related diseases.

Cost is likely to be an important factor driving socioeconomic inequalities in diet and limiting their reduction in the UK and elsewhere. We found that socioeconomic inequalities persisted in adherence to the fruit and vegetable recommendation and oily fish recommendation. This could be due to the higher costs of diets that met these recommendations, 17% and 16%, respectively, compared to diets that did not.[72] Analysis of national UK food prices found that in absolute terms, the cost of healthier foods increased to a greater extent over a 10-year period than less-healthy foods.[74] Nonetheless, food prices overall have fallen in real terms over our study period, and this could have contributed to the improvement in overall adherence to dietary recommendations we observed.[231] A smaller improvement was seen between 2000-01 and 2008-12, which could be associated with the rise of food prices again between 2007 and 2012.[231]

The persisting and emerging age inequalities we found suggest that cross-sectional age differences in diet reported elsewhere are likely true age effects rather than cohort effects. Older adults are often found to have healthier diets than younger adults. Many of the barriers to healthy eating in young adults point to the food environment, social norms and pressures, and lack of skill and motivation to prepare healthy foods.[97,101,230] Self-reported prevalence of some of these barriers are lower in older age groups.[97,101]

Women are thought to have healthier diets because they tend to be more health-conscious.[230] Nonetheless, we found that sex differences in diet diminished over time. This increased equality in diet quality could be a reflection of increased gender equality in society as a whole.[232] Conversely, with more women participating in the workforce and decreasing time available for household duties over time,[233,234] decreasing inequalities may be a result of women's diets getting worse, rather than men's improving. Indeed, we found evidence that the proportion of women adhering to the red and processed meat recommendation decreased between 2000-01 and 2008-12. Although greater gender dietary equality should be encouraged, this should not be at the expense of women's diets. The same deterioration was seen in the non-manual group at the same time. This could also point to changes in time allocation. For example, time spent eating away from the home has increased over time, especially in higher socioeconomic groups, and out-of-home eating is associated with lower diet quality.[235,236]

Ethnic differences in diet are often difficult to study due to the small proportion of ethnic minority individuals participating in surveys. However, we found that non-white participants had consistently higher odds of achieving dietary recommendations than white participants. This could be due to a range of factors, including different sociocultural environments and food beliefs.[85] Further focus on ethnic minorities in the UK may help to identify healthy dietary behaviours that could be promoted to the whole population.

Total energy intake decreased over time, despite the rising prevalence of obesity observed over the same time period.[209] A decrease in energy expenditure that was greater than the decrease in energy intake may explain the rise in obesity.[237] However, food supply data suggests that energy intake has been fairly consistent in the UK over our study period, although these data do not take food waste into consideration.[238] It is also possible that increased public awareness and health consciousness resulted in more under-reporting of food intake over time.[239] Secular changes in eating habits and lifestyle may also have affected people's recall of food intake.[240] Consuming food 'on-the-go' has increased in the UK – a more fast-paced lifestyle might mean that snacks and light meals are more easily omitted in dietary records.[241,242]

We found reduced inequalities in adherence to the salt recommendation by sex and ethnicity over time, and a substantial increase in overall adherence between 2000-01 and 2008-12. This could be due to the UK Salt Reduction Programme introduced in 2003,[243,244] which included voluntary reformulation targets for the food industry as well as public information campaigns.[245] Previous studies suggest that the combination of behavioural and structural elements of this programme led to its success in reducing inequalities.[246] In contrast, a lack of such coordinated effort for the other components of diet may explain persisting inequalities. An evaluation of the UK's 5-a-day public information campaign, which aims to increase fruit and vegetable consumption, found small improvements in overall intake and inequality reduction two years following its introduction.[247] This suggests that public awareness alone is not enough to improve population diet quality substantially. The comprehensive multi-component programmes for sugar and calorie reduction recently announced in England should, therefore, be welcomed from an equity point of view.[248,249]

2.5.4 Conclusions

We found that most sociodemographic inequalities in adherence to key UK dietary recommendations persisted between 1986 and 2012. Alongside, we found low to moderate, but improving, overall adherence to dietary recommendations. Further interventions to reduce dietary inequalities in the UK as well as improve overall population diet quality are needed.

3 FOOD INSECURITY IN UK ADULTS

3.1 Abstract

Objective To estimate food insecurity prevalence among UK adults and investigate associations with sociodemographic characteristics, diet, and health.

Design Weighted cross-sectional survey data. Food insecurity was measured using the USDA Adult Food Security Survey Module. Data were analysed using adjusted logistic regression models.

Setting United Kingdom.

Participants 2551 participants (aged 18-64 years); sub-sample (*n*=1949) used to investigate association between food insecurity and overweight.

Results Food insecurity prevalence was 24.3%. Higher odds of food insecurity were observed among participants who: reported that making ends meet was difficult vs. easy (OR=19.76, 95% CI 13.78-28.34), were full-time students vs. non-students (3.23, 2.01-5.18), had low vs. high education (2.30, 1.66-3.17), were male vs. female (1.36, 1.01-1.83), and reported their ethnicity as mixed (2.32, 1.02-5.27) and white other (2.04, 1.04-3.99) vs. white British. Odds of food insecurity were higher in participants living with children vs. alone, especially in single-parent households (2.10, 1.19-3.70). Odds of food insecurity decreased per year of increase in age (0.95, 0.94, 0.96) and were lower in participants not looking for work vs. full-time employed (0.60, 0.42-0.87). Food insecure vs. food secure adults had lower odds of consuming fruit (0.59, 0.47-0.74) and vegetables (0.68, 0.54-0.86) above the median frequency, and higher odds for fruit juice (1.39, 1.10-1.75). Food insecure vs. food secure adults had higher odds of reporting unhealthy diets (1.65, 1.31-2.10), poor general health, (1.90, 1.50-2.41), poor mental health (2.10, 1.64-2.69), high stress (3.15, 2.42-4.11), and overweight (1.32, 1.00-1.75).

Conclusions Food insecurity prevalence was high and varied by sociodemographic characteristics. Food insecurity was associated with poorer diet and health.

3.2 Introduction

Food security is *"when all people at all times have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life"*.[250] Despite being a high-income country, prevalence of individual-level food insecurity was estimated at 8% among adults,[251] and over 20% in low-income households, in the United Kingdom (UK) in 2016.[188] In 2018-19, the Trussell Trust (the UK's largest network of food banks) provided emergency food aid to 1,006,050 adults, five times more than in 2012/13.[183]

The cost of living has increased in the UK since the mid-2000s, whilst wages have stagnated.[127] For example, the cost of domestic fuel and transportation increased approximately 45% and 81% in the last decade, respectively.[252] Due to welfare reform and austerity measures in the UK, individuals receiving benefit payments have experienced cuts and delays to their payments.[253–255] Rising childcare costs is further cited as an increasingly large financial burden on families.[252] Food prices have also increased during this time.[252] Consequently, individuals with low incomes may face an absolute shortage of food, or a shortage of healthier foods due to their high cost relative to less healthy foods.[74] Indeed, lower-income households in the UK spend a larger proportion of their total expenditure on food (17%) compared to higher-income households (8%).[256] Lower-income households also spend a larger proportion of their food budget on basic necessities, such as bread and milk, and a smaller proportion on vegetables compared to higher-income households.[256,257]

Food insecurity has been reported in the academic literature since the 1990s,[258] and has been found to be associated with poor diet and health. In a systematic review, food insecure adults were found to have lower intake of fruit, vegetables, and dairy compared to food secure adults.[116] Increased rates of mental health problems, diabetes, hypertension, and hyperlipidaemia among food insecure adults, compared to food secure adults, have also been reported.[259] Findings on the association between food insecurity and obesity have been mixed. However, a positive association between food insecurity and obesity is more consistently reported among women than in men,[260] suggesting that the association could differ between population subgroups. In Canada, food insecurity prevalence was reported to be higher among Aboriginal adults and individuals without a degree, as well as in households that relied on social assistance, or had children.[261] Despite this wealth of evidence, it is almost exclusively based on data from North America. Findings from North America may not be generalisable to other contexts due to differences in welfare policies, economic situation, and food environment context (including food prices, food culture, and food accessibility).[127,262]

In the UK, associations between food insecurity and age and ethnicity have been reported in women living in the city of Bradford.[263] Food insecurity was found to be associated with presence of common mental disorders and poorer health among mothers in the Born in Bradford cohort.[264,265] Single-parent households and households with more children have also been reported to have higher risk of food insecurity compared to other household types.[266] Some UK studies have examined associations with food insecurity using food bank usage as a proxy measure of food insecurity. Food banks provide emergency food parcels to alleviate hunger.[267] However, food bank usage may be an inaccurate measure of food insecurity. Food banks are not the only source of food aid and use is stigmatised.[268] Thus, food bank usage is likely to underestimate the prevalence of food insecurity.[269] Further, food bank users have been found to experience more financial strain and adverse life events, compared to other disadvantaged groups in which food insecurity is prevalent,[191] meaning that users may not be representative of all those experiencing food insecurity.

Few studies have investigated the prevalence of food insecurity, variations within the population, and associations with diet and health in the general UK population. In this study, we aimed to estimate prevalence of food insecurity among UK adults using a national sample of the general population, investigate associations between food insecurity and sociodemographic characteristics (sex, age, ethnicity, household composition, employment status, student status, ability to make ends meet, and education), diet (fruit and vegetable intake frequency and self-rated healthiness of diet), and health (self-rated general health, mental health and stress, and body mass index (BMI)).

3.3 Methods

3.3.1 Study population

We used cross-sectional UK data from wave 1 of the International Food Policy Study (IFPS).[192] Participants were recruited through the online *Nielsen Consumer Insights Global Panel* and partner panels, which select panel members using both probability and non-probability sampling methods. Email invitations with unique survey access links were sent to a random sample of panellists within a specified age range; panellists known to be ineligible were not invited. To account for differential response rates by age, approximately 2000 participants aged 18-30 years and 2000 participants aged 31-64 years were recruited. In total, 4047 UK adults were recruited for the baseline survey conducted in December 2017. Full details regarding the IFPS methods can be found elsewhere.[192] In our analysis, participants were excluded for incomplete adult food security status (n=767) and missing diet and health outcome data (n=729). This resulted in an analytical sample of 2551 participants. Due to a large number of missing

BMI values (*n*=602), we used a smaller analytical sub-sample (*n*=1949) to explore the association between adult food security and BMI.

3.3.2 Measuring adult food security

Adult food security was measured using the validated Adult Food Security Survey Module (AFSSM) developed by the United States Department of Agriculture, which is the adult portion of the most commonly used measure globally (the Household Food Security Survey Module – HSSFM).[167] Minor changes in wording were made for the IFPS to adapt the measure for use in an online self-administered survey. The AFSSM comprises ten questions related to household food sufficiency in the last 12 months, with a total potential score of 0-10. Participants receive one point for each affirmative response ('yes', 'often', 'sometimes', 'almost every month', or 'some months but not every month') given. Questions relate to having enough to eat, worrying about food, balanced meals, reducing sizes of meals or skipping meals, hunger, and weight loss (see **Supplementary Table B1**). Questions were administered in a three-stage design, reducing participant burden, as participants could potentially be confirmed as food secure using the first three questions. Further questions were only then asked if these questions highlighted potential food insecurity. The AFSSM assigns participants to four categories: high food security (score 0), marginal food security (score 1-2), low food security (score 3-5), and very low food security (score 6-10). For our analysis, we categorised participants as: food secure (score 0-2) or food insecure (score 3-10). The majority of participants who were excluded for incomplete adult food security status (*n*=599) had missing values due to a systematic programming error that prevented some eligible participants from progressing into the second stage.

3.3.3 Correlates

We used self-reported data available from the IFPS questionnaire that related to sociodemographic characteristics, diet, and health to explore associations with food insecurity.

3.3.3.1 Sociodemographic characteristics

Participants reported their sex (male and female), age (continuous), ethnicity (white British, white other, mixed, Asian, black and other/unknown), employment status (full-time employment, part-time employment, looking for work, and not looking for work), student status (full-time, part-time, and not studying), and ability to make ends meet (difficult, neither easy nor difficult, and easy). Participants also reported the highest level of education completed, which we categorised as: low (GCSE or below – school leaving qualifications taken at around age 16 years), medium (A level and NVQ level 4-5 – school leaving qualifications taken at around age 18 years), and high (degree or equivalent). Participants reported their current living situation, which we used to categorise participants' household composition as living with: no other adults and no children (i.e.

alone), other adults and no children, no other adults and with children (i.e. single-parent household), and other adults and children.

3.3.3.2 Frequency of fruit and vegetable intake

In lieu of more detailed dietary assessment, participants were asked how many times they consumed fruits, vegetables (including lettuce salads but excluding all types of potatoes), and fruit juice, using questions adapted from the validated 2017 Behavioural Risk Factor Surveillance System (BRFSS) fruit and vegetable intake module, which was developed in the United States.[270–272] Participants provided answers per day, week, month or year, as preferred, which we then converted to the standard indicator of frequency per day. To address outliers, intake frequency was capped at the mean plus three standard deviations (stratified by sex) and higher values were reassigned the cap value, as recommended by *Pérez* 2002.[273] For vegetables, we first excluded two values (634 and $1.03e^{13}$ times per day) due to implausibility before calculating the cap value.

3.3.3.3 Self-rated healthiness of diet and health

Participants rated the healthiness of their diet, their general health, and their mental health as: poor, fair, good, very good, or excellent. We categorised responses as: poor (poor and fair) or good (good, very good, and excellent). Participants were also asked about the amount of stress in their lives, and reported whether most days were: not at all stressful, not very stressful, a bit stressful, very stressful, or extremely stressful. We categorised answers as: low stress (not at all stressful, not very stressful, and a bit stressful) or high stress (very stressful and extremely stressful).

3.3.3.4 Body mass index

We calculated BMI (weight/height^2) for 1949 participants in the analytical sub-sample from self-reported height and weight, categorising participants as: not overweight (BMI≤25) or overweight (BMI>25). Other participants had missing height and/or weight values (n=511), or were excluded due to an extreme BMI value (<14 or >48), extreme height (<3 ft/0.91 m or >7 ft/2.13 m), and/or extreme weight (<45 lb/20.4 kg or >1100 lb/499.0 kg). The large number of missing and implausible weight values was partly due to a programming error, which meant participants were not able to answer using British Imperial measures (stones and pounds), which are commonly used units of body weight in the UK.

3.3.4 Statistical methods

Wald tests were used to test differences between food secure and food insecure adults in all measured correlates. Adjusted logistic regression models were used to estimate odds, with 95% confidence intervals, of food insecurity across sociodemographic subgroups (sex, age, ethnicity, household composition, student status, employment status, ability to make ends meet, education), mutually adjusting for other sociodemographic

characteristics. Adjusted logistic regression models were also used to estimate odds, with 95% confidence intervals, of food insecure adults consuming above the median intake frequency for fruit, vegetables, and fruit juice, and reporting poor healthiness of diet, general health, mental health, high stress, and overweight, compared to food secure adults, adjusting for sex, age, ethnicity, and household composition. Interaction between sex, age, ethnicity, and household composition and adult food security on their effect on diet and health were tested (see **Supplementary Table B2**). Where interaction terms were statistically significant, stratified results are presented. We report significant interactions with age (continuous) by age groups: 18-24 years, 25-30 years, 31-39 years, 40-49 years, 50-59 years, and 60-64 years.

Weighted data were used in all analyses. Post-stratification sample survey weights were based on 2016 mid-year estimates and adjusted the study sample to be representative of the UK adult population in terms of sex, age, and region of residence (see **Supplementary Table B3**). Sample weights were scaled separately for the main analytic sample and the BMI sub-sample. Significance levels were set at a two-tailed *P*-value ≤0.05 for all tests. All analyses were performed using Stata/SE 13.

3.3.5 Sensitivity analyses

We present two adjusted logistic regression models for the association between sociodemographic characteristics and food insecurity. Model 1 adjusted for sex, age, ethnicity, and household composition. Model 2 additionally adjusted for markers of socioeconomic position: employment status, student status, ability to make ends meet, and education. In our main analyses for associations between food insecurity and diet and health, we did not adjust our logistic regression models for markers of socioeconomic position, which we theorised to be determinants of food insecurity rather than confounders of any relationships with diet and health. In our sensitivity analyses, we tested this assumption by additionally adjusting these models for employment status, student status, ability to make ends meet, and education (see **Table 3.1** for distribution of characteristics). The associations between sex, age, ethnicity, and household composition, and diet and health outcomes are presented in **Supplementary Table B4**.

Incomplete food security status data were mostly due to systematic survey errors, resulting in follow-up questions not being asked of some eligible participants (*n*=599). This was more likely if participants indicated potential food insecurity in one or two, rather than three, of the first three questions. Because of the large number of participants we excluded due to missing food security status, we conducted a sensitivity analysis where we included participants with missing food security status, and in turn, assumed they were all food secure or all food insecure.

3.4 Results

3.4.1 Population characteristics

Our main analytical sample included 2551 adults (see **Table 3.1**). Overall, 24.3% of participants were food insecure, including 15.5% who were classified as having very low food security (see **Table 3.2**). A sub-sample was used to examine associations with BMI (*n*=1949). The main sample and BMI sub-sample did not differ significantly in sociodemographic characteristics and, when weighted, were representative of the UK adult population in terms of sex, age, and region of residence (see **Supplementary Table B3**).

Table 3.1. Weighted distribution of sociodemographic characteristics among full analytic sample (*n*=2551) and BMI sub-sample (*n*=1949)

	Full analytical sample				BMI sub-sample			
Characteristic	**Overall**	**Food Secure**	**Food Insecure**	**Pearson's F Statistic** (*P*-Value)	**Overall**	**Food Secure**	**Food Insecure**	**Pearson's F Statistic** (*P*-Value)
Total, % (95% CI)		75.7 (73.7, 77.6)	24.3 (22.4, 26.3)	N/A		78.2 (76.0, 80.3)	21.8 (19.7, 24.1)	N/A
Sex, % (95% CI)								
Male	48.9 (46.7, 51.2)	48.3 (45.7, 50.9)	50.9 (46.2, 55.6)	0.88 (0.35)	51.3 (48.7, 53.9)	50.4 (47.5, 53.4)	54.4 (48.7, 59.9)	1.45 (0.23)
Female	51.1 (48.8, 53.3)	51.7 (49.1, 54.3)	49.1 (44.4, 53.8)		48.7 (46.1, 51.3)	49.6 (46.7, 52.5)	45.7 (40.1, 51.3)	
Age, median (IQR)	44 (32, 54)	46 (34, 56)	36 (28, 46)	113.94 (<0.0001) ***	45 (32, 55)	47 (34, 56)	37 (28, 46)	76.16 (<0.0001) ***
Ethnicity, % (95% CI)								
White British	85.2 (83.5, 86.7)	86.5 (84.6, 88.2)	81.1 (77.1, 84.6)	3.25 (0.01)*	84.2 (82.2, 86.0)	85.3 (83.0, 87.3)	80.4 (75.7, 84.4)	3.10 (0.01)*
White other	4.6 (3.8, 5.7)	4.4 (3.5, 5.5)	5.3 (3.3, 8.5)		5.2 (4.2, 6.4)	5.3 (4.2, 6.7)	4.8 (2.9, 7.8)	
Mixed	2.5 (1.9, 3.3)	1.8 (1.2, 2.6)	4.8 (3.3, 7.1)		2.8 (2.1 , 3.8)	1.9 (1.3, 3.0)	5.9 (3.7, 9.1)	
Asian	4.1 (3.3, 5.1)	3.8 (2.9, 4.9)	5.1 (3.4, 7.6)		4.6 (3.7, 5.8)	4.4 (3.4, 5.8)	5.4 (3.4, 8.5)	
Black	1.5 (1.1, 2.1)	1.5 (1.0, 2.3)	1.4 (0.8, 2.6)		1.3 (0.8, 1.9)	1.2 (0.8, 2.0)	1.4 (0.7, 3.0)	
Other & unknown	2.1 (1.5, 3.1)	2.1 (1.3, 3.3)	2.2 (1.2, 3.9)		1.9 (1.2, 3.1)	1.9 (1.0, 3.4)	2.1 (1.1, 4.2)	
Household composition, % (95% CI)								
No other adults, no children	15.2 (13.6, 16.9)	15.9 (14.1, 18.0)	13.0 (10.2, 16.4)	26.51 (<0.0001) ***	16.1 (14.2, 18.1)	17.1 (15.0, 19.5)	12.4 (9.3, 16.5)	22.05 (<0.0001) ***
Other adults, no children	52.0 (49.7, 54.2)	56.5 (54.0, 59.1)	37.7 (33.4, 42.2)		52.9 (50.3, 55.5)	56.9 (54.0, 59.7)	38.6 (33.3, 44.2)	
No other adults, with children	5.8 (4.8, 7.1)	4.0 (3.1, 5.2)	11.4 (8.4, 15.2)		5.3 (4.1, 6.7)	3.4 (2.5, 4.7)	11.8 (8.0, 17.0)	
Other adults, with children	27.0 (25.0, 29.1)	23.5 (21.4, 25.8)	38.0 (33.5, 42.7)		25.8 (23.6, 28.1)	22.6 (20.3, 25.1)	37.2 (31.9, 42.7)	

Characteristic	Full analytical sample				BMI sub-sample			
	Overall	**Food Secure**	**Food Insecure**	**Pearson's F Statistic** (*P*-Value)	**Overall**	**Food Secure**	**Food Insecure**	**Pearson's F Statistic** (*P*-Value)
Employment status, % (95% CI)								
Full time	57.2 (55.0, 59.4)	57.4 (54.8, 59.9)	56.6 (52.0, 61.2)	6.50 (<0.0001) ***	58.9 (56.3, 61.4)	58.5 (55.6, 61.3)	60.3 (54.7, 65.7)	5.09 (0.004) ***
Part time	18.5 (16.8, 20.3)	18.5 (16.5, 20.5)	18.6 (15.3, 22.4)		18.2 (16.3, 20.3)	18.4 (16.2, 20.7)	17.7 (13.7, 22.6)	
Looking for work	4.7 (3.9, 5.7)	3.5 (2.7, 4.5)	8.6 (6.4, 11.4)		4.1 (3.2, 5.2)	3.0 (2.2, 4.1)	8.0 (5.5, 11.4)	
Not looking for work	19.2 (17.5, 21.0)	20.5 (18.5, 22.6)	15.3 (12.4, 18.8)		18.6 (16.7, 20.7)	20.0 (17.8, 22.4)	13.8 (10.5, 17.8)	
Unknown	0.4 (0.2, 0.9)	0.3 (0.1, 0.9)	0.9 (0.3, 2.6)		0.2 (0.04, 0.8)	0.2 (0.02, 1.2)	0.2 (0.03, 1.6)	
Student status, % (95% CI)								
No	87.1 (85.6, 88.5)	90.9 (89.4, 92.2)	75.4 (71.3, 79.1)	26.80 (<0.0001) ***	87.5 (85.8, 89.0)	90.8 (89.1, 92.3)	75.5 (70.6, 79.8)	20.06 (<0.0001) ***
Yes, full time	8.6 (7.5, 9.9)	5.9 (4.8, 7.1)	17.1 (13.9, 20.8)		8.5 (7.3, 10.0)	5.8 (4.7, 7.2)	18.2 (14.5, 22.6)	
Yes, part time	4.1 (3.4, 5.1)	3.1 (2.4, 4.0)	7.4 (5.4, 10.1)		3.8 (3.0, 4.9)	3.2 (2.4, 4.2)	6.1 (4.0, 9.3)	
Unknown	0.1 (0.03, 0.6)	0.1 (0.02, 0.9)	0.2 (0.02, 1.1)		0.2 (0.04, 0.8)	0.2 (0.02, 1.2)	0.2 (0.03, 1.6)	
Making ends meet, % (95% CI)								
Difficult	22.1 (20.2, 24.1)	10.4 (9.0, 12.1)	58.5 (53.8, 63.0)	160.03 (<0.0001) ***	19.6 (17.6, 21.7)	9.5 (8.0, 11.3)	55.6 (49.9, 61.1)	113.85 (<0.0001) ***
Neither easy nor difficult	33.4 (31.3, 35.6)	35.7 (33.3, 38.2)	26.4 (22.5, 30.7)		32.6 (30.2, 35.0)	34.5 (31.7, 37.3)	25.9 (21.3, 31.0)	
Easy	44.0 (41.8, 46.3)	53.3 (50.7, 55.9)	14.9 (11.9, 18.5)		47.6 (45.0, 50.2)	55.7 (52.8, 58.5)	18.6 (14.6, 23.4)	
Unknown	0.5 (0.3, 0.9)	0.6 (0.3, 1.1)	0.2 (0.03, 1.7)		0.3 (0.1, 0.8)	0.4 (0.2, 1.0)	0	
Education[a], % (95% CI)								
Low	29.0 (26.9, 31.1)	25.5 (23.3, 27.8)	39.8 (35.3, 44.6)	13.10 (<0.0001) ***	26.0 (23.8, 28.4)	23.2 (20.8, 25.9)	36.1 (30.7, 41.8)	8.46 (<0.0001) ***
Medium	27.2 (25.2, 29.3)	27.4 (25.2, 29.8)	26.6 (22.6, 30.9)		26.9 (24.6, 29.2)	27.2 (24.7, 29.9)	25.8 (21.3, 30.9)	
High	43.4 (41.2, 45.6)	46.7 (44.2, 49.3)	33.0 (28.8, 37.5)		46.8 (44.3, 49.4)	49.3 (36.4, 52.2)	38.0 (32.7, 43.5)	
Unknown	0.5 (0.2, 0.9)	0.4 (0.2, 0.8)	0.7 (0.2, 2.2)		0.3 (0.1, 0.6)	0.3 (0.1, 0.7)	0.2 (0.02, 1.2)	

Characteristic	Full analytical sample				BMI sub-sample			
	Overall	**Food Secure**	**Food Insecure**	**Pearson's F Statistic** (*P*-Value)	**Overall**	**Food Secure**	**Food Insecure**	**Pearson's F Statistic** (*P*-Value)
Body mass index, % (95% CI)								
Underweight (<18.5)	N/A	N/A	N/A	N/A	4.6 (3.7, 5.8)	4.0 (3.1, 5.2)	6.9 (4.6, 10.2)	2.39 (0.07)
Normal (18.5-25)	N/A	N/A	N/A		46.7 (44.1, 49.3)	47.7 (44.8, 50.6)	43.1 (37.7, 48.7)	
Overweight (25.1-30)	N/A	N/A	N/A		31.3 (28.9, 33.8)	31.7 (29.0, 34.5)	29.9 (24.9, 35.3)	
Obese (>30)	N/A	N/A	N/A		17.4 (15.5, 19.5)	16.6 (14.6, 19.0)	20.1 (15.5, 25.7)	

CI, confidence interval. IQR, interquartile range. N/A, not applicable.
[a]Low=GCSE level or equivalent (UK qualification level 2) and below, Medium= A level and NVQ level 4-5 or equivalent (UK qualification level 3-5), High= degree and equivalent (UK qualification level 6) or above.
* P≤0.05, **P≤0.01, ***P≤0.001

Table 3.2. Weighted proportion of adult food security status (*n*=2551)

Food security classification	Score	Prevalence (%)	Dichotomous food security classification	Prevalence (%)
High food security	0	71.6	Food secure	75.7
Marginal food security	1-2	4.1		
Low food security	3-5	8.8	Food insecure	24.3
Very low food security	6-10	15.5		

3.4.2 Sociodemographic correlates of food insecurity

3.4.2.1 Descriptive analysis

In the univariable analyses, food insecure adults, compared to food secure adults, were younger (median age 36 years vs. 46 years, *P*<0.0001) and more likely to be a student (24.5% vs. 9.0%, *P*<0.0001) (see **Table 3.1**). Among the food insecure group, there was a higher proportion of Asian and mixed ethnicity participants and lower proportion of white British participants, compared to the food secure group (*P*<0.01). Food insecure adults, compared to food secure adults, were also more likely to be living with a child (49.4% vs. 27.5%, *P*<0.0001), particularly in single-parent households. Although food insecure adults were more likely to be looking for work (*P*<0.0001), compared to food secure adults, the proportion reporting full-time (57%) and part-time (19%) employment was similar in both groups. Food insecure adults, compared to food secure adults, were more likely to report difficulty making ends meet (58.5% vs. 10.4%, *P*<0.0001) and have low education (39.8% vs. 25.5%, *P*<0.0001). Food security status did not differ by sex (*P*=0.35) or BMI (*P*=0.07).

3.4.2.2 Sociodemographic characteristics of food insecure adults

In the model adjusted for markers of sociodemographic characteristics, including socioeconomic variables (model 2), there were higher odds of food insecurity among male participants compared to female participants, OR 1.36 (95% CI 1.01-1.83) (see **Table 3.3**). Odds of food insecurity decreased with each year of age increase, OR 0.95 (95% CI 0.94-0.96). The odds of food insecurity were higher among participants who reported their ethnicity as white other, OR 2.04 (95% CI 1.04-3.99) and mixed, OR 2.32 (95% CI 1.02-5.27), compared to white British. Participants living with children had higher odds of food insecurity, compared to those living alone, especially if living in a single-parent household, OR 2.10 (95% CI 1.19-3.70). Participants who reported not looking for work had lower odds of food insecurity compared to participants who reported being in full-time employment, OR 0.60 (95% CI 0.42-0.87). The odds of food insecurity were higher among full-time students compared to non-students, OR 3.23 (95% CI 2.01-5.18). Participants reporting difficulty making ends meet had substantially higher odds of food insecurity compared to participants who reported that making ends meet was easy, OR 19.76 (95% CI 13.78-28.34). Participants with low education had higher odds of food insecurity compared to those with high education, OR 2.30 (95% CI 1.66-3.17).

Table 3.3. Adjusted odds (95% confidence intervals) of food insecurity by sociodemographic characteristics (*n*=2551)

		Model 1, OR (95% CI)	**Model 2,** OR (95% CI)
Sex	Female	REF	REF
	Male	1.26 (1.00, 1.60)*	1.36 (1.01, 1.83)*
Age, years		0.95 (0.94, 0.96)***	0.95 (0.94, 0.96)***
Ethnicity	White British	REF	REF
	White other	1.31 (0.73, 2.41)	2.04 (1.04, 3.99)*
	Mixed	2.33 (1.31, 4.14)**	2.32 (1.02, 5.27)*
	Asian	1.17 (0.68, 2.03)	1.69 (0.87, 3.29)
	Black	0.73 (0.32, 1.69)	0.52 (0.14, 1.88)
	Other & unknown	1.11 (0.52, 2.38)	1.23 (0.52, 2.93)
Household composition	No other adults, no children	REF	REF
	Other adults, no children	0.66 (0.46, 0.93)*	0.61 (0.41, 0.93)*
	No other adults, with children	3.69 (2.18, 6.25)***	2.10 (1.19, 3.70)**
	Other adults, with children	1.62 (1.13, 2.32)**	1.59 (1.05, 2.42)*
Employment status	Full time	REF	REF
	Part time	1.15 (0.83, 1.60)	0.76 (0.50, 1.15)
	Looking for work	2.17 (1.33, 3.52)**	0.84 (0.46, 1.56)
	Not looking for work	1.07 (0.77, 1.47)	0.60 (0.42, 0.87)**
Student status	No	REF	REF
	Yes, part time	2.06 (1.29, 3.30)***	1.59 (0.80, 3.14)
	Yes, full time	2.23 (1.56, 3.20)***	3.23 (2.01, 5.18)***
Making ends meet	Easy	REF	REF
	Neither easy nor difficult	2.54 (1.83, 3.53)***	2.55 (1.83, 3.57)***
	Difficult	20.03 (14.13, 28.38)***	19.76 (13.78, 28.34)***
Education	High	REF	REF
	Medium	1.34 (1.01, 1.79)*	1.13 (0.81, 1.57)
	Low	2.79 (2.11, 3.69)***	2.30 (1.66, 3.17)***

Model 1: mutually adjusted for sex, age, ethnicity, and household composition.
Model 2: mutually adjusted for sex, age, ethnicity, and household composition, employment status, student status, making ends meet, and education.
* P≤0.05, **P≤0.01, ***P≤0.001

3.4.3 Diet and health

3.4.3.1 Descriptive analysis

Food secure and food insecure adults differed significantly on all diet and health outcomes in the univariable analyses, except for median fruit intake and BMI (see **Table 3.4**). In unadjusted analyses, both food secure and food insecure adults had a median fruit intake of once per day, whereas food insecure adults had lower vegetable intake frequency (1.07 times/day vs. 1.29 times/day, *P*<0.0001) and higher fruit juice intake frequency (0.39 times/day vs. 0.29 times/day, *P*=0.0001). A larger proportion of food insecure adults, compared to food secure adults, reported poor healthiness of diet (46.7% vs. 33.8%, *P*<0.0001), poor general health (42.4% vs. 29.2%, *P*<0.0001), poor mental health (39.7% vs. 22.2%, *P*<0.0001), and high stress (37.3% vs. 14.3%, *P*<0.0001). Approximately half of all the participants were overweight (*P*=0.62).

Table 3.4. Distribution of outcome measures (with sample weights applied)

		Overall Sample (*n*=2551)	**Food Secure** (*n*=1890)	**Food Insecure** (*n*=661)	**Pearson's F Statistic** (*P*-Value)
Dietary component					
Fruit, median (times/day)		1.00	1.00	1.00	0.00 (1.00)
Vegetables, median (times/day)		1.16	1.29	1.07	37.69 (<0.0001)
Fruit juice, median (times/day)		0.29	0.29	0.39	15.62 (0.0001)
Self-rated diet and health					
Healthiness of diet, % (95% CI)	Poor	36.9 (34.7, 39.1)	33.8 (31.4, 68.7)	46.7 (42.0, 51.4)	23.84 (<0.0001)
	Good	63.1 (60.9. 65.3)	66.2 (63.7, 68.7)	53.3 (48.6, 58.0)	
General health, % (95% CI)	Poor	32.4 (30.3, 34.6)	29.2 (26.9. 31.7)	42.4 (37.8, 47.1)	26.54 (<0.0001)
	Good	67.6 (65.4, 69.7)	70.8 (68.4, 73.1)	57.6 (52.9, 62.2)	
Mental health, % (95% CI)	Poor	26.4 (24.5, 28.5)	22.2 (20.1, 24.5)	39.7 (35.3, 44.3)	53.30 (<0.0001)
	Good	73.6 (71.5, 75.5)	77.8 (75.6, 79.9)	60.3 (55.7, 64.7)	
Stress, % (95% CI)	High stress	19.9 (18.1, 21.8)	14.3 (12.6, 16.3)	37.3 (32.8, 42.1)	107.19 (<0.0001)
	Low stress	80.1 (78.2, 81.9)	85.7 (83.7, 87.4)	62.7 (57.9, 67.2)	
BMI[a], % (95% CI)	Not overweight	51.3 (48.7, 53.9)	51.7 (48.7, 54.6)	50.0 (44.4, 55.7)	0.25 (0.62)
	Overweight	48.7 (46.1, 51.3)	48.3 (45.4, 51.3)	50.0 (44.3, 55.7)	

CI, confidence interval.
[a] BMI sub-sample used (*n*=1949: 1495 food secure and 454 food insecure)

3.4.3.2 Frequency of fruit and vegetable intake

In the adjusted models, odds of consuming fruits and vegetables above median frequency were lower in food insecure adults compared to food secure adults, OR 0.59 (95% CI 0.47-0.74) and OR 0.68 (95% CI 0.54-0.86), respectively, but higher for fruit juice, OR 1.39 (95% CI 1.10-1.75) (see **Table 3.5**). There were interactions by sex, ethnicity, and age, but not household composition (see **Supplementary Table B2**). The adjusted odds of fruit intake above median frequency were significantly lower in food insecure adults, compared to food secure adults, across all age groups (ORs ranging from 0.39 to 0.62) except those aged 40-49 years and 60-64 years, where the association was not significant. The associations between food insecurity and vegetable and fruit juice intake frequency were not significant in men, but were in women: OR 0.53 (95% CI 0.39-0.73) and OR 1.66 (95% CI 1.21-2.28), respectively. Age also altered the association between food insecurity and vegetable intake frequency; the association was statistically significant among those aged 31-39 years, OR 0.59 (95% CI 0.36-0.98), and 50-59 years, OR 0.35 (95% CI 0.17-0.71), but not in other age groups. The association between food insecurity and fruit juice intake frequency was only statistically significant in two ethnic groups (white British and black). These associations were in opposite directions, with higher odds of above median fruit juice intake frequency among food insecure adults than food secure adults who were white British, OR 1.50 (95% CI 1.16-1.93), and lower odds for participant who were black, OR 0.11 (95% CI 0.02-0.62).

Table 3.5. Achieving intake frequency above the median for fruit, vegetables, and fruit juice among food insecure adults

		Fruit (*n*=2551)	**Vegetable** (*n*=2551)	**Fruit juice** (*n*=2551)
Overall	Food secure	REF	REF	REF
	Food insecure	0.59 (0.47, 0.74)***	0.68 (0.54, 0.86)**	1.39 (1.10, 1.75)**
Sex	Male	N/A	0.86 (0.62, 1.20)	1.15 (0.83, 1.60)
	Female	N/A	0.53 (0.39, 0.73)***	1.66 (1.21, 2.28)**
Ethnicity	White British	N/A	N/A	1.50 (1.16, 1.93)**
	White Other	N/A	N/A	1.55 (0.53, 4.51)
	Mixed	N/A	N/A	0.74 (0.20, 2.75)
	Asian	N/A	N/A	1.18 (0.44, 3.18)
	Black	N/A	N/A	0.11 (0.02, 0.62)*
	Other & unknown	N/A	N/A	4.20 (0.60, 29.16)
Age groups	18-24	0.55 (0.31, 0.96)*	0.61 (0.34, 1.11)	N/A
	25-30	0.62 (0.45, 0.85)**	1.02 (0.74, 1.41)	N/A
	31-39	0.51 (0.31, 0.86)**	0.59 (0.36, 0.98)*	N/A
	40-49	0.70 (0.42, 1.17)	0.83 (0.50, 1.38)	N/A
	50-59	0.39 (0.21, 0.75)**	0.35 (0.17, 0.71)**	N/A
	60-64	0.62 (0.19, 2.00)	0.56 (0.17, 1.83)	N/A
Household composition	No other adults, no children	N/A	N/A	N/A
	Other adults, no children	N/A	N/A	N/A
	No other adults, with children	N/A	N/A	N/A
	Other adults, with children	N/A	N/A	N/A

AFI, adult food insecurity. N/A, not applicable (because no significant interaction was detected).
Logistic regression models mutually adjusted for sex, age, ethnicity, and household composition.
* P≤0.05, **P≤0.01, ***P≤0.001

3.4.3.3 Healthiness of diet and health

Food insecure adults had higher adjusted odds of reporting unhealthy diets compared to food secure adults, OR 1.65 (95% CI 1.31-2.09) (see **Table 3.6**). Food insecure participants also had higher odds of reporting poor general health, OR 1.90 (95% CI 1.50-2.41). This association was statistically significant in all age groups, except for 18-24 years and 50-59 years. Food insecure participants also had higher adjusted odds of reporting poorer mental health, OR 2.10 (95% CI 1.64-2.69) and high stress, OR 3.15 (95% CI 2.42-4.11). The strength of these associations increased with age. The association with mental health also differed by household composition, as it was not statistically significant for participants living alone, but was significant for other household composition categories. Additionally, in the BMI sub-sample, food insecure adults had higher odds of overweight compared to food secure adults, OR 1.32 (95% CI 1.00-1.75). This association appeared to be stronger in women than in men, but once stratified, the confidence intervals crossed one and became statistically non-significant. The association with BMI only reached statistical significance in the 40-49 years age group.

Table 3.6. Self-reported healthiness of diet and health outcomes among food insecure adults

		Poor healthiness of diet (*n*=2551)	**Poor general health** (*n*=2551)	**Poor mental health** (*n*=2551)	**High stress** (*n*=2551)	**Overweight** (*n*=1949)
Overall	Food secure	REF	REF	REF	REF	REF
	Food insecure	1.65 (1.31, 2.09)***	1.90 (1.50, 2.41)***	2.10 (1.64, 2.69)***	3.15 (2.42, 4.11)***	1.32 (1.00, 1.75)*
Sex	Male	N/A	N/A	N/A	N/A	1.30 (0.88, 1.91)
	Female		N/A	N/A	N/A	1.36 (0.91, 2.04)
Age groups	18-24 years	N/A	1.21 (0.64, 2.28)	1.45 (0.79, 2.65)	3.15 (1.57, 6.33)**	1.12 (0.49, 2.56)
	25-30 years	N/A	2.16 (1.54, 3.02)***	2.00 (1.41, 2.82)***	2.44 (1.68, 3.52)***	1.42 (0.97, 2.08)
	31-39 years	N/A	2.04 (1.18, 3.52)**	2.34 (1.32, 4.13)**	3.43 (1.87, 6.29)***	1.34 (0.70, 2.58)
	40-49 years	N/A	2.61 (1.53, 4.45)***	2.33 (1.35, 4.00)**	3.14 (1.79, 5.51)***	2.16 (1.14, 4.06)*
	50-59 years	N/A	1.63 (0.89, 2.99)	2.39 (1.24, 4.58)**	3.80 (1.97, 7.36)***	0.76 (0.35, 1.68)
	60-64 years	N/A	4.56 (1.17, 17.74)*	17.10 (3.72, 78.56)***	8.43 (2.50, 28.47)***	1.04 (0.32, 3.38)
Household composition	No other adults, no children	N/A	N/A	1.79 (0.94, 3.39)	N/A	N/A
	Other adults, no children	N/A	N/A	2.15 (1.49, 3.08)***	N/A	N/A
	No other adults, with children	N/A	N/A	2.57 (1.05, 6.29)*	N/A	N/A
	Other adults, with children	N/A	N/A	2.22 (1.43, 3.45)***	N/A	N/A

AFI, adult food insecurity. N/A, not applicable (because no significant interaction was detected).
Logistic regression models adjusted for sex, age, ethnicity, and household composition.
There were no significant interactions between adult food insecurity and ethnicity for any of the included diet and health variables
* P≤0.05, **P≤0.01, ***P≤0.001

3.4.4 Sensitivity analyses

Adjusting for additional markers of socioeconomic position altered some of our findings. The associations between sociodemographic characteristics and food insecurity were similar in models 1 and 2 (see **Table 3.3**). However, adjusting for employment status, student status, ability to make ends meet, and education removed the association between looking for work and food insecurity. The associations between food security status and fruit, vegetable, and fruit juice intake frequencies did not change (see **Supplementary Table B5**). However, the associations with self-reported healthiness of diet, general health, mental health, and overweight were no longer statistically significant (see **Supplementary Table B6**). The association with self-reported stress, however, remained strong, OR 2.16 (95% CI 1.59-2.95).

When we assumed that all participants with missing adult food security status were food secure (or food insecure), the weighted prevalence of food insecurity was 20.6% (or 43.6%). The true value is likely to be somewhere in between.

3.5 Discussion

We found that the prevalence of food insecurity was 24.3% among a national sample of UK adults, which is higher than previous estimates in the UK. Participants reporting that making ends meet was difficult compared to easy had almost 20 times the odds of food insecurity, when adjusted for other sociodemographic characteristics. The adjusted odds of food insecurity was higher in males compared to females, those who reported their ethnicity as white other or mixed compared to white British, full-time students compared to non-students, and participants with low compared to high education. Participants with children, especially in single-parent households, had higher adjusted odds of food insecurity compared to those living alone. Younger adults also had higher adjusted odds of food insecurity compared to older adults. We found food insecure adults to have lower adjusted odds of consuming above the median frequency for fruits and vegetables, and higher adjusted odds of consuming fruit juice, compared to food secure adults. We also found that food insecure adults had higher odds of reporting poor healthiness of diet, general health, and mental health, as well as high stress and overweight, compared to food secure adults. Together, these findings highlight the high prevalence of food insecurity in the UK, especially among some socioeconomically disadvantaged groups, and add to the evidence for associations between food insecurity and poorer diet and health. However, the cross-sectional nature of this study limits our interpretation of these associations.

3.5.1 Comparison of results to other studies

Difficulty in making ends meet, younger age, having children, and low education were found to be associated with food insecurity in the UK in our study, consistent with previous work.[188] Similar to our findings, other studies have also found that food

insecure adults consumed fewer fruits and vegetables, and had less healthy diets in general, compared to food secure adults.[116] We also observed poorer self-reported physical and mental health, and high self-reported stress among food insecure adults, which is consistent with other studies.[115,259,274,275] Power and colleagues found that food insecurity was associated with poor health in UK mothers, but this was not significant when adjustment for perceived financial situation was made.[265] In our study, associations between food insecurity and health were also extinguished once socioeconomic factors were adjusted for, with the exception of the association with high self-reported stress. The attenuation of these associations suggests that part of the association between food insecurity and these outcomes was due to covariance of food insecurity with socioeconomic factors. Socioeconomic characteristics were associated with food insecurity in our adjusted models, with those reporting that making ends meet was difficult having almost 20 times higher adjusted odds of food insecurity compared to those reporting that making ends meet was easy.

The Food and You Survey (wave 4, 2016) reported prevalence of adult food insecurity (measured by AFSSM) in the UK as 8%,[251] which was substantially lower than we observed. The difference could be due to differences in sociodemographic characteristics between the two samples. Unlike the current work, the Food and You Survey included participants aged 16-18 years and over 65 years. In the Food and You Survey, prevalence of food insecurity was lowest in over 65 year-olds (1-2%), who represented 22% of the sample. Participants may also be more willing to disclose food insecurity in anonymised online surveys (such as IFPS) than in face-to-face interviews (such as the Food and You Survey).

3.5.2 Interpretation of findings and implications for policy

Reported difficulty in making ends meet had the strongest association with food insecurity in our adjusted models. With rising prices of relatively inflexible necessities, such as the 45% rise in fuel costs in the UK over the last decade,[252] pressure has been put on household budgets. This may be at the expense of diet quality. Food insecurity was associated with poorer self-rated healthiness of diet, suggesting that food insecure adults were aware of their poor diet. We observed higher fruit juice intake among food insecure adults compared to food secure adults, an association also reported in the United States.[276] Fruit juice may be preferred by food insecure adults under economic constraints, as fruit juice is cheaper than the equivalent whole fruit.[277] Although fruit juice can count as one portion of fruit per day according to the UK's 5-a-day recommendation, it is a major source of free-sugars. The World Health Organisation (WHO) recommends limiting free sugar intake to no more than 10% of total energy intake, with further benefits from reducing to less than 5%.[278] Thus, the additional fruit juice consumed by food insecure adults could have a negative cumulative health effect.

Food insecurity was associated with poorer health outcomes, especially high self-reported stress and poor mental health, pointing to a strong correlation between food insecurity and mental wellbeing. These findings are in line with previous research from elsewhere,[264,275] and are supported by research that found food insecurity and food bank use to be stigmatising, isolating, and shameful for those experiencing food insecurity.[193,194] Although food insecurity was less prevalent in older adults compared to younger adults, the association with poor health outcomes appeared stronger in the older age groups, especially for poor mental health and high stress. The persisting association between high self-reported stress and food insecurity in this study even after adjustments for socioeconomic variables suggests that this association is specific to food insecurity, over and above socioeconomic deprivation. Further studies are needed to determine the causality of these associations and, if so, mechanisms driving them. Nonetheless, regardless of the direction of association, we must acknowledge the stressful lives of those experiencing food insecurity. Many food insecure individuals report experiencing adverse life events and financial strain.[191] Food insecure adults had higher odds of overweight compared to food secure adults. Reliance on cheap energy-dense foods in favour of nutrient-dense foods such as fruit and vegetables is likely to be a common coping strategy when facing food insecurity,[257] leading to compromised diet quality but not necessarily reduced caloric intake.

The UK has a high prevalence of individual-level food insecurity relative to its poverty rate, compared to other European countries, which may be related to the UK's wide income inequality.[120] The suboptimal diet of the UK population as a whole, and especially in lower socioeconomic groups,[279] points to a need for structural changes to the food, economic, and welfare systems. Addressing the high and rising cost of food, especially healthy foods,[74] could be one important approach. We observed that food insecurity was more likely in participants who reported difficulty making ends meet. Unemployment and delayed social benefit payments are frequently cited reasons for using food banks.[191] However, food insecurity is not just a problem among unemployed individuals, as 76% of the food insecure adults in our sample reported being employed. People working full-time on the National Living Wage do not necessarily achieve the Minimum Income Standard – the income needed to reach a minimum socially acceptable standard of living.[252] This points to the UK welfare system and wage-related policies being insufficient to protect all members of society from food insecurity, and its potential impacts on physical and mental health.

Whilst structural changes may be the most effective way to address food insecurity, these are politically contentious and have long policy timelines. In the meantime, interventions that address the symptoms of food insecurity, including hunger and poor diet quality, could help to alleviate the immediate impacts. The Trussell Trust provided 1.6 million emergency food parcels in 2018/19.[183] The government's Healthy Start

programme, which provides expectant mothers and mothers of young children on low incomes with vouchers to purchase milk, fruits, and vegetables,[280] could also reduce hunger and improve diet quality. However, the scheme has benefited fewer individuals than intended, due to low uptake.[280] Reported barriers to uptake include stigma surrounding voucher use, complexity related to the application process, receipt of vouchers and use, and lack of awareness.[280] Over time, the real value of Healthy Start vouchers has also diminished, from £2.80 in 1992 (equivalent to £5.69 in 2018) when the scheme started, to £3.10 today.[281] Increasing the uptake and value of this scheme may be particularly valuable as food insecurity is more prevalent in adults living with children, compared to adults living alone. Food insecurity was also higher among younger adults and students, who may benefit from targeted interventions.

3.5.3 Strengths and limitations

This study sample, when weighted, was representative of the UK adult population in terms of sex, age, and region of residence (see **Supplementary Table B3**), providing a unique opportunity to estimate food insecurity prevalence and explore correlates of food insecurity in a general UK adult population. To our knowledge, this is the first study in the UK to explore associations between adult food security and diet and health in a general population sample. However, excluding participants with missing adult food security status may have introduced selection bias. Nonetheless, our sensitivity analysis estimated food insecurity prevalence at between 20.6% and 43.6% in our sample. Even the conservative estimate of 20.6% indicates a high prevalence that cannot be ignored.

The AFSSM is a validated measure of adult food security;[167] however, it focuses on food adequacy. The scale does not capture other elements of food security: preferences, safety, or nutrition, with only one question related to 'balanced meals'. The BRFSS fruit and vegetable module has moderate validity and reliability when compared to reference dietary assessment methods.[270] Unfortunately, more detailed dietary assessment was not included in the IFPS. Future work could explore associations between food insecurity and more holistic markers of diet quality. Self-rated health provides a validated proxy of actual health,[282] and moderate associations have been found between self-rated mental health and validated mental health scales.[283] However, as with all self-reported data, these data may be subject to social desirability bias.

3.5.4 Future research

Routine measurement of food security, rather than just food bank usage data, in the UK population would help confirm the relationships we have reported and track prevalence, determinants, and outcomes of food insecurity over time. Since our analysis was conducted, the UK government has announced that food insecurity will be routinely measured from April 2019 in the annual Family Resources Survey.[284] This will also allow

the impact of planned and unplanned interventions that may influence food security to be evaluated.

3.5.5 Conclusions

Food insecurity was prevalent among UK adults and correlated with various sociodemographic characteristics. Reported difficulty in making ends meet had the strongest association with food insecurity. Food insecurity was also associated with poorer diet and health, as measured by a number of markers. Food insecurity is unlikely to be a healthful experience and may be both influenced by, and lead to, poor physical and mental health.

4 UK NEWS MEDIA COVERAGE OF FOOD INSECURITY

4.1 Abstract

Background/objectives Food insecurity is a growing concern in the UK. News media can reflect and shape public and political views. We sought to provide a picture of the news media coverage of food insecurity in the UK. We aimed to examine the reporting frequency of food insecurity in UK newspapers and explore how the problem of food insecurity was described, and what drivers and solutions were proposed.

Methods Using Factiva, we searched for news articles that were substantively about food insecurity in the UK, published between 01 January 2016 and 11 June 2019. In total, 436 articles met our inclusion criteria. We investigated whether the number of articles included differed over the study period and by newspaper. We then took a random sample of articles and conducted a thematic analysis to saturation, resulting in 132 (30%) articles being coded and analysed.

Results The number of included articles fluctuated seasonally. 74% of included articles were published in left-leaning or politically central publications. Major themes that developed through our thematic analysis were: definitions of food insecurity, consequences for food insecure individuals, insufficient income as an immediate driver, government versus individual responsibility, charitable food aid, and calls for government action. Compared to previous work, discussions of 'holiday hunger' in children and the use of 'food waste' to solve food insecurity were more prominent. Whilst the existing solutions reported in articles relied on charitable food aid, there was recognition that government policies could provide long-term, income-based solutions. These measures were generally supported by the public, charities, and food insecure individuals, but contested within government.

Conclusions Food insecurity in the UK was of media interest. Newspapers were used as an advocacy channel to call for government action. There was some reported government acceptance of responsibility. However, implementation of upstream solutions is still needed.

4.2 Introduction

Food insecurity can be defined as *"the inability to consume an adequate quality or sufficient quantity of food in socially acceptable ways, or the uncertainty that one will be able to do so"*.[113] Food insecurity has been identified as a growing problem in United Kingdom (UK).[188] In Chapter 3, I estimated that 24% of UK adults aged 18-64 years were living in food insecurity in 2017.[285] To deepen my understanding of the high prevalence of food insecurity I found in a nationwide UK sample, I sought to explore the framing of and attitude towards food insecurity in the UK, and discussions surrounding its drivers and solutions. It is important to understand the possible interventions that could be employed to reduce food insecurity, their feasibility and potential acceptability across different actors, including governmental bodies, the general public, and various advocacy groups. Therefore, alongside the quantitative work I presented in Chapter 3, which estimated a high prevalence of food insecurity in the UK, I conducted qualitative work in parallel to explore the framing of food insecurity in the UK, focusing on how the problem was described and what drivers and solutions were proposed by different actors.

Public discourse shapes and reflects public opinion.[195] News articles have previously been analysed to explore the framing of public health problems.[286,287] Food insecure individuals reported feelings of stigma and shame.[193] This may be perpetuated by negative social attitudes and blaming of individuals within the public discourse.[194] Newspapers are also an important tool for public health advocacy, and can have substantial impact on the public and political agenda.[195] Therefore, analysing newspaper content on food insecurity could provide insight into the public's knowledge and perception of, and the political attitude to, food insecurity in the UK. This could shed light on the political will and public acceptability regarding addressing food insecurity.

Previous studies have investigated UK news media portrayal of food insecurity and food bank use. One study found no news articles discussing food banks in 2007, and few before 2012.[196] However, the number of articles increased dramatically between 2012 and 2014, corresponding with the increase in food bank usage.[288] The emergence of tension between three key sets of players in the media discourse was also noted: church leaders and the Trussell Trust (the UK's largest charity supporting a network of food banks) cited changes to the welfare system as the reason for increases in food bank usage, whilst the government attributed the rise to the increased supply of food banks.[289] An absence of individuals directly experiencing food insecurity within news media discussions was also noted in this study. Another study reported similar findings for news articles on food insecurity in the UK published between 2006 and 2015, adding that few articles specifically discussed food insecurity among children and families.[197] This study also found that the majority of news articles were written in response to a specific event, report, or television programme (reactive). Both studies noted that the

Trussell Trust was a main actor in news media discussions of food insecurity. The studies also noted welfare reform as a main theme within articles from 2013. At this time, the new Universal Credit welfare system was introduced by the government to replace and unify six means-tested benefits: working tax credits, child tax credits, income-related jobseeker's allowance, housing benefits, and income support.[290] The system is being rolled out gradually and is set to be in effect across the whole country by 2023.[290]

To our knowledge, there are no studies on the news media coverage of food insecurity in the UK that have included articles published after 2015. Yet, food insecurity remains prevalent.[188,285] Thus, our study aimed to explore if, and how, food insecurity was portrayed in UK national newspapers from 2016 onwards by examining the reporting frequency and the themes of published articles in terms of the proposed nature of the problem, its drivers, and solutions.

4.3 Methods

We searched Factiva, an online database of media sources, for UK national newspaper articles related to food insecurity. We searched for uses of the words and phrases "foodbank", "food bank", "food insecur*", "food poverty", and "holiday hunger", restricting articles to those published in the UK between 01 January 2016 and 11 June 2019 – when searches were conducted. We included all 12 national newspapers (*The Guardian, Independent, The Times, The Sun, Financial Times, The Telegraph, Daily Star, Daily Mail, Daily Express, Daily Mirror*, *Morning Star, Sunday People*, including all Sunday editions, covering both print and online versions).

The searches returned 2058 articles. The Factiva database automatically removed some duplicates. AY removed remaining duplicates during the screening process, keeping the latest version of the article, or the longest version where multiple versions were published on the same day, based on the publication date and word count provided by Factiva. Articles with different headlines, but where over 80% of the content was the same, were treated as duplicates in the same way. News round-ups and summaries were excluded, assuming that more detailed articles would also be published alongside.

All remaining articles were assessed against inclusion and exclusion criteria (see **Table 4.1**) for eligibility by AY with duplicate screening by HSL, HF, MK, or JA. Discrepancies were resolved through discussion.

Table 4.1. Inclusion and exclusion criteria

	Include	Exclude
Article type	Articles that have had some editorial input (e.g. news articles, feature articles, letters from readers, opinions)	Reader-generated online comments
Context	Articles about real life people and situations	TV listings or articles related to TV dramas, films, or fictional characters; articles about food insecurity in animals
Topic	Topic of the article is substantively about food insecurity – the problem, its drivers, or solutions	Topic of the article is not substantively about food insecurity i.e. mentioned in passing
Country	Articles discussing food insecurity in the UK	Articles discussing food insecurity in countries other than the UK
Unit of measurement	Articles discussing food insecurity at the household or individual level	Articles discussing food insecurity at the national or global level e.g. main topic is UK's self-sufficiency in food production

The included articles were first analysed quantitatively to investigate patterns in the frequency of publication. We counted the number of included articles by newspaper title, political stance,[291] and newspaper type as classified by the Audit Bureau of Circulations (ABC).[292] Newspaper type is indicative of readership demographics, with readers of 'quality' newspapers more likely to have higher occupational level compared to readers of 'popular' newspapers.[293] We also looked at the content of news articles in the ten months of our study period that had the highest number of included articles to explore if these articles predominantly discussed a specific event, report, or topic – this process was data-driven.

Articles were then imported into NVivo 12 Pro for qualitative analysis. We conducted a thematic analysis to explore how the problem of food insecurity, and its drivers and solutions, were discussed within the articles.[294] AY developed the preliminary coding framework based on previous literature and an initial reading of the data. This framework was applied to a random 10% sample of articles to further develop the coding framework. This framework was then discussed and agreed with JA and MW. The agreed coding framework was applied to a further randomly selected 10% of articles and subsequently discussed and agreed with HF and MK, without further amendments. AY used the final, agreed framework to code articles in randomly selected 10% samples until saturation was reached and no further themes were identified. In total, 132 (30%) included articles were coded.

4.4 Results

4.4.1 Included articles

Of the 2058 articles screened, 436 (21%) met the inclusion criteria and were included. Article lengths varied from 58 to 4811 words, with a median length of 608 words. The number of news articles included varied by publication. The *Independent* and *The Guardian/Observer* together were responsible for over half (55%) of the included articles (see **Table 4.2**). Overall, politically left-leaning newspapers accounted for 44% of articles, centralist newspapers for 32%, and right-leaning for 22%. Quality newspapers accounted for 62% of articles, mid-market for 4%, and popular for 30%.

Table 4.2. Number of included articles by newspaper title, political stance, and newspaper type

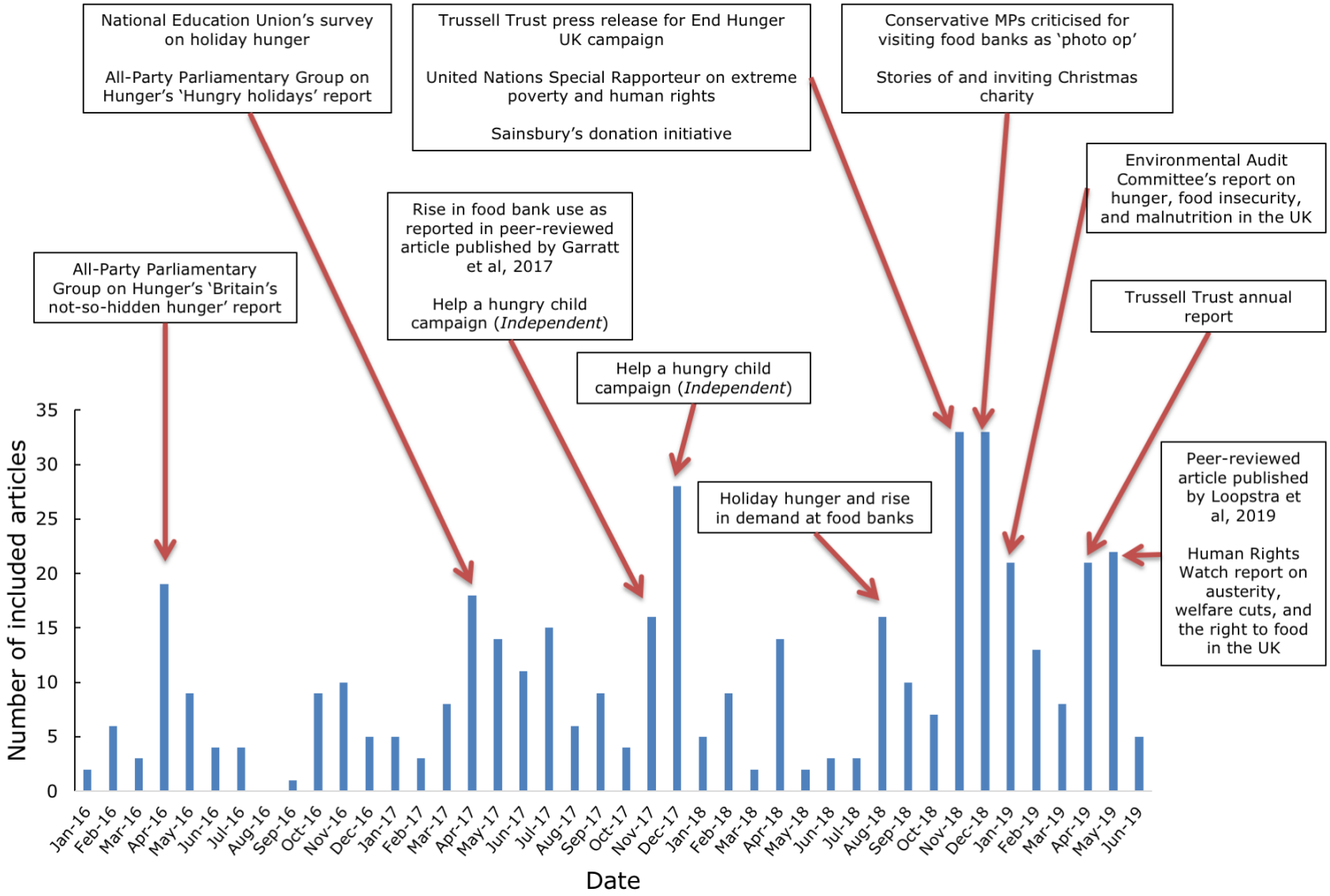
Newspaper	Number of articles (%)	Political stance	ABC classification[292]
Independent	131 (30.0)	Centre[291]	Quality
The Guardian/Observer	110 (25.2)	Left [291]	Quality
Daily Mirror/Sunday Mirror	75 (17.2)	Left [291]	Popular
The Sun/Sunday Sun	40 (9.2)	Right [291]	Popular
The Times/Sunday Times	24 (5.5)	Right[291]	Quality
Daily Express/Sunday Express	11 (2.5)	Right [291]	Mid-market
Financial Times	11 (2.5)	Right[295]	ND
Daily Star	8 (1.8)	Centre[295]	Popular
People/Sunday People	8 (1.8)	ND	Popular
Morning Star	7 (1.6)	Left[296]	ND
Daily Mail/Mail on Sunday	7 (1.6)	Right [291]	Mid-market
The Telegraph	4 (0.9)	Right[291]	Quality
Total	**436 (100)**		

ABC, Audit Bureau of Circulations. ND, no data.

4.4.2 Frequency of reporting

The number of news articles substantively about food insecurity remained high each year, but fluctuated by month (see **Figure 4.1**). The three months with the highest number of articles were in the run up to Christmas in December 2017 and November and December 2018. In 2017, the *Independent* ran the 'Help a Hungry Child' campaign in aid of the Felix Project, a charity that collects food that would otherwise be wasted and redistributes it to people who are food insecure. In 2018, multiple groups encouraged Christmas charity to organisations supporting food insecure people. Most other peaks corresponded with reports, such as those published by the Trussell Trust and the All-Party Parliamentary Group on Hunger. Both groups were previously identified as key actors in the news media discussion of food insecurity.[196,197]

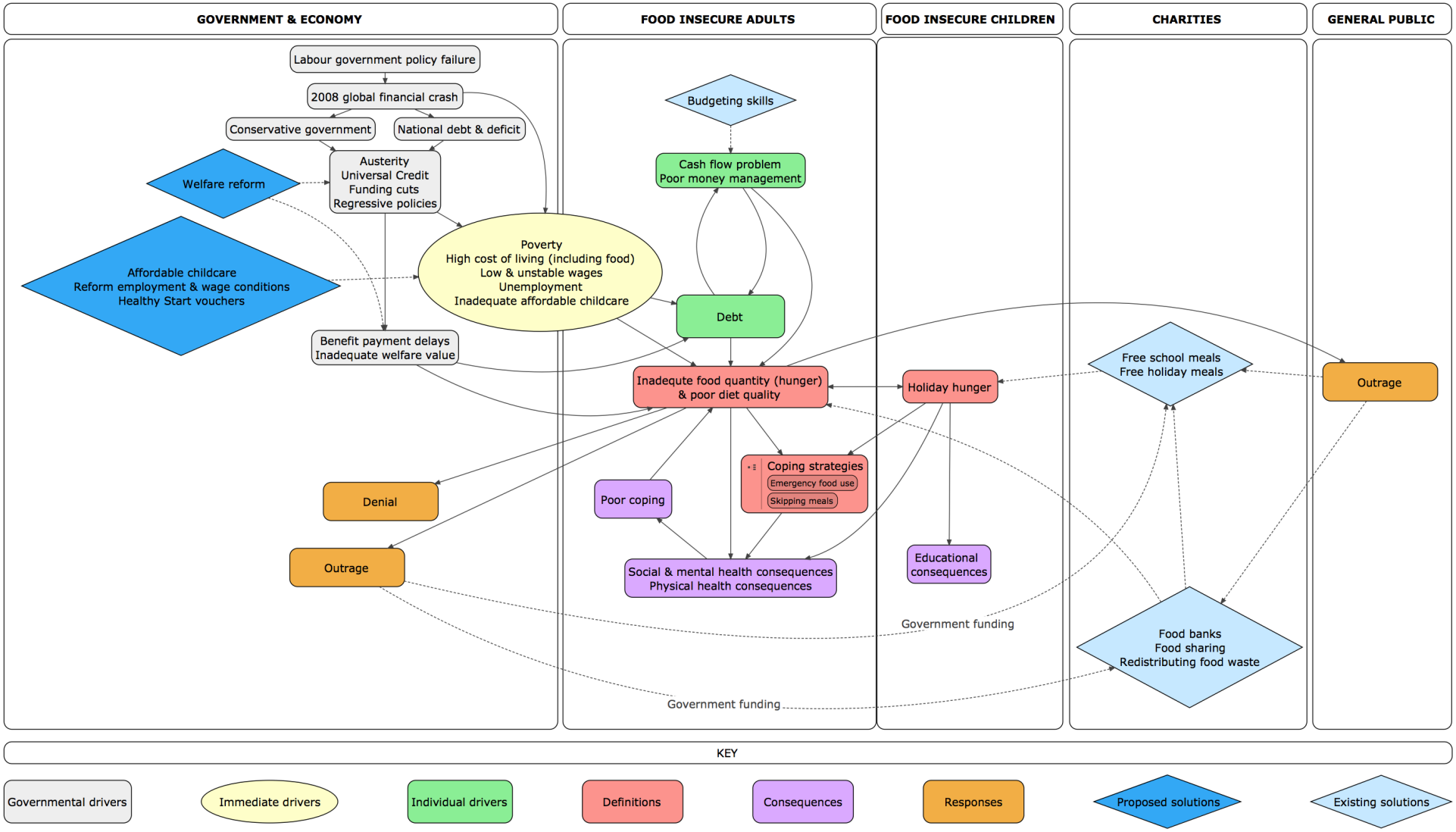
Figure 4.1. Number of included articles by month and the stories covered in the 10 months with the highest number of publications



4.4.3 Thematic analysis

Whilst some articles only reported the latest statistics from recently published reports, such as the rise in food bank usage or the proportion of teachers reporting hunger among their students, many articles provide more in-depth discussions of the problem, its drivers, and solutions. **Figure 4.2** is a conceptual map that represents how key ideas within included articles link with each other. It is important to note here that this figure does not necessarily represent 'causation', and some links are contested between different actors. From this, we drew out key themes related to the problems (definitions of food insecurity and consequences for food insecure individuals), drivers (insufficient income as an immediate driver and government versus individual responsibility), and solutions (charitable food aid and calls for government action). Below we discuss each in turn, illustrating how our sample of news articles discussed the links represented in **Figure 4.2**.

Figure 4.2. Conceptual map of the problem, drivers, and solutions of food insecurity as portrayed in UK newspapers, 2016-2019



4.4.3.1 Problem

The key themes related to the problem of food insecurity were 'definitions of food insecurity' and 'consequences for food insecure individuals'.

4.4.3.1.1 Definitions of food insecurity

The problem of food insecurity was defined in several ways (illustrated in red in **Figure 4.2**), with a focus on limited food quantity in children and adults. There was an emphasis on the timing of food insecurity for children, with discussions of 'holiday hunger'.

4.4.3.1.1.1 Food insecurity as limited food quantity and quality

The definition of food insecurity quoted in the introduction is more expansive than simply food insufficiency.[113] However, in the news articles, food bank usage was frequently presented as synonymous with food insecurity and often used to illustrate the severity of food insecurity in the UK:

> *"Overall 1,109,309 emergency food packages were distributed by the Trussell Trust in 2015-16 – up slightly from last year. The charity, Britain's leading food bank provider, said that the figure was 'one million too many' and urged the Government and the public not to accept the levels of food poverty in the UK as 'the new normal'."* (*Independent*, 15 April 2016)

When not defined by food bank usage, articles largely defined food insecurity as insufficient food quantity and by its symptoms, such as hunger and meal skipping:

> *"many have to skip meals and cut back on food to get by."* (*Independent*, 10 January 2019)

Some articles made mention of diet quality, illustrated by consumption of typically 'healthy' foods such as fruit and vegetables:

> "*[t]he families of nearly 4 million children would struggle to afford enough fruit, vegetables and other healthy foods to meet the government's nutritional guidelines"* (*Independent*, 05 September 2018)

4.4.3.1.1.2 Food insecurity as holiday hunger in children

The discussion of food insecurity in children was prominent in included articles. Holiday hunger was commonly used to define the extent of child food insecurity:

> "*[d]uring the school term, almost all of these children are entitled to a free school meal. During the summer holidays, their families – already stretched to the limit – somehow have to find the money for those extra meals*." (*Sunday Express*, 09 July 2017)

The term 'holiday hunger' starts to be used in news article headlines in April 2017, but mentions of hungry children and greater food insecurity in families with children during holidays were found in earlier articles in our sample.

4.4.3.1.1.3 Food insecurity used to illustrate extreme poverty and destitution

Despite excluding articles that mentioned food insecurity in passing (as part of a more general discussion of poverty), poverty remained a prominent theme in included articles. Food insecurity and food bank usage were frequently used as illustrative of, and synonymous with, absolute poverty and destitution:

> *"The Joseph Rowntree Foundation said it will urge Alston [UN rapporteur on extreme poverty and human rights] to examine how tougher benefit sanctions lead to greater destitution, which means people not being able to keep warm, fed, dry and clean. It found that last year 1.5 million people fell into destitution at some point – just over one in 50 people – with the highest levels in Manchester, Liverpool and Middlesbrough."* (*The Guardian*, 22 August 2018)

4.4.3.1.2 Consequences for food insecure individuals

There was recognition within news articles that the consequences of food insecurity for individuals could be complex and varied (shown in purple in **Figure 4.2**). Some articles discussed mental health consequences:

> *"Our research highlights that poor mental health is both a cause and a consequence of poverty. Of 20 food bank users we interviewed during one week, 18 said they had experienced poor mental health – stress, anxiety and depression – in the last 12 months. Six said they had considered or attempted suicide in the past year."* (Wandsworth Foodbank, *The Guardian*, 11 May 2017)

Poor mental health and physical health were discussed as caused by and causing food insecurity due to insufficient support:

> *"Illness, disability, family breakdown or the loss of a job could happen to any of us and we owe it to each other to make sure sufficient financial support is in place when we need it most. It's hard to break free from hunger if there isn't enough money coming in to cover the rising cost of absolute essentials like food and housing."* (*Independent*, 24 April 2018)

Discussion of physical health in relation to food insecurity often made reference to periods of British history renowned for poverty. Words such as "Victorian" or "Dickensian" were used, indicating an incompatibility with modern day living:

> *"Health experts have warned of the return of Victorian scourges such as rickets and stunted growth due to child food poverty and malnutrition."* (*Independent*, 19 December 2017)

Other consequences discussed included the influence of food insecurity on social interactions and reluctance to seek help:

> *"The food bank was a last resort for people who were mostly existing, not living, and this unsurprisingly led to stigma, shame, and embarrassment for many who were desperately trying to make ends meet."* (*The Guardian*, 22 April 2016)

For children, educational consequences were also cited frequently alongside a lack of future opportunities:

> *"Scientific studies have found that [food insecure children] lose one hour of learning time a day as a result of being distracted. This diminishes their school results, impacting on their chances for a good future."* (*Independent*, 30 November 2017)

Articles also discussed how families distributed scarce food, with adults cutting back to ensure children did not have to, in order to cope with food insecurity. One article reported findings from a poll conducted by the Young Women's Trust:

> *"46 per cent of mothers in the UK aged under 25 do not eat proper meals in order to ensure their children are fed, while more than a quarter have used food banks."* (*Independent*, 28 March 2017)

4.4.3.2 Drivers

We developed two themes within drivers of food insecurity: immediate drivers and upstream drivers. The immediate drivers centred on insufficient income (shown in yellow), whilst debates over whether upstream drivers were individual (shown in green) or governmental (shown in grey) were reported.

4.4.3.2.1 Insufficient income as an immediate driver

The high cost of living, particularly housing and fuel costs, was cited as the direct reasons for food insecurity, by food insecure individuals and charities:

> *"More than a quarter (28 per cent) of* [food bank users] *who had experienced rising expenses said this was due to housing costs, such as rent or energy, going up, with tenants in private housing were more likely to find it difficult to keep up with rents than socially rented properties." (Independent,* 29 June 2017)

Low wages and unstable incomes were also frequently cited as reasons for food insecurity among the 'working poor':

> "[w]e have 900,000 workers on zero-hours contracts not knowing when the next pay day will be." (*The Daily Mirror*, 28 April 2017)

Some articles focused on particular groups that were more likely to be food insecure. For example, there was some acknowledgement of the disadvantage that young mothers had faced:

> *"Young mums are telling us they want to work and become financially independent but they face huge barriers like discrimination from employers, a lack of available and affordable childcare, a lack of flexible working opportunities and inconsistent support from Jobcentre Plus. On top of that, they are entitled to less government support and lower wages because of their age."* (Young Women's Trust, *Independent*, 28 March 2017)

4.4.3.2.2 Upstream drivers: government versus individual responsibility

Although there was apparent consensus in the data that the immediate drivers of food insecurity were low income and the high cost of living, there was disagreement as to whether these drivers were becoming more prevalent in the UK, and if so, why this was the case. The upstream drivers of food insecurity identified in the articles can be broadly categorised as governmental or individual.

4.4.3.2.2.1 Governmental drivers: austerity and welfare

Articles pointing to government policies as the drivers of food insecurity cited austerity policies following the global financial crash in 2008, which resulted in national debt and deficit:[297]

> *"wages stagnated and working conditions worsened under Tory austerity policies after the financial crash."* (*The Guardian*, 19 November 2018)

The UK has been under the leadership of a centre-right Conservative (known colloquially as Tory) government since 2010, first in coalition with the Liberal Democrats, and then as a single-party government from 2015.[298] During this time, a number of fiscal policies have been introduced as part of an austerity programme, resulting in funding cuts to social security and public services, and welfare reform.[299] The design and implementation of the Universal Credit social security system, as part of these reforms, was particularly strongly linked to food insecurity in included articles:

> *"Food banks handed out a record number of meals last year after the chaotic introduction of universal credit, the government's flagship welfare overhaul, left claimants unable to afford meals when their benefits were delayed*." (*The Guardian*, 25 April 2017)

A major problem with Universal Credit identified was delayed initial payments – of at least five weeks – when switching from the old system to Universal Credit. The "harsh taper rate which punishes people for earning more" (*The Sun,* 31 January 2019) was also considered problematic.

Regressive policies were perceived as exacerbating wealth inequality and driving food insecurity within articles:

> *"[t]he root of the problem is our refusal to share the wealth we have more equitably. Instead of tackling inequality, we are pursuing policies that intensify it."* (*Sunday Express,* 09 July 2017)

Politicians from the Labour party, the main opposition party, acknowledged the government's responsibility for tackling food insecurity and criticised the government's actions and inaction:

> *"Labour leader Jeremy Corbyn said: 'No one should be cold or hungry at Christmas. It's time this Government opened its eyes to the misery it is causing and immediately stop the roll out of Universal Credit.' Labour MP Neil Coyle added: 'The Government can cut demand for foodbanks at the stroke of a pen but has so far remained heartless in the face of the horrific suffering it has caused so many families needing foodbanks this year.'* (*Daily Mirror*, 27 November 2018)

4.4.3.2.2.2 Individual drivers: money management and cash flow

In contrast, some articles discussed individual responsibility, particularly poor money management, as a cause of food insecurity. For example, government representative described food insecurity as a "cash flow issue" (*The Daily Mirror*, 30 May 2017).

As in previous research,[(197)] we found few articles supporting the idea that food insecurity was a matter of failed individual responsibility. Articles mentioning individual responsibility as a cause of food insecurity generally did so in a context of critiquing politicians for such views, suggesting that they were not in line with the views of the newspaper and its audience.

4.4.3.2.2.3 Governmental responses to food insecurity

The governmental responses to food insecurity reported in included articles were varied. There was some denial – that food insecurity was a problem in the UK, that the government had a role in causing food insecurity, and that it was government's

responsibility to tackle food insecurity. In other cases there was some admission from government sources that food bank use was rising and linked to the Universal Credit roll out.

Whilst acknowledging the root cause of food insecurity as unemployment and low income, the government denied that these problems exist in the UK and their part in causing it:

> *"Household incomes have never been higher and the number of children living in workless households is at a record low, but we know there's more to do ensure that every family has access to nutritious, healthy food. We already provide support through free school meals and our Healthy Start Vouchers, while we spend £90bn a year on working-age welfare and will be spending £28bn more by 2022 than we do now." (Independent*, 10 January 2019*)*

When government representatives acknowledged the problem of food insecurity, they often supported charity as a solution whilst denying a link between benefit delays and food bank usage:

> *"Britain has a proud tradition of volunteering and of civil society and faith groups providing support to vulnerable people and this Government welcomes that. We know that the reasons for food-bank use are complex and often overlapping, so it is misleading to claim that it is driven by benefit delays. The vast majority of benefits are paid on time and improvements are being made year on year."* (*Independent*, 03 January 2016)

Government officials attempted to demonstrate their support for charity by visiting food banks. This was met with cynicism and outrage in articles:

> *"I feel absolutely incensed at the sight of Iain Duncan Smith and the rest of his smirking, smug, self-satisfied Tory cronies posing at foodbank collection points. He and the other Tory hypocrites are acting as if they're Santa Claus or fairy godmothers rather than the Scrooges they really are." (The Daily Mirror,* 18 December 2018)

Some Conservative politicians additionally pointed responsibility to their predecessors, the Labour party, who were in government from 1997 to 2010:

> *"Inevitably, the state can't do everything, so I think that there is good within food banks. The real reason for the rise in numbers is that people know that they are there and Labour deliberately didn't tell them."* (*The Daily Express*, 15 September 2017)

Nonetheless, as scrutiny of the new welfare system increased, there was some government acknowledgement of problems with the Universal Credit system:

> *"Despite compelling evidence, senior Tories have repeatedly denied that Universal Credit is a factor behind the surge in the use of foodbanks. But Welfare Secretary Amber Rudd has at last accepted there is a link. She told MPs yesterday: 'It is absolutely clear that there were challenges with the initial roll-out of Universal Credit. And the main issue that led to an increase in foodbank use could have been the fact that people had difficulty accessing their money early enough.'"* *(The Daily Mirror*, 12 February 2019*)*

4.4.3.3 Solutions

We found mentions of solutions that were individual (skills-based), charity-based, and structural in included articles. Solutions are illustrated within diamonds in **Figure 4.2**. Solutions reported as currently existing are coloured light blue, and solutions that were proposed but are not enacted are coloured dark blue.

4.4.3.3.1 Skills-based solutions

Some articles reported on food banks providing budgeting tips and cheap recipes alongside food aid to combat food insecurity. The Trussell Trust was often quoted as advocating for structural interventions from government. Yet, their introduction of budgeting skills solutions suggests that they believed structural solutions were unlikely to be forthcoming imminently:

> *"As well as helping with problems relating to benefit payments and housing, the [food bank] advisers assisted people with managing their money and dealing with their debts. In the future a variety of types of assistance will be offered. McAuley says: 'We're calling it 'money help'. In some places it won't be financial advice – it will be budgeting skills.'"* (*The Guardian*, 30 January 2016)

4.4.3.3.2 Charitable food aid

Existing solutions to food insecurity discussed in articles were predominantly centred on charitable food aid. As found in previous studies,[196,197] food bank usage dominated the news media discussion of food insecurity. However, food banks were reported to be struggling to cope with rising demand, demonstrated by the headline, "*Food bank runs out of food due to growing numbers in need of support"* in the *Independent* on 01 May 2017.

Some articles encouraged donations from the public and celebrated the success of charity projects, whilst others highlighted that charity initiatives were not sustainable and addressed the symptoms rather than the root causes of food insecurity. In some cases the same organisation expressed both – superficially contradictory – views:

> *"The Trussell Trust's chief executive, Emma Revie, said it was unacceptable that people had to use food banks in the first place, and the state should not rely on them to fix its shortcomings. 'We do not want to be a part of the welfare state, we can't be a part of the system.'"* (*The Guardian*, 25 April 2019)

The redistribution of 'food waste' was also prominent in discussion of solutions within articles. Various initiatives were described where food that would otherwise end up in landfill was identified and used to feed people experiencing food insecurity. Given the environmental harms of food waste, these food redistribution initiatives were often described as a double win for both environment and food insecurity:

> *"The charity [Felix Project] has been working since 2016 to fight hunger with surplus in-date produce, responding to the twin demons of food poverty and food waste. Now, it will be channelling all funds raised by The Independent's [Help a Hungry Child] appeal to provide fresh and nutritious food for hungry children to access at market stalls in primary schools."* (*Independent*, 07 December 2017)

Food waste redistribution was also described as providing an opportunity for the commercial sector to contribute to solving the dual problems of food waste and food insecurity:

> *"Britain's biggest supermarkets will commit to double the amount of surplus food they redistribute in a new drive to reduce waste."* (*The Times*, 24 January 2017)

4.4.3.3.3 Call for government action

Within included articles, there were calls from charities, advocacy groups, and the general public for government action to address the perceived root causes of food insecurity – poverty and wealth inequality. In particular, there were calls for welfare reform to prevent delays to benefit payments, increase the value of benefits, and extend eligibility for welfare support:

> *"Most of West Cheshire [food bank]'s six recommendations on how to reduce the rising numbers of people dependent on its charity food handouts focus on welfare policy: more efficient jobcentre administration, a less punitive sanctions system, adequate levels of benefit payment, and a properly functioning local welfare safety net." (The Guardian,* 22 July 2016)

Others called for improved workers' rights, including ensuring that job contracts were secure and increasing the National Living Wage.[252] Government policies that could ensure more flexible working options and affordable childcare for parents wishing to find employment were also mentioned:

> *"Young mums have told us that they need better support from jobcentres, cheaper childcare, and flexible and part-time working opportunities to help them to find jobs and provide for their families. Now is not the time to be removing support for these young people, but to be helping them to build a fair financial future." The Guardian,* 31 March 2017)

This would help food insecure families, especially young mothers (under 25 years) who are currently ineligible for some benefits and have lower wages.[300]

The public response, found mostly in letters and opinion pieces, frequently captured outrage about both the problem and perceived drivers of food insecurity:

> *"families starving in our once-proud country is a disgrace. The Trussell Trust is doing an amazing job, as are other foodbanks around the country, but this is 2017 and as usual the rich get richer and tell those who struggle that they must just get on with it."* (*The Daily Mirror,* 28 April 2017)

Although the majority of actors (aside from government representations themselves) supported the notion of government-led action to address poverty, there was some support for the government's current welfare system:

> *"'Universal credit is one of the most effective poverty-fighting tools in existence,' said Edward Davies, the head of policy. 'When it is fully rolled out, hundreds of thousands more people will have a job as a result.'" (*Centre for Social Justice*, The Guardian*, 22 August 2018*)*

As illustrated in **Figure 4.2**, governmental solutions are upstream of charitable solutions, and have the potential to address the perceived root causes of food insecurity and provide the most sustainable solutions. Reluctance from the government to take action to tackle food insecurity was portrayed throughout our study period. However, some shifts in government response were noted.

4.5 Discussion

4.5.1 Summary of key findings

This is the first study to include a broad view of food insecurity in the UK whilst exploring how it is portrayed in newspapers, providing an updated and comprehensive account. Food insecurity remained a topic of interest within newspapers, especially in politically left-leaning and centralist newspapers. A high number of publications in a given month usually coincided with an event or report (reactive reporting), with one notable newspaper-led Christmas charity campaign run by the *Independent* in 2017 (proactive reporting). Although there was a heavy reliance on food bank usage as the definition of food insecurity, as previous reported,[196,197] there was now also recognition of holiday

hunger, poor diet quality, and reduced social participation among food insecure individuals. However, the development of a more nuanced understanding of the problem was not reflected in reported solutions, which still heavily rely on food banks. Redistribution of food waste has gained popularity in news articles as another charity-based solution. The perceived immediate drivers of food insecurity reported remain low income and high cost of living. Whether and why these drivers have increased in the UK continue to be disputed. However, the government has reportedly admitted a link between welfare reform (including the introduction of Universal Credit) and food insecurity. There were calls, from the general public and advocacy groups, for the perceived upstream drivers of food insecurity, poverty and wealth inequality, to be address structurally by the government.

4.5.2 Strengths and limitation of the study

This study provided an updated view on how food insecurity was discussed in UK newspapers, including all 12 UK national newspapers from January 2016 to June 2019. Unlike previous studies, we included letters and opinion pieces, to capture how newspapers were being used as a channel of communication by the general public and advocacy groups. We also used a wider concept of food insecurity compared to previous work, where the focus was exclusively on food banks or a specific population subgroup.[196,197]

We randomly sampled articles to code for our thematic analysis. Saturation was reached after analysing 132 (30%) articles. Many articles within our sample covered the same stories. By taking a random sample for analysis, we efficiently captured a large proportion of unique stories. However, this approach might have been less able to capture potential variation in coverage of the same story between newspapers.

Our inclusion criteria focused on articles that were substantively about food insecurity. This meant exclusion of many articles that used food insecurity as an example of poverty or destitution. However, food insecurity is a part of poverty, and the wider drivers and solutions may not have been captured fully in our work. Nonetheless, poverty, welfare reform, and the competing costs of living prevailed as strong themes in our analysis even with these exclusions.

4.5.3 Comparison to previous studies

Similar to previous studies,[196,197] we found that reporting on the rise of food bank usage was very common and many articles relied on food bank usage data to introduce the topic of food insecurity. However, we observed some recognition that food bank usage was not the only definition of food insecurity, with some discussion of poor diet quality and the wider consequences of food insecurity. Although reported solutions to food

insecurity have also diversified beyond food banks, they still relied heavily on charity. Food waste redistribution has become a prominent solution discussed.

Unlike in previous work,[197] accounts from individuals experiencing food insecurity were common. Nonetheless, news articles remained largely reactive and often reported the latest statistics reported by organisations such as the Trussell Trust and the All-Party Parliamentary Group on Hunger, which were found to be key organisations represented in newspapers previously.[196,197] They continued to have a strong advocacy presence in the news media, and appear to help maintain news media interest on this issue. However, reports from other organisations were also commonly cited within articles in this study, such as the human rights reports and the report by the Environmental Audit Committee.[301,302]

Some articles reported that the government recognised food insecurity as a problem and one associated with the Universal Credit welfare system, which they previously denied.[196] Therefore, the drivers of food insecurity seem less contested than in previous studies, with increasing support for government action and acknowledgement that government inaction was a driver of food insecurity. However, included articles did not indicate complete government acceptance of responsibility.

In contrast to previous work, we found reporting on children and families experiencing food insecurity to be common.[197] This change could be due to some prominent reports and campaigns in 2017, including by the All-Parliamentary Group on Hunger.[303] There is often more protection afforded to children due to their perceived vulnerability. The reframing of obesity as a problem of childhood appears to have been a successful strategy to drive structural solutions in the UK.[304,305] Perhaps the government will also prioritise the problem of food insecurity as the conversation continues to focus on children.

4.5.4 Interpretation and implications

The number of included articles fluctuated seasonally. More articles were published in the lead up to Christmas (observed in 2017 and 2018 in our sample). Christmas is a time of year that is traditionally associated with togetherness and giving.[195] The timing may be strategic to elicit emotion and encourage public support for charitable solutions. This could be important in a context where most solutions rely on volunteers and donations. Though not a long-term solution, the success of these interim solutions is necessary to provide temporary help for people experiencing food insecurity. Although the British public seem to expect inequalities in health, wealth, and political power,[306] we found a strong sense of outrage associated with the existence of hunger in the UK. There was support from the general public and from charities for both short-term charitable solutions and longer-term political and structural changes.

The focus on government responsibility within the included articles could be due to the majority of articles being published in left-leaning and centralist newspapers, particularly *The Guardian* and the *Independent*. The political ideology of these publications may mean that social problems are more likely to be viewed as structural rather than individual. Left-leaning publications may also be more willing to criticise the current centre-right Conservative government. However, *The Sun, a* right-leaning newspaper was responsible for 40 (9%) of included articles. At the bottom of some included articles in *The Sun*, there was advice on "what to do if you have problems claiming Universal Credit" suggesting that the publication recognised that some of its readers might be likely to be experiencing financial difficulties, and thus food insecurity. This may reflect the demographic of the readership, as *The Sun* has a higher proportion of younger readers and readers on lower incomes compared to other national UK newspapers.[293]

Although the first food waste redistribution organisation (Crisis FareShare) was established in the UK in 1994, it was only noted as a major theme in newspaper reporting of food insecurity from 2014.[197] The increase in news media coverage since 2014, and continued interest beyond 2016 identified in this study, might reflect the increasing attractiveness of the alignment of simultaneously reducing food insecurity and food waste. This solution may also be considered more systemic.

Instead of working on improving welfare support and employment policies, the government has largely in principle, and sometimes financially, supported charity initiatives as the solution to food insecurity, according to the included news articles. However, there has been some recent political interest in tackling food insecurity, with the Children's Future Food Inquiry and the House of Lord's Select Committee Inquiry on Food, Poverty, Health, and Environment looking into food insecurity in the UK.[307,308] The Nation Food Strategy is also underway, and mentions the need to deliver healthy and affordable food to people regardless of where people live and how much they earn.[309] Further, there has been government commitment to measuring food insecurity annually using the USDA Food Security Survey Module, the most commonly used measure in high-income countries.[284] With robust monitoring of the prevalence of food insecurity, targets to reduce food insecurity can be set and progress can be monitored.

4.5.5 Conclusions

There was media interest in food insecurity, especially in left-leaning and centralist newspapers and especially during the summer holidays and Christmas period. News media discussions of food insecurity were dominated by talk of food banks, as previously found. However, in contrast to previous work, children have become a main focus within the food insecurity discussion, which could increase political will for action. Reported existing solutions to food insecurity rely on charitable food aid. Redirecting food waste to reduce food insecurity has become more prominent in news media discussions, perhaps

appealing to those wanting more systemic solutions and those who are environmentally conscious. The government's role in contributing to, as well as resolving, food insecurity in the UK was recognised by charities and members of the general public. Articles called for welfare reform and improved employment policies. Despite initial governmental denial, there was some recent government acceptance of responsibility. However, structural changes to address the drivers of food insecurity are still needed.

5 ETHNIC DIFFERENCES IN DIET AND SOCIOECONOMIC PATTERNING OF DIET

5.1 Abstract

Background/objectives Socioeconomic inequalities in diet quality are consistently reported, but few studies have investigated whether and how such inequalities vary across ethnic groups. This study aimed to examine differences in diet quality and socioeconomic patterning of diet quality across ethnic groups.

Subjects/methods Cross-sectional data from the HELIUS study were used. Dutch, South-Asian Surinamese, African Surinamese, Ghanaian, Turkish, and Moroccan adults (aged 18-70 years) were randomly sampled stratified by ethnicity. Dietary intake was estimated among a sub-sample (n=4602) from 200-item, ethnic-specific food frequency questionnaires, and diet quality assessed using the Dutch Healthy Diet Index 2015 (DHD15-Index). Wald tests were used to compare non-Dutch and Dutch participants, and first generation and second generation ethnic minority participants. Adjusted linear regression models were used to examine differences in DHD15-Index by three indicators of socioeconomic position: educational level, occupational status, and perceived financial difficulties. All analyses were stratified by sex.

Results Dutch participants had lower median DHD15-Index than most ethnic minority participants (P<0.0001). Second generation ethnic minority participants had lower median DHD15-Index than first generation ethnic minority participants (P<0.0001). Lower educational level was associated with lower DHD15-Index among Dutch men (P_{trend}<0.0001), South-Asian Surinamese men (P_{trend}=0.01), Dutch women (P_{trend}=0.0001), African Surinamese women (P_{trend}=0.002), and Moroccan women (P_{trend}=0.04). Lower occupational status was associated with lower DHD15-Index in Dutch men, β -7.8 (95% CI -11.7, -3.9) and all women (β -4.4 to -8.8), except Turkish women. DHD15-Index was not associated with perceived financial difficulties in most groups.

Conclusions We observed variations in diet quality across ethnic groups. Low socioeconomic position was not consistently associated with poor diet quality in all ethnic groups. This may be due to ethnicity-specific retention of traditional diets, irrespective of socioeconomic position.

5.2 Introduction

Poor diet is a major risk factor for poor health, and dietary risk is not evenly distributed within populations.[38] Socioeconomic gradients in diet quality have been well documented in high-income countries, but much of the data used have poor representation of ethnic minority groups.[310,311] Prevalence of disease is often higher in ethnic minority groups, and socioeconomic position is on average lower,[312] so poorer diet quality among these groups may be expected. Dietary patterns and dietary behaviours differ between ethnic groups,[80,313] which could contribute to ethnic differences in diet quality, and could also modify the relationship between socioeconomic position and diet.[79] These relationships warrant further study, as interventions and policies aiming to improve population diet quality and reduce dietary inequalities should take subgroup differences into consideration.

This study aimed to explore ethnic and socioeconomic inequalities in diet quality across five ethnic groups. First, we examined ethnic differences in the Dutch Healthy Diet Index score 2015 (DHD15-Index), which reflects adherence to the latest Dutch dietary recommendations.[314] We then explored differences in the socioeconomic patterning of diet quality across ethnic groups by examining associations between DHD15-Index and three markers of socioeconomic position: educational level, occupational status, and perceived financial difficulties.

5.3 Methods

5.3.1 Data source and study participants

Participants were from the Healthy Life in an Urban Setting (HELIUS) study, a large cohort of adults (aged 18-70 years) residing in Amsterdam.[312] Participants were randomly sampled, stratified by ethnicity (Dutch, Surinamese, Turkish, Moroccan, and Ghanaian).[198,312] Full details of the study, including response rates, are available elsewhere.[198,312,315] Our study used baseline data, collected between 2011 and 2015, on the subset of participants who completed an ethnic-specific food frequency questionnaire (FFQ) as part of the HELIUS Dietary Patterns study.[200,315] The semi-quantitative FFQs were developed for the HELIUS study, with approximately 200 food items selected based on their percentage contribution to, and variance in, nutrient intake.[200] This analysis did not include Ghanaian participants as dietary intake in this group was measured using an FFQ with a different structure.[316] Therefore, we included Dutch, Surinamese, Turkish, and Moroccan participants with complete FFQ data. Participants with incomplete socioeconomic position data were excluded (n=95). We further excluded 318 participants due to implausible energy intake using the Willett methods (<800 kcal/day and >4000 kcal/day for men, <500 kcal/day and >3500 kcal/day for women).[317]

The HELIUS study was approved by the Academic Medical Center Ethics Review Board. Written informed consent was obtained from all participants.

5.3.2 Ethnicity

The municipality register of Amsterdam contains data on country of birth of citizens and of their parents, thus allowing for sampling based on the country of birth indicator of ethnicity.[312] Participants were considered to be of non-Dutch ethnicity if they were born outside of the Netherlands with at least one parent born outside of the Netherlands (first generation), or born in the Netherlands with both parents born outside the Netherlands (second generation). After data collection, Surinamese participants were further classified according to self-reported ethnic origin (obtained by questionnaire) into: 'African' or 'South-Asian'. For the Dutch sample, the study invited people who were born in the Netherlands and whose parents were born in the Netherlands. Participants of this study were classified as: Dutch, South-Asian Surinamese, African Surinamese, Turkish, or Moroccan. Throughout this article, we refer to ethnicity irrespective of nationality.

5.3.3 Measuring socioeconomic position

5.3.3.1 Educational level

Participants were split into four categories based on self-reported highest educational attainment: (1) higher (higher vocational and university), (2) intermediate (intermediate vocational and higher secondary schooling), (3) lower (lower vocational and lower secondary schooling), and (4) elementary (never been to school and elementary schooling).

5.3.3.2 Occupational status

Occupational level was classified using the Dutch Standard Occupational Classification 2010 from self-reported occupation. In our analysis, we combined occupational level and employment status to give four categories of occupational status. Three ordinal categories were based on occupational level: (1) higher (scientific and higher occupations), (2) intermediate, and (3) lower (elementary and lower occupations). Individuals receiving long-term welfare or seeking employment were also included in the 'lower' category. Those with an employment status of 'unknown/not in workforce' and no occupational level data were placed in a fourth heterogeneous category.

5.3.3.3 Perceived financial difficulties

Participants were asked: "During the past year, did you have problems managing your household income?" Four response options were given: "No, no problem at all", "No problems, but I have to watch what I spend", "Yes, some problems", and "Yes, lots of problems". In our analysis, we combined the "Yes" categories.

5.3.4 Measuring adherence to dietary recommendations and DHD15-Index

Using estimated daily intakes derived from FFQ data and following the methodology described by Looman *et al*,[314] we calculated DHD15-Index for each participant based on adherence to 13 of the 15 Dutch dietary guidelines: vegetables, fruit, wholegrains, legumes, nuts and seeds, dairy, fish, tea, cooking fats and oils, red meat, processed meat, sugar-sweetened beverages (SSBs) and fruit juices, and alcohol (see **Supplementary Table D1**). Each dietary component was scored between 0 and 10, and the DHD15-Index was a sum of all 13 components, giving a DHD15-Index between 0 and 130. A higher score indicated better diet quality. We were unable to assess compliance with the coffee and salt guidelines due to lack of data.

5.3.5 Covariates

Covariates associated with diet quality and/or reporting of dietary intake, and that varied across ethnic groups were included in our regression models. The fully adjusted models included potential confounders: age (continuous), marital status (married/cohabiting or not), number of people in the household (continuous), smoking status (current smoker or not), physical activity level (international standard for physical activity[1] met or not), daily energy intake (continuous), and body mass index (continuous). All covariates were based on self-reported data from the HELIUS questionnaire, except for body mass index which was measured during a physical examination.

5.3.6 Statistical methods

To examine ethnic differences in diet quality, we calculated age-adjusted medians (lower quartiles, upper quartiles) for DHD15-Index and the individual dietary components for each ethnic group. Medians were used due to the skewness of the data and we adjusted for age due to differences in age distribution between the ethnic groups. For the ethnic minority groups, we also stratified the age-adjusted median DHD15-Index by migration generation. Wald tests were used to compare DHD15-Index distribution for the non-Dutch groups to the Dutch group, and for the first generation ethnic minority participants to the second generation ethnic minority participants. We used adjusted linear regression models to examine the association between socioeconomic position and DHD15-Index across ethnic groups. We built separate models to explore the associations according to three measures of socioeconomic position: educational level, occupational status, and perceived financial difficulties. We obtained *P* for trends by testing equality of means across the socioeconomic strata. A stepwise approach was used to explore the effect of different individual-level, household-level, and health-related variables (see **Supplementary Tables D2-D7**). We stratified all analyses by sex as diet quality and some dietary recommendations differ for men and women (see **Supplementary Table**

[1] Short Questionnaire to Assess Health Enhancing Physical Activity (SQUASH) standard: ≥30 minutes of moderate- or high-intensity activity per day on at least 5 days per week

D1).[3] Significance levels were set at a two-tailed *P*-value ≤0.05 for all tests. All analyses were conducted in Stata SE 15.

5.3.7 Sensitivity analyses

In order to understand the effect of one socioeconomic measure on another for diet quality, we ran regression models without mutual adjustment (presented in the main report) and then added other socioeconomic measures to our model individually (presented in **Supplementary Tables D8-D13**). Educational level and occupational status were moderately correlated (r=0.7) and perceived financial difficulties was weakly associated with educational level (r=0.3) and occupational status (r=0.3).

5.4 Results

5.4.1 Population characteristics

Overall, 4602 participants were included in this study (see **Table 5.1**). Dutch participants tended to have higher socioeconomic position compared to other ethnic groups, with higher educational attainment, higher occupational level, and a lower proportion of participants reporting financial difficulties. Most (82%) of the ethnic minority participants were first generation migrants, with the median time since migration and age at migration ranging from 28 years to 37 years and 18 years to 21 years, respectively, across the ethnic groups.

Table 5.1. Descriptive characteristics of study population

	Men					Women				
Characteristic	**Dutch** (*n*=633)	**South-Asian Surinamese** (*n*=395)	**African Surinamese** (*n*=298)	**Turkish** (*n*=273)	**Moroccan** (*n*=258)	**Dutch** (*n*=789)	**South-Asian Surinamese** (*n*=576)	**African Surinamese** (*n*=646)	**Turkish** (*n*=305)	**Moroccan** (*n*=429)
Age (years), median (LQ, UQ)	52 (40, 60)	49 (41, 58)	53 (46, 59)	45 (35, 51)	44 (35, 53)	49 (35, 59)	49 (41, 56)	51 (43, 57)	42 (32, 49)	39 (30, 49)
Educational level[a], n (%)										
Higher	390 (61.6)	117 (29.6)	69 (23.2)	60 (22.0)	58 (22.5)	492 (62.4)	136 (23.6)	205 (31.7)	65 (21.3)	81 (18.9)
Intermediate	141 (22.3)	111 (28.1)	91 (30.5)	77 (28.2)	84 (32.6)	162 (20.5)	164 (28.5)	234 (36.2)	94 (30.8)	145 (33.8)
Lower	88 (13.9)	120 (30.4)	124 (41.6)	84 (30.8)	59 (22.9)	119 (15.1)	199 (34.6)	186 (28.8)	56 (18.4)	76 (17.7)
Elementary	14 (2.2)	47 (11.9)	14 (4.7)	52 (19.1)	58 (22.5)	16 (2.0)	77 (13.4)	21 (3.3)	90 (29.5)	127 (29.6)
Occupational status[b], n (%)										
Higher	370 (58.5)	100 (25.3)	65 (21.8)	44 (16.2)	44 (17.1)	439 (55.6)	116 (20.1)	161 (24.9)	50 (16.4)	71 (16.6)
Intermediate	150 (23.7)	104 (26.3)	73 (24.5)	49 (18.0)	64 (24.8)	190 (24.1)	177 (30.7)	251 (38.9)	65 (21.3)	93 (21.7)
Lower	88 (13.9)	166 (42.0)	140 (47.0)	164 (60.1)	138 (53.5)	119 (15.1)	238 (41.3)	198 (30.7)	126 (41.3)	148 (34.5)
Unknown/not in workforce	25 (4.0)	25 (6.3)	20 (6.7)	16 (5.9)	12 (4.7)	41 (5.2)	45 (7.8)	36 (5.6)	64 (21.0)	117 (27.3)
Presence of financial difficulties, n (%)										
No	327 (51.7)	152 (38.5)	74 (24.8)	44 (16.1)	54 (20.9)	332 (42.1)	132 (22.9)	137 (21.2)	51 (16.7)	87 (20.3)
No, but watch spending	221 (34.9)	140 (35.4)	111 (37.3)	73 (26.7)	85 (33.0)	326 (41.3)	215 (37.3)	240 (37.2)	88 (28.9)	159 (37.1)
Yes	85 (13.4)	103 (26.1)	113 (37.9)	156 (57.1)	119 (46.1)	131 (16.6)	229 (39.8)	269 (41.6)	166 (54.4)	183 (42.7)
Migration generation, n (%)										
1st generation	N/A	330 (83.5)	264 (88.6)	214 (78.4)	204 (79.1)	N/A	486 (84.4)	569 (88.1)	232 (76.1)	301 (70.2)
2nd generation	N/A	65 (16.5)	34 (11.4)	59 (21.6)	54 (20.9)	N/A	90 (15.6)	77 (11.9)	73 (23.9)	128 (29.8)
Time since migration (years), median (LQ, UQ)	N/A	37 (31, 39)	35 (22, 39)	28 (23, 35)	30 (23, 36)	N/A	34 (24, 38)	31 (21, 38)	28 (23, 34)	29 (21, 35)
Age at migration (years), median (LQ, UQ)	N/A	18 (11, 23)	21 (15, 27)	18 (12, 24)	18 (11, 24)	N/A	19 (12, 25)	21 (14, 28)	18 (11, 22)	18 (8, 23)

	Men					Women				
Characteristic	**Dutch** (*n*=633)	**South-Asian Surinamese** (*n*=395)	**African Surinamese** (*n*=298)	**Turkish** (*n*=273)	**Moroccan** (*n*=258)	**Dutch** (*n*=789)	**South-Asian Surinamese** (*n*=576)	**African Surinamese** (*n*=646)	**Turkish** (*n*=305)	**Moroccan** (*n*=429)
Marital status, n (% married/cohabiting)	429 (67.8)	228 (57.7)	147 (49.3)	203 (74.4)	196 (76.0)	427 (54.1)	239 (41.5)	168 (26.0)	188 (61.6)	258 (60.1)
Number of people in household, median (LQ, UQ)	2 (1, 3)	2 (1, 4)	2 (1, 3)	3 (2, 4)	4 (2, 5)	2 (1, 3)	2 (1, 4)	2 (1, 3)	3 (2, 4)	4 (2, 5)
Current smoking status, n (% yes)	149 (23.5)	135 (34.2)	101 (33.9)	81 (29.7)	48 (18.6)	174 (22.1)	95 (16.5)	117 (18.1)	82 (26.9)	20 (4.7)
Physical activity norm met[c], n (% yes)	459 (72.5)	216 (54.7)	196 (65.8)	141 (51.7)	150 (58.1)	601 (76.2)	291 (50.5)	362 (56.0)	121 (39.7)	167 (38.9)
Energy intake (kcal), median (LQ, UQ)	2375 (2004, 2887)	2130 (1752, 2606)	2372 (1833, 2911)	2329 (1837, 2934)	2394 (1755, 3018)	1960 (1629, 2298)	1743 (1362, 2150)	1816 (1391, 2313)	1871 (1474, 2441)	1814 (1399, 2279)
BMI (kg/m^2), median (LQ, UQ)	24.8 (22.7, 27.4)	25.3 (23.1, 27.6)	26.3 (23.8, 28.8)	27.9 (25.2, 30.4)	26.8 (24.6, 29.4)	23.5 (21.5, 26.2)	26.5 (23.2, 29.8)	28.2 (24.9, 32.2)	27.2 (24.1, 32.0)	27.5 (23.8, 31.8)
Presence of chronic disease[d], n (% yes)	96 (15.2)	140 (35.4)	54 (18.1)	72 (26.4)	86 (33.3)	92 (11.7)	192 (33.3)	181 (28.0)	95 (31.2)	111 (25.9)

BMI, body mass index. LQ, lower quartile. N/A, not applicable. UQ, upper quartile.
[a]Higher=higher vocational schooling or university. Intermediate=intermediate vocational schooling or intermediate/higher secondary schooling. Lower=lower vocational schooling or lower secondary schooling. Elementary=never been to school or elementary schooling.
[b]Higher=higher grade professional occupations. Intermediate=Lower grade professional and routine non-manual occupations. Lower=skilled and unskilled manual occupations, and unemployed (seeking work or receiving social benefits). Unknown/not in workforce=unknown occupational level (employed but no occupation level data available) and not in workforce (retired, student, homemaker, or incapacitated to work).
[c]Met the Short Questionnaire to Assess Health-Enhancing Physical Activity (SQASH) international norm for physical activity (≥30 minutes of moderate- and high-intensity activity per day on at least 5 days per week)
[d]Presence of one or more chronic disease (diabetes, cardiovascular disease, myocardial infarction, or cancer)

5.4.2 DHD15-Index

The distribution of DHD15-Index varied by ethnicity, with Dutch and African Surinamese participants having the lowest age-adjusted median (P<0.0001) (see **Table 5.2**). Among the ethnic minority groups, first generation participants had higher DHD15-Index compared to second generation participants (see **Table 5.3**). This difference was statistically significant when tested with all four ethnic minority groups combine (P<0.0001), but not significant when stratified by ethnicity. The median DHD15-Index does appear higher among first generation participants compared to second generation participants in all ethnic minority groups, but the small number of second generation participants within our sample (n=580 across all ethnic groups) means that there was likely insufficient power to detect a difference when stratified by ethnicity. DHD15-Index did not change for first generation participants when additionally adjusted for time since migration.

Table 5.2. Age-adjusted median (lower quartile, upper quartile) DHD15-Index score by ethnicity and sex

	Dutch	South-Asian Surinamese	African Surinamese	Turkish	Moroccan	Pearson's F Statistic (P-value)
Overall	83.3 (71.5, 94.8)	87.0 (75.8, 98.0)	82.5 (71.7, 92.6)	88.5 (79.1, 97.5)	89.4 (79.2, 100.4)	18.10 (<0.0001)***
Men	78.6 (67.8, 90.2)	83.3 (72.3, 93.9)	77.4 (67.2, 88.6)	85.4 (76.8, 95.0)	87.5 (76.1, 97.9)	13.78 (<0.0001)***
Women	86.9 (76.0, 97.7)	90.4 (78.7, 100.4)	84.4 (73.4, 94.4)	90.8 (81.7, 98.5)	90.4 (80.8, 101.1)	10.19 (<0.0001)***

* P≤0.05, **P≤0.01, ***P≤0.001

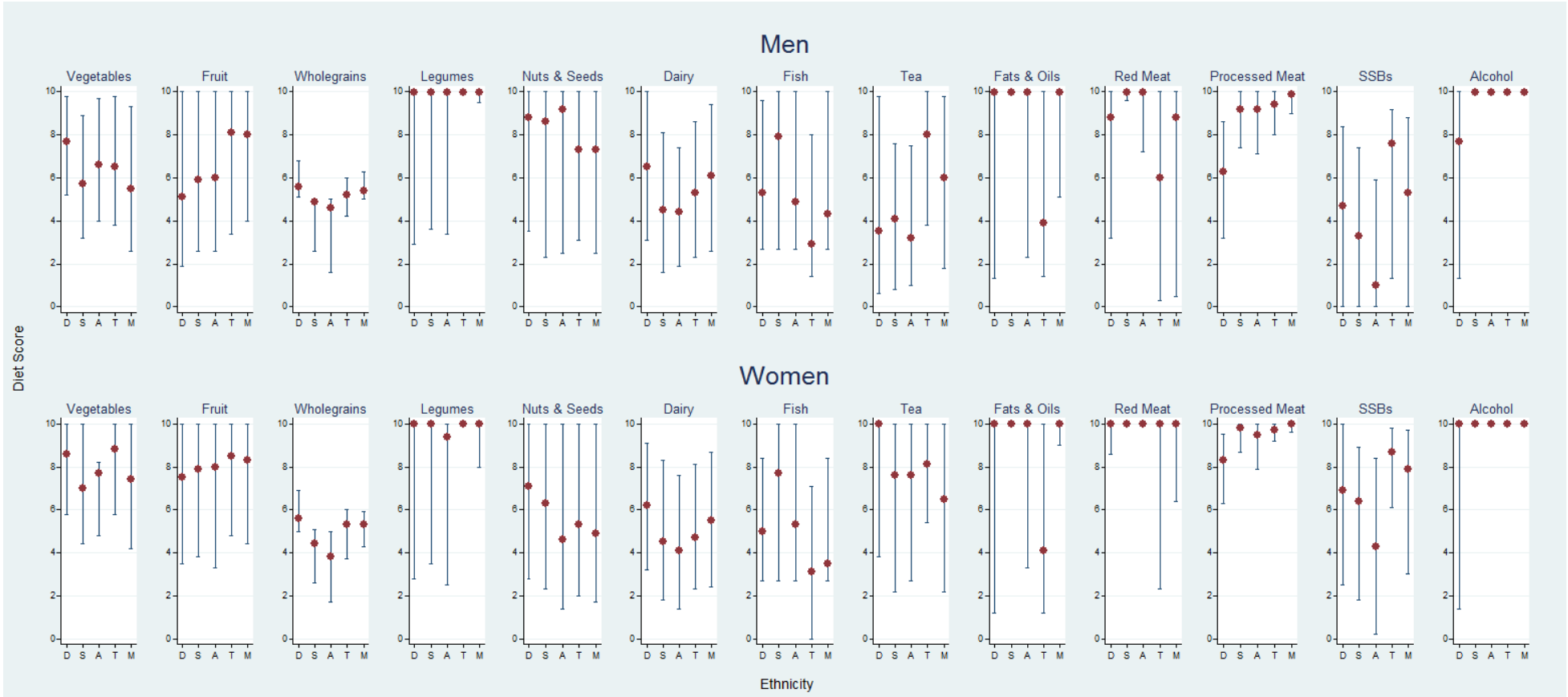
Figure 5.1 shows age-adjusted median (lower quartile, upper quartile) scores for individual dietary components. There were differences between the ethnic groups for all dietary components, except for nuts and seeds in men (see **Supplementary Table D14**) and fruit, legumes, red meat, and alcohol in women (see **Supplementary Table D15**). Dutch men had higher vegetable intake than men from other ethnic groups, but the lowest fruit intake. Adherence to the wholegrain and dairy recommendations was moderately low in all ethnic groups, but highest among Dutch participants. Fish intake was low-to-moderate overall, with South-Asian Surinamese scoring highest. All ethnic groups had a healthy ratio of liquid/soft fats to solid fats used in cooking, except for Turkish participants. Turkish men scored particularly poorly for red meat, whilst Dutch participants scored the worst for processed meat. Scores for SSBs and fruit juice were especially poor among African Surinamese participants. All groups scored highly for alcohol, but variation in scores was high in Dutch participants and scores lowest among Dutch men.

Table 5.3. Age-adjusted median (lower quartile, upper quartile) DHD15-Index score by ethnicity and migration generation

		Ethnic minorities combined	South-Asian Surinamese	African Surinamese	Turkish	Moroccan	Pearson's F Statistic (*P*-value)
1st generation	Model 1	87.6 (75.7, 97.6)	88.3 (77.2, 98.6)	83.2 (72.3, 92.9)	90.2 (81.0, 98.6)	91.6 (81.3, 101.8)	20.15 (<0.0001)
	Model 2	87.4 (77.0, 97.1)	88.3 (76.9, 98.7)	83.3 (72.7, 92.8)	89.5 (80.6, 98.4)	91.1 (81.4. 100.6)	12.16 (<0.0001)
2nd generation		82.9 (73.2, 94.1)	79.8 (69.6, 92.5)	75.3 (64.8, 88.4)	81.9 (72.5, 91.8)	83.3 (71.3, 94.9)	3.53 (0.01)
Pearson's F Statistic (*P*-value)[a]		20.44 (<0.0001)	0.00 (0.96)	0.74 (0.39)	0.15 (0.70)	0.14 (0.71)	

Model 1 adjusted for age. Model 2 adjusted for age and time since migration (years).
[a]Test comparing 1st generation (Model 1) to 2nd generation
* P≤0.05, **P≤0.01, ***P≤0.001

Figure 5.1. Age-adjusted median (lower quartile, upper quartile) DHD15-Index for individual food group components by ethnicity and sex



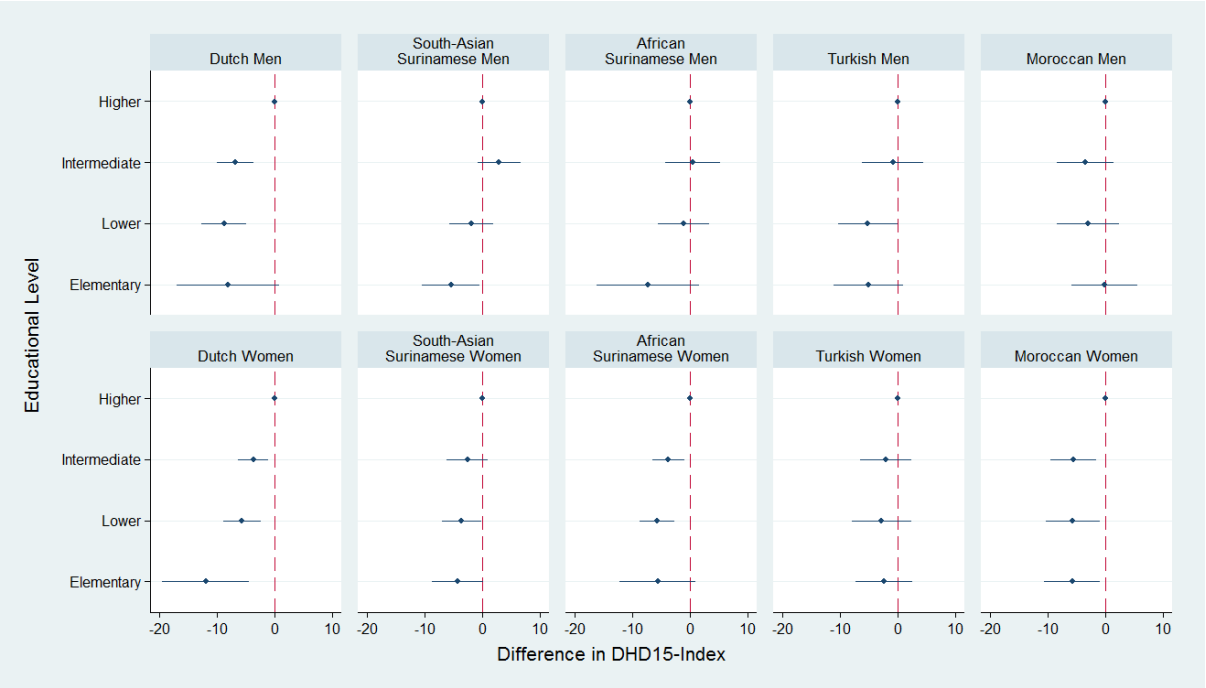
SSBs, sugar-sweetened beverages. D, Dutch. S, South-Asian Surinamese. A, African Surinamese. T, Turkish. M, Moroccan.

5.4.3 Socioeconomic inequalities in DHD15-Index

5.4.3.1 Educational level

Figure 5.2 shows the beta-coefficients (95% CIs) for the fully adjusted linear regression models (model 4) examining associations between educational level and DHD15-Index, stratified by ethnicity and sex (see **Supplementary Tables D2** and **D3** for further details, including the stepwise models).

Figure 5.2. Differences in DHD15-Index by educational level, stratified by ethnicity and sex



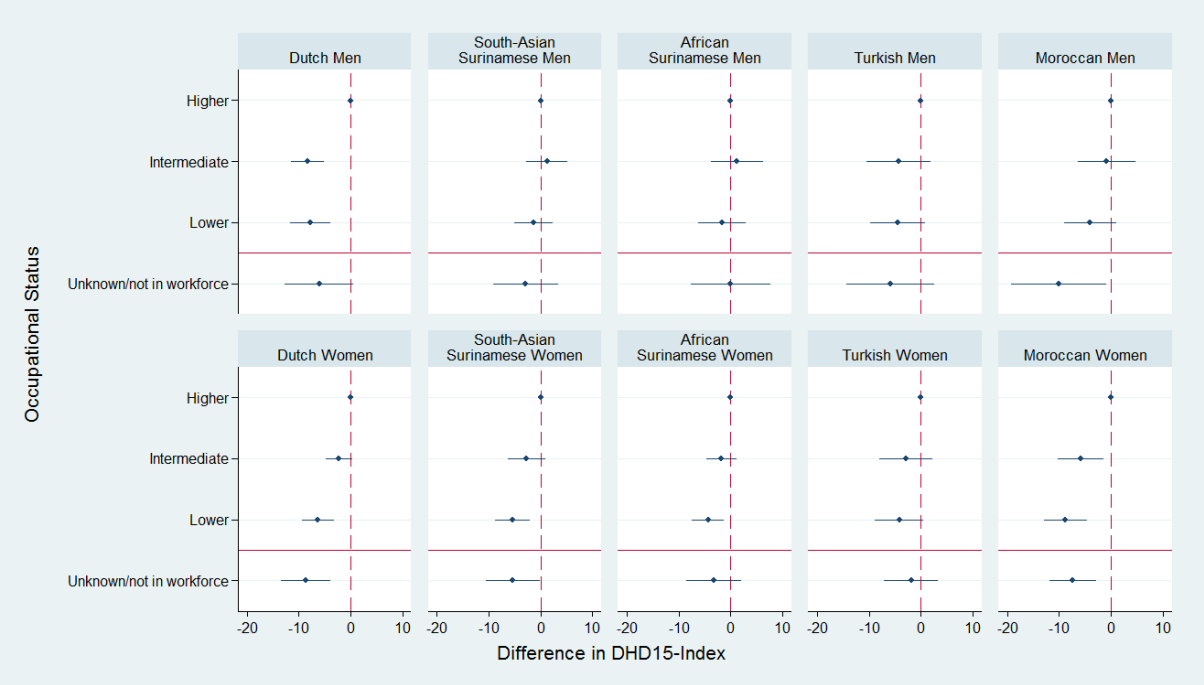
Reference group: higher educational level. Regression models adjusted for age, marital status, number of people in the household, smoking status, meeting of physical activity recommendation, energy intake, presence of one or more chronic disease, and body mass index.

An educational gradient in DHD15-Index was observed among Dutch men, with those less educated having a lower DHD15-Index (P_{trend}<0.0001). South-Asian Surinamese men with elementary education had lower DHD15-Index than those with higher education (P_{trend}=0.01). No educational differences were observed in men from other ethnic groups. Lower educational level was associated with lower DHD15-Index among Dutch women (P_{trend}=0.0001). African Surinamese women with lower and intermediate educational level had lower DHD15-Index compared to those with higher educational level (P_{trend}=0.002). Moroccan women in all educational groups had lower DHD15-Index compared to the higher educational level group (P_{trend}=0.04). No educational differences in DHD15-Index were observed for South-Asian Surinamese or Turkish women.

5.4.3.2 Occupational status

Figure 5.3 shows results of the fully adjusted linear regression models examining associations between occupational status and DHD15-Index (further information in **Supplementary Tables D4** and **D5**).

Figure 5.3. Differences in DHD15-Index by occupational status, stratified by ethnicity and sex



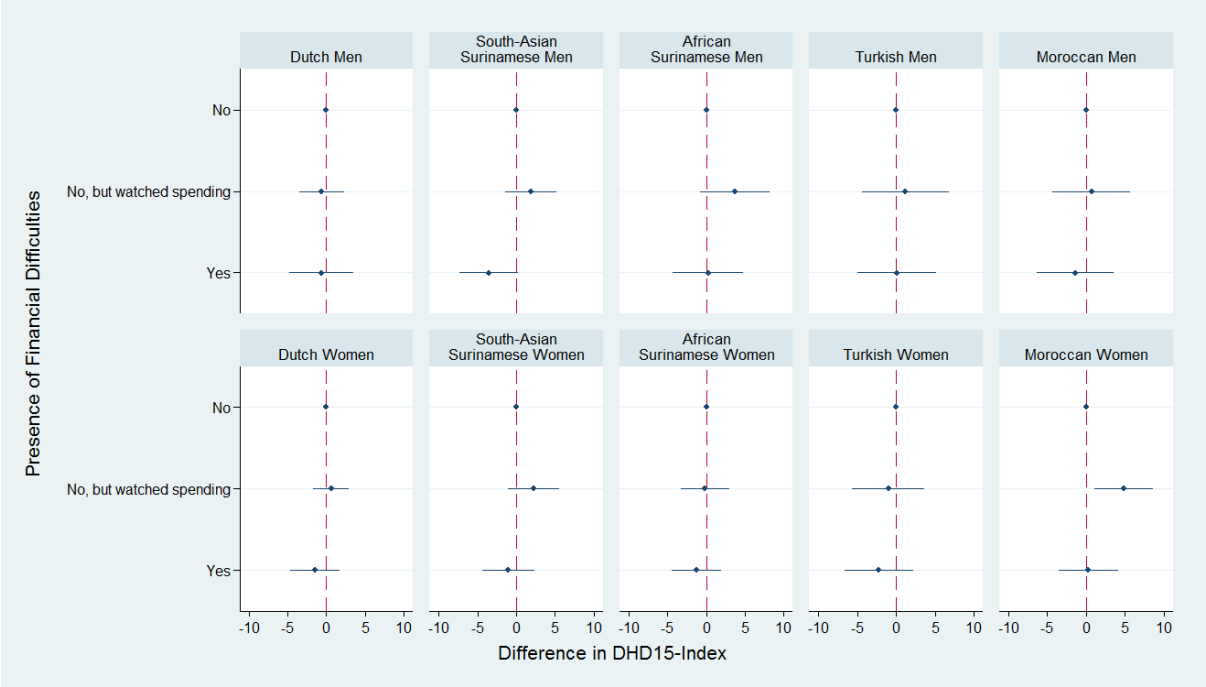
Reference group: higher occupational level. Ordinal occupational levels above the red line, unknown/not in workforce group below the red line. Regression models adjusted for age, marital status, number of people in the household, smoking status, meeting of physical activity recommendation, energy intake, presence of one or more chronic disease, and body mass index.

Dutch men with intermediate and elementary occupations had lower DHD15-Index than those with higher occupational status (P_{trend}<0.0001). No occupational differences were seen among men from other ethnic groups, but those in the unknown/not in workforce group had lower DHD15-Index compared to those with higher occupation status among Moroccan men. Women with elementary level occupations had lower DHD15-Index than those with higher level occupations among Dutch (P_{trend}<0.0001), South-Asian Surinamese (P_{trend}=0.01), African Surinamese (P_{trend}=0.04), and Moroccan (P_{trend}=0.001) participants. No association was observed in Turkish women.

5.4.3.3 Perceived financial difficulties

Figure 5.4 presents the results of the fully adjusted linear regression models examining associations between perceived financial difficulties and DHD15-Index (more details in **Supplementary Tables D6** and **D7**).

Figure 5.4. Differences in DHD15-Index by perceived financial difficulties, stratified by ethnicity and sex



Reference group: no financial difficulties. Regression models adjusted for age, marital status, number of people in the household, smoking status, meeting of physical activity recommendation, energy intake, presence of one or more chronic disease, and body mass index.

No differences in DHD15-Index were observed in men by perceived financial difficulties in any of the ethnic groups. For women, Moroccan participants who reported that they did not have financial difficulties but did watch their spending had a higher DHD15-Index than those who reported no financial difficulties at all (P_{trend}=0.01).

5.4.4 Sensitivity analyses

In our sensitivity analyses, we mutually adjusted our regression models for socioeconomic measures (see **Supplementary Tables D8-D13**). In general, similar trends were observed, however, most associations were attenuated. Educational differences in DHD15-Index remained for Dutch men and African Surinamese women only. This suggests that the association between educational level and diet quality in the other groups may have been largely through occupational status. Occupational differences in DHD15-Index reduced for most groups once educational level was adjusted for, which could be partly mediating this relationship. However, occupational differences in DHD15-Index remained significant for Dutch men, South-Asian Surinamese women, and Moroccan women.

5.5 Discussion

We found ethnic differences in diet quality, operationalised as the DHD15-Index, with most ethnic groups having higher diet quality than the Dutch. Ethnic differences were observed for the intake of most food groups, thus variation in diet quality was not driven by any specific food group. First generation ethnic minority participants had better diet

quality compared to second generation ethnic minority participants. Educational differences in DHD15-Index were clearest among Dutch participants, and also observed in South-Asian Surinamese men, African Surinamese women, and Moroccan women. Occupational differences in diet quality were seen among Dutch men and in most ethnic groups for women. These differences, as expected, favoured those of higher socioeconomic position. Differences in DHD15-Index by perceived financial difficulties were not seen in most groups.

5.5.1 Strengths and limitations

The HELIUS study provided large samples of five ethnic groups, with dietary data through ethnic-specific FFQs and details of socioeconomic position through three proxy measures: educational level, occupational status, and perceived financial difficulties. This offered a rare opportunity to explore diet quality across ethnic groups and in relation to a variety of measures of socioeconomic position. FFQs are one of the best ways of capturing habitual dietary intake in ethnically diverse populations.[200] However, as with all self-reported data, FFQs are subject to social desirability bias. FFQs also yield higher DHD15-Index compared to 24-hour recalls, therefore absolute DHD15-Index may be inflated.[314] DHD15-Index is associated with body mass index and all-cause mortality,[314,318] but further research is needed to explore whether there are ethnic differences in these associations.

Our observations may be relevant to other contexts with similar ethnic groups, however, the specificities of the Dutch migration history may limit generalisability of the findings. Nonetheless, ethnic differences in diet quality have been reported elsewhere, although most studies are from the United States and find that ethnic minority groups have poorer diet quality than the ethnic majority group.[82,319] The educational gradient and occupational differences in diet quality observed in some groups in this study are consistent with many previous studies.[178,320] To our knowledge, few studies have compared the association between socioeconomic position and diet quality across ethnic groups. Those that have, found socioeconomic and ethnic inequalities in diet independently, and interaction between the two variables.[79,203,321]

5.5.2 Interpretation of findings and implications for policy

Lower overall socioeconomic position was seen among ethnic minority groups compared to the Dutch group. However, most ethnic minority groups had higher DHD15-Index than the Dutch group. Socioeconomic gradients in diet quality were also not seen in all ethnic groups. This could suggest resilience to the negative consequence of lower educational level and occupational status for diet quality amongst these groups. Further understanding this relationship could help to improve diet quality in whole populations. Factors associated with diet in ethnic minority groups can be clustered into seven themes: migration context; social and cultural environment; food beliefs and

perceptions; accessibility of food; the body; psychosocial; and social and material resources.[85] These likely impact on differences in overall diet quality between ethnic groups, and could also explain differences in socioeconomic patterning of diet quality between ethnic groups.

As populations around the world become more ethnically diverse, it is important to recognise that many dietary patterns can be supportive of good diet quality, and dietary public health should value traditional food cultures and variation in dietary habits. Global trends of urbanisation and economic growth are linked to nutritional and epidemiological transitions, and increased prevalence of non-communicable diseases.[322] For migrants, dietary acculturation whereby migrant populations adopt dietary habits of their host country over time, may also worsen diet quality and health outcomes.[323] The better diet quality among first generation ethnic minority participants compared to second generation ethnic minority participants in our sample suggests that diet quality may be deteriorating due to dietary acculturation. Eighty-two percent of the ethnic minority participants in our study were first generation immigrants. Retention of elements of traditional diets could explain better diet quality among migrants compared to Dutch participants, assuming that the Western diet is less healthy.[324] This could also explain inconsistent socioeconomic patterning of diet quality among ethnic minority groups if components of the traditional diets are retained as a way of expressing cultural identity, regardless of socioeconomic position.[313] Cultural expectation of hospitality,[84] and the food preferences of family and friends, especially in collectivist cultures, may also prevent or slow shifts in dietary habits from the traditional diet. Alternatively, the lack of association seen could be due to the proxy measures of socioeconomic position requiring different interpretations depending on ethnicity, as the same objective educational level could be associated with different social and environmental contexts and job prospects for different ethnic groups.

Whilst DHD15-Index focuses on diet quality as a whole, we saw that scores for individual components varied substantially across ethnic groups too. This suggests that the dietary components that need most attention differ by ethnicity, and this knowledge could be useful in developing dietary interventions and tailoring dietary advice. Consistent with the notion of the Western diet,[324] we found higher processed meat and alcohol intake, and lower fruit intake (significant only in men) among Dutch participants, but more favourable intakes of dairy and wholegrains compared to the other ethnic groups. Turkish participants scored substantially worse for cooking oils and fats compared to other ethnic groups, and African Surinamese participants scored particularly poorly for SSBs and fruit juice. On the other hand, guidelines were well met for some dietary components. For example, the median score was 10 out of 10 for legumes, cooking fats and oils, and alcohol for most groups.

In our study, perceived financial difficulties was not associated with diet quality for most groups. This was an unexpected finding as previous studies have shown an association between diet cost and diet quality.[69,72] There could be various explanations for the lack of association in our analysis. The question used may have been a poor measure of financial difficulties. The only significant difference in diet was between those reporting that they had no financial difficulties but were careful with spending and those with no financial difficulties at all. This could be because participants who were careful with finances were also more likely to be careful with other aspects of their lives, including diet, and the two groups may not have differed in terms of financial resources. Furthermore, short-term financial difficulty could be a poor measure of socioeconomic position, with educational level and occupational status potentially providing more stable and long-term proxies.[203] The presence of educational and occupational, but not financial, differences in diet quality may also suggest that the mechanism driving socioeconomic differences in diet quality is psychosocial rather than material. Alternatively, diet cost may not be a barrier to good diet quality among Amsterdam residents, perhaps due to low food costs, a healthy food environment, and/or good support for those who are financially struggling to meet their dietary needs.[73]

5.5.3 Conclusions

Diet quality varied across ethnic groups, with better diet quality in most ethnic minority groups compared to the majority ethnic group. Nonetheless, diet quality was suboptimal in all groups and improvement of diet should remain a public health priority for the whole population. Low socioeconomic position was only associated with poorer diet quality in some ethnic groups, indicating that socioeconomic deprivation is not a universal indicator of poor diet quality. Similarities in diet quality across the socioeconomic spectrum in some groups may be due to retention of elements of traditional diets irrespective of socioeconomic position. Future dietary interventions should consider the role of culture and tradition in maintaining dietary habits.

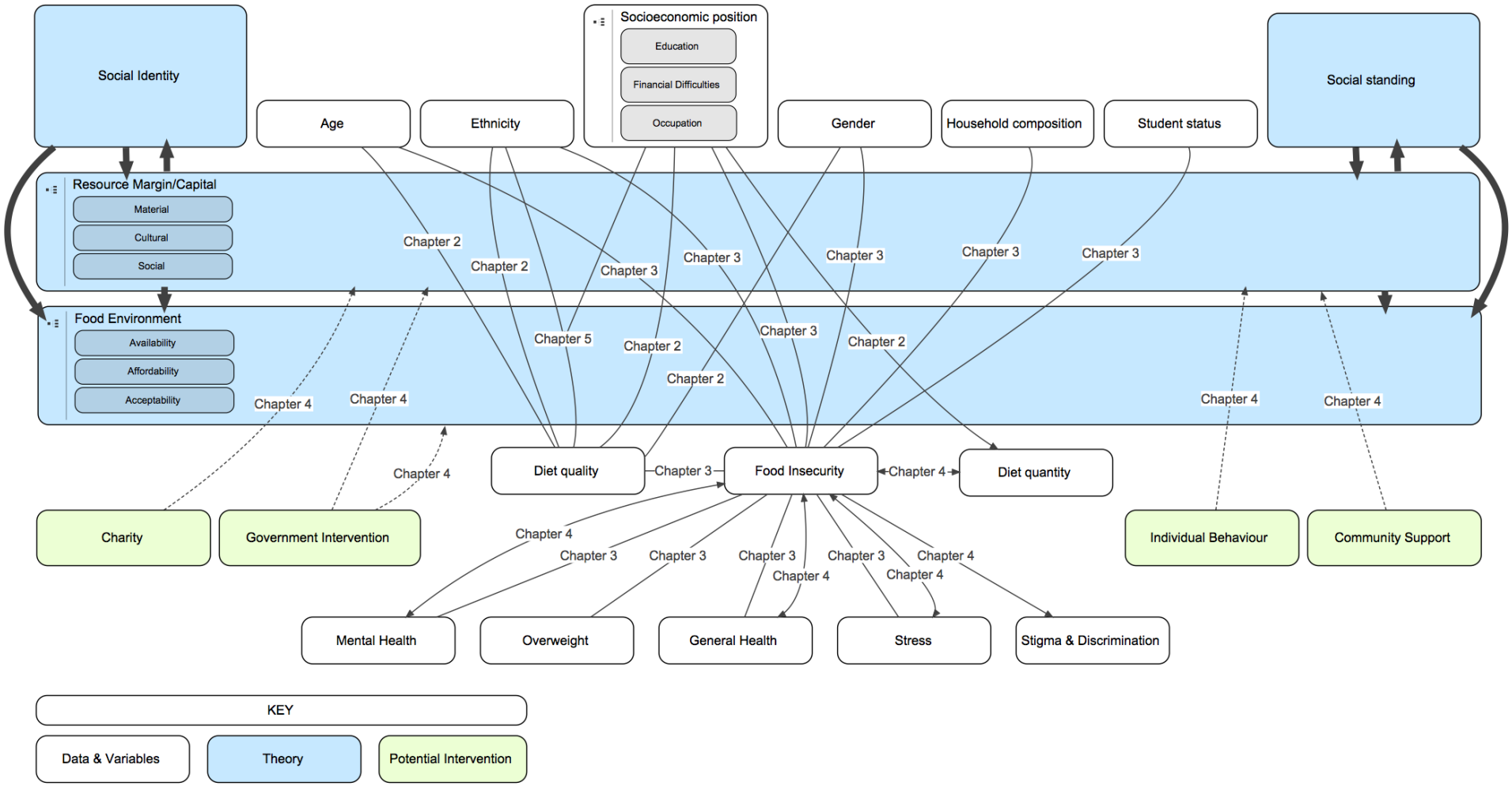
6 DISCUSSION

6.1 Summary of key findings

This dissertation addresses key research questions related to social inequalities in diet, contributing new findings to the scientific literature using quantitative and qualitative research methods. These observations identified key groups with poor diet quality and provide support for material, social, and environmental explanations of diet and health inequalities. Evidence on the mechanisms by which diet inequalities manifest, and identification of high-risk groups, could help to inform interventions that aim to reduce diet inequalities and ultimately health inequalities, which policy documents have cited as a priority in the UK and globally.

My research broadly fits into a framework where social identity and social standing influence the resources people have (and resources may also reinforce people's social identity and social standing). These resources influence how people interact with their food environment, and influence the food environment people are exposed to. This in turn affects people's diet and health outcomes. **Figure 6.1** illustrates how chapters of my dissertation fit together alongside this theoretical framework (shown in blue). Social identity and social standing are operationalised as sociodemographic characteristics that influence the way people interact with their food environment both directly and indirectly through the levels of resources and capital available; resources/capital also influence social identity and social standing, and may reinforce these associations. The data and variables I used within my dissertation are shown in white, with lines indicating where associations were found. Where the data suggested a direction of association, this is shown with arrows. Interventions, suggested within news articles presented in Chapter 4, to reduce diet inequalities and food insecurity are shown in green. These interventions could potentially impact on the resources people have, and governmental intervention could potentially impact on the food environment as well through policies and regulations. The suggested interventions are linked to the theoretical framework to show where the interventions could act (dotted lines).

Figure 6.1. Conceptual map of studies contained within this dissertation and theoretical framework



Chapter 2 tracked how social inequalities in diet have changed over time in the UK. This work illustrated that most of the diet inequalities seen in 2012 had been present since the first national nutrition survey conducted in 1986. Adherence to all dietary recommendations studied improved over time for most population subgroups, but adherence to the recommendations for fruit and vegetables and oily fish remain very poor, with only around 20% of the population meeting either of these recommendations. Improvement in meeting the salt recommendation was the most noticeable, and there were reductions in gender, socioeconomic, and ethnic inequalities in meeting the salt recommendation. The simultaneous population-wide improvement and reduction in social inequalities in salt intake is likely to be associated with the UK Salt Reduction Programme, which led to widespread industry reformulation.[245] Daily energy intake decreased over time, but the continual rise in obesity prevalence suggests that energy intake remained too high relative to energy expenditure and that perhaps under-reporting of food intake increased over time.[237,239]

Chapter 3 estimated the prevalence of food insecurity among UK adults, aged 18 to 64 years, at 24% in 2017. This prevalence is higher than previously estimated.[251] Food insecurity was associated with all self-reported markers of poor diet and health included in this study, with the strongest associations observed with poor mental health and high stress. This work also identified population subgroups that are most in need of interventions to prevent food insecurity. Food insecurity was around 20 times more likely in those who reported having difficulty making ends meet compared to those who reported that making ends meet was easy. Food insecurity was also more prevalent among students, individuals living with children (especially in single-parent households), and in some ethnic minority groups compared to their peers.

Chapter 4 demonstrated the news media interest in food insecurity in the UK, especially from politically left-leaning and centralist newspapers. Reporting was more prevalent in the summer, when 'holiday hunger' was a major theme, and in the lead up to Christmas, when charity was encouraged. News media discussions of food insecurity were often reactive to an event or report, and were dominated by articles on food bank usage. The Trussell Trust was prominent within news media discussions, advocating for solutions to food insecurity and reporting on the prevalence of food bank usage. The redistribution of 'food waste' was another commonly reported charity-based solution over our study period, 2016 to 2019. The general public was portrayed as supportive of solutions to food insecurity within news articles, actively supporting charity initiatives and calling for government action to reform welfare support and employment policies in order to address poverty and wealth inequality, which were perceived as the root causes of food insecurity.

Chapter 5 showed that socioeconomic patterning of diet quality is not always uniform across different ethnic groups. In a multi-ethnic cohort of Amsterdam residents, the relationship between socioeconomic position and diet quality was strongest among the Dutch ethnic majority and was less consistent among ethnic minority groups. Diet quality was also higher, on average, in ethnic minority groups compared to the ethnic majority, despite lower socioeconomic position among the ethnic minority groups. This may be due to cultural factors protecting against the negative effect of low socioeconomic position on diet quality in ethnic minority groups. Retention of some elements of dietary habits from the ethnic minority group's traditional culture could be beneficial to health in ethnic minority groups residing in Western countries. Poorer diet quality was observed among second generation ethnic minority participants compared to first generation ethnic minority participants, pointing to a deterioration of diet quality due to dietary acculturation over generations.

Together, the research in this dissertation highlights how suboptimal population diet and social inequalities in diet have persisted, despite improving population diet and reducing health inequalities being identified as governmental priorities. Inequalities in diet were seen throughout this dissertation, according to education, occupation, gender, age, and ethnicity. Diet quality tended to be better among those with higher educational level compared to lower education level, higher occupational level compared to lower occupation level, women compared to men, older adults compared to younger adults, and ethnic minority groups compared to the ethnic majority group in the UK and the Netherlands. The associations were sometimes stronger in some population subgroups compared to others, indicating a multiplicative effect of some influences, and highlighting a need to consider multiple dimensions when exploring the influence of social characteristics on diet and health outcomes. For example, in Chapter 3, food insecure individuals were found to have poorer diet and health outcomes, and this was more pronounced among older adults compared to younger adults, despite younger adults being more likely to be food insecure than older adults. These findings support a unified explanation of diet inequalities, where several competing, or multiplicative, factors influence people's ability to navigate their food environments and achieve a healthy diet, including their financial, social, cultural resources.

6.2 Strengths and limitations of the research

My research focused on ethnic minority and low socioeconomic groups, especially those experiencing food insecurity, conducting studies of groups previously under-researched in dietary public health. My research utilised large datasets, containing robust data that were able to answer my research questions. Chapter 2 used the best nutritional surveillance data available at the national level within the UK. Extensive dietary data for large ethnic minority samples are uncommon. Chapter 5 utilised a dataset with rich data

on diet, socioeconomic position, and culture to explore ethnic and socioeconomic differences in diet quality.

Chapter 2 and 3 provide a UK-specific picture of diet inequalities and food insecurity using nationwide samples of UK adults. Although similar studies have been conducted elsewhere, mainly in the US and Canada, these studies were important to conduct in the UK for academic and policy purposes. Associations may differ from country to country, due to differences in the social and physical environment and economic context.[127,262] Policymakers likely place more importance on evidence from their own settings. This is especially crucial in relation to food insecurity, where I showed that policymakers denied the existence of food insecurity in the UK and their responsibility in alleviating the problem in Chapter 4.

Chapter 4 updated previous work exploring news media coverage of food insecurity in the UK,[196,197] at a time when food bank use is rising,[267] and food insecurity prevalence is high (see Chapter 3). News media coverage is indicative of the social acceptability of policy interventions, as it provides insight into the public and political knowledge and attitude. By using quantitative and qualitative methods within this dissertation, I was able to answer a breadth of questions related to food insecurity and diet inequalities – quantifying the problem of food insecurity using a nationwide sample and qualitatively exploring the wider drivers and consequences of food insecurity.

Chapter 5 highlights that socioeconomic inequalities in diet are not inevitable and can be diminished. Accumulation of comparable evidence across several countries may help to identify key factors that drive associations by revealing cross-country differences and similarities, which would advance epidemiological understanding of dietary public health and diet inequalities. These mechanisms could then potentially be targeted with interventions.

6.2.1 Methodological considerations

The methodological considerations for each chapter are presented within the chapters themselves. Here, I discuss the overarching considerations.

6.2.1.1 Social desirability bias

Most of the data used in this dissertation were self-reported and may be subject to social desirability bias. This may be a particularly pertinent consideration in this dissertation, as studies have found ethnic differences in response patterns to questionnaires,[283] and differing levels of social desirability according to sex and age.[325,326] Topics perceived as stigmatising, such as food insecurity and poverty,[193,194] may also be more prone to socially desirable responses. However, if social desirability did influence disclosure of food insecurity, we would expect to have underestimated the prevalence of food insecurity. Therefore, food insecurity would be a common and detrimental problem that needs

urgent addressing regardless. Furthermore, there are some variables where self-reporting was important. As I was interested in the experience of food insecurity and ethnic identity, self-report was the most appropriate method to obtain these data.

6.2.1.2 Under-representation and selection bias

Ethnic minority and low socioeconomic groups are less likely to participate in surveys and are under-represented in public health research,[327] which may have resulted in some ethnic differences not being detected due to small sample sizes. Furthermore, those who do participate may not be representative of that ethnic group. For example, language difficulty may a barrier to participating in research.[328] Therefore, ethnic minority participants included in research may have less difficulty with the language of the host country compared to those who decline to take part. However, some ethnic inequalities in diet were detected despite low representation of ethnic minority participants in Chapter 2. Ethnic minority representation was less than 10% across all survey years, but ethnic inequalities in meeting three of four dietary recommendations were observed despite low statistical power to detect differences. The use of a large multi-ethnic sample in Chapter 5 meant that ethnic inequalities in diet could be investigated with good statistical power. Furthermore, the HELIUS questionnaire was developed in multiple languages, and participants who had difficulty with filling in the questionnaire were offered an interview with a trained, same-sex interviewer who spoke the participant's preferred language.[312] This likely helped to retain those with language difficulty.

6.2.1.3 Assessment of diet

Dietary data used in this dissertation all relied on self-reported dietary intake through diet diary records or food frequency questionnaires. These methods are prone to misreporting, however, they provide a feasible and cost-effective measure of dietary intake at the population-level.[329] The associated strengths and limitations of these methods are commonplace within dietary public health, as these are common tools used to assess dietary intake. There is evidence that people under-report dietary intake.[240] When assessing dietary intake against dietary recommendations, under-reporting may underestimate adherence to recommendation for foods we should increase our intake of, such as fruit and vegetables. Conversely, under-reporting of food intake may overestimate adherence to recommendations for foods we should decrease our intake of, such as red and processed meat. We must also consider that under-reporting may not be uniform across food groups, meals, or population subgroups. This could have led to biases in our estimations of food intake, and potentially differences in accuracy across population subgroups. One study found that snacks, condiments, and beverages were more likely to be under-reported, as were foods eaten as afternoon snacks.[240] Food frequency questionnaires were found to underestimate vegetable intake, but not fruit intake.[330] This may be because vegetables are often incorporated into dishes and more likely to be forgotten during recall, compared to fruits that are often eaten individually. A

systematic review found that under-reporting of energy intake was more likely in overweight participants, compared to non-overweight participants, especially among women.[331] Under-reporting of energy intake has also been found to be associated with older age and lower education, and was more common among non-Hispanic black participants compared to non-Hispanic white participants in the US.[332]

Adherence to dietary recommendations may have been inflated due to social desirability, and misreporting may have increased over time due to public health messaging, which has made people more aware of the socially desirable response. However, over the study period of Chapter 2, there were large scale public information campaigns to increase fruit and vegetable intake and to reduce salt intake in the UK. Substantial and sustained improvements were observed for salt intake, where messaging was accompanied by industry reformulation,[244] but not for fruit and vegetables, where there was a public information campaign only.[247] This suggests that increased awareness due to public messaging was not the only contributor to better reported adherence to recommendations.

Dietary intake was assessed against national dietary recommendations in Chapters 2 and 5. The UK dietary recommendations are set and revised by the Scientific Advisory Committee on Nutrition and the Dutch guidelines by the Health Council of the Netherlands.[42,43,333–335] Better diet quality, as measured by a higher DHD15-Index (a composite measure based on the Dutch guidelines), is associated with lower relative risk of all-cause mortality.[318] In the absence of more detailed measures of diet quality, frequency of fruit and vegetable intake was used as a proxy measure of diet quality in Chapter 3. Low fruit and vegetable intake is one of the dietary risks most strongly associated with health.[38] High salt intake is another dietary risk that has one of the largest effects on population health, and was included in my analysis in Chapter 2, but not in Chapter 5 due to lack of data. However, measurement of salt intake can be inaccurate and the use of estimated salt intake from dietary records may have led to under-estimation of salt intake.[336,337]

An alternative way to measure dietary intake would be to use objective measures, such as nutritional biomarkers, which are biological indicators of nutritional status.[338] However, the invasiveness and expense of these methods for dietary assessment means that these methods are less commonly used and when used, are usually only performed in a subset of the study sample. Biomarkers are available in DNSBA and NDNS, and therefore, future studies could investigate the evolution of diet inequalities in the UK using such measures. However, biomarkers tell us limited information about the food sources, and capture metabolites rather than consumption, so may be influenced by factors such as genetic variability, smoking status, or nutrient-nutrient interactions, resulting in a skewed biomarker measure of dietary intake.[339] Biomarkers are also not

available for all nutrients of interest and may not represent usual intake due to the short half-life of some metabolites.[338,340] Therefore, there is no method of dietary assessment that is completely accurate, but the limitations of the method used should be considered when interpreting findings and analyses using various methods for comparison may be useful.

6.2.1.4 Assessment of socioeconomic position

Different self-reported, individual-level proxy measures of socioeconomic position were used in this dissertation. Where possible, I tested my hypotheses using multiple markers of socioeconomic position, as socioeconomic position encompasses a range of attributes that determine the resources available to a person and reflects their social standing.[28,108,133] These may all influence diet and health outcomes simultaneously, and are brought together in the salutogenic explanation of health inequalities,[134] which proposes health as generated using the margin of resources that individuals have access to, and when using different forms of capital to explain health inequalities,[132] as discussed in Chapter 1. However, some factors may be particularly prominent in some situations, for example, material resources are vital for food security. Comparison of different socioeconomic measures gives some indication of the mechanism behind the association if some proxy measures are associated, and others not, with diet and health outcomes. In some studies, I was limited by data availability and comparability. For example, in Chapter 2, occupational social class was the only measure of socioeconomic position that was available across all three surveys. The use of occupational social class as a measure of socioeconomic position also required estimation of one classification (RGSC) from another (NS-SEC) for the last survey, as the official UK classification of occupational social class changed over the study period, 1986 to 2012.[222]

Sociodemographic factors such as gender, ethnicity, and age may influence social standing and/or access to resources.[108] Therefore, markers of socioeconomic position may require different interpretations depending on the population subgroup studied. For example, high educational level in an ethnic majority group might correlate with high occupational level, but not within an ethnic minority group due to lack of opportunities and discrimination.[202] This could be partly responsible for the differences in socioeconomic patterning of diet quality observed in Chapter 5. Conversely, some individuals may have greater access to resources despite a low socioeconomic position. For example, homemakers may not have a high occupational level, but could be financially supported by a working partner. In Chapter 2, individuals were assigned to an occupational class based on the highest earner in the household, taking account of household rather than individual resources. In Chapter 5, individuals not in the workforce formed a heterogeneous category of non-workers who were not looking for work.

6.2.1.5 Assessment of ethnicity

In two of three datasets used in Chapter 2 and in the dataset used in Chapter 3, ethnicity was self-reported. However, in the earliest dataset used in Chapter 2, ethnicity was selected by an interviewer. The assignment of ethnicity by an interviewer is likely to have led to errors and biases, as interviewers were assigning ethnicity to participants based on perception alone.[341] In the dataset used in Chapter 5, ethnicity was based on the birthplace of the participant and of their parents, which was obtained from the municipality register of Amsterdam.[312] This provided a stable and objective measure of ethnicity. Participants born outside of the Netherlands, with at least one parent also born outside of the Netherlands, were considered of non-Dutch ethnicity (first migration generation). Participants who were born in the Netherlands, with both parents born outside of the Netherlands, were also considered of non-Dutch ethnicity (second migration generation). Participants born in the Netherlands, with both parents also born in the Netherlands, were classified as Dutch. This means that migration that occurred three or more generations ago was not considered in this classification. Country of birth/migration generation does not directly consider other dimensions of ethnicity, such as identity, or shared culture or religion. In the dataset used in Chapter 5, different ethnic backgrounds among participants from the same home country was thought to be an important consideration for Surinamese participants. To account for this, participants further self-reported their ethnic origin as African or South-Asian.[312] Ethnic differences in health may also reflect demographic differences between ethnic groups, for example, differential age structures between ethnic groups.[161] Age was adjusted for in my analyses presented in Chapter 5 to account for this.

6.2.1.6 Assessment of food insecurity

Food insecurity was measured using the most commonly used tool, the USDA AFSSM, which has been validated and used in several other high-income country settings.[167] However, this tool only measures food insufficiency and concerns about food insufficiency.[114] Chapter 4 was able to further our understanding of other consequences of food insecurity through quotes from food insecure individuals, charity representatives, and advocacy groups within news articles. The use of quantitative and qualitative data provided a fuller picture of food insecurity - its social, physical, and mental consequences. To date, the USDA AFFSM has rarely been used in the UK. However, its validity and reliability when adapted and used in other high-income countries suggests that this tools is appropriate for this setting also.[167]

6.2.1.7 Assessment of sex/gender

Sex and gender are two different but related concepts, the former used to describe the biological differences between males and females, whilst the latter a social and culture-dependent construct used to describe the differences between men and women.[170] In this dissertation, I used sex as a proxy for gender. At the population level, the two

concepts are highly correlated. In Chapter 3, the only dataset where both variables were available, 99% of participants reported identifying as cisgender (where males reported identifying as men, and females reported identifying as women). Therefore, whilst recognising the disadvantage and discrimination that transgender and gender non-conforming people experience,[342,343] sex was a suitable proxy for gender within these population studies. Furthermore, as discussed in Chapter 1, differences between males and females in terms of diet quality, are likely to be related to their roles in society (i.e. gender) rather than biological differences (i.e. sex). Differences arising from sex will not be modifiable or unjust, and therefore do not fit within the definition of inequality as presented in Chapter 1.

6.2.1.8 Cross-sectional data and study design

The majority of my research relied on cross-sectional data and used a cross-sectional study design. Cross-sectional studies are often criticised as the direction of causation may be difficult to establish,[344] and the limitations of this study design should be considered in the interpretation of my findings. Reverse causality is plausible in some cases. For example, in Chapter 3, I showed that food insecurity was associated with poorer diet and health outcomes. It could be that food insecurity was causing poorer health, or that poorer health was causing food insecurity. Alternatively, the association could be bi-directional, which is suggested through accounts within Chapter 4. Food insecure individuals explained how food insecurity led to poor mental health, high stress, and poor physical health. Food insecure individuals also recounted how poor mental and physical health perpetuated food insecurity through reduced working capacity. These findings relate to the selection explanation of health inequalities in the Black report,[12] which suggested that there was the potential for reverse causation, but that social disadvantage predominantly led to poor health rather than the other way around.[12,121] In other cases, for example with the associations observed between sociodemographic characteristics and diet outcomes in Chapters 2 and 5, it is unlikely that reverse causation is relevant.[345]

Aside from temporality, we may wish to consider the other domains within the Bradford Hill 'criteria' that are commonly used to assess the causal nature of associations.[346] According to these guidelines, many aspects of the association between socioeconomic position and diet do suggest a causal relationship. The reported associations between socioeconomic position and diet quality are strong and consistent across many studies and settings.[67] Socioeconomic gradients in diet quality, for example as observed among ethnically Dutch participants in Chapter 5, indicate a dose response. It is also, of course, plausible that low socioeconomic position causes poor diet quality. This could be through various mechanisms including insufficient material resources, low social standing (that leads to high stress, low control, low self-esteem, and low social participation), exposure to unhealthy food environments and social environments that encourage poor diets, or

some of these mechanisms in combination. Likewise, personal characteristics leading to poor diet is plausible through the same mechanisms. However, as with much dietary public health research, experimental data on food insecurity and how sociodemographic characteristics are related to diet and health are limited. Therefore, the experiment and coherence criteria are difficult to satisfy. Nonetheless, I would argue that causality can be inferred, if direction of causation can be established, for the relationship between social characteristics and diet. Moreover, causation may be in both directions, but to a greater degree in the direction of socioeconomic position affecting health than the reverse,[347] as discussed in Chapter 1.

Diet and socioeconomic position, two of the main measures of interest within this dissertation, may change over time. Another criticism of cross-sectional data is that they only provide a snapshot of the relationships of interest. In Chapter 5, my focus was on ethnic minority individuals, most of whom were migrants. Dietary habits among migrant populations, and their subsequent generations, can change with dietary acculturation,[348] both at the individual-level and between generations. The inter-generational change in diet through dietary acculturation was alluded to by the poorer diet quality found among second generation ethnic minority participants compared to first generation ethnic minority participants in Chapter 5. In Chapter 3, I investigated diet and health outcomes among food insecure individuals. One of the major challenges with researching food insecurity is that it is difficult to capture the uncertainty of food insecurity. For some individuals, the level of food insecurity that is experienced changes constantly, depending on the level of income they have at that time. Fluctuation in income could be due to seasonality of work, benefit payment delays, and unforeseen circumstances, for example.[349]

6.2.2 Limitations of available data

The research in this dissertation was at times constrained by data availability and the consistency of measurements over time. In Chapter 2, I was only able to compare adherence to dietary recommendations where dietary intake was measured similarly across the three surveys. For example, I was not able to compare adherence to the fibre recommendation as fibre intake was assessed using the Southgate method in 1986-87 and the Englyst method in the NDNS Rolling Programme (2008-12). The two methods include different types of starch in their estimates, and estimates from one method could not be easily converted to the other.[350]

Food insecurity was not monitored nationally in the UK at the time of conducting my analysis presented in Chapter 3, as it is in some countries, such as the US and Canada.[351,352] The UK government has now pledged to measure food insecurity prevalence in the population annually from April 2019, so repeated cross-sectional analyses may be possible in the future with these data and future waves of the IFPS.[284]

This monitoring will support goal setting and evaluation of interventions aiming to reduce food insecurity. It could also help explore the wider determinants of food insecurity and hold the government accountable for reducing food insecurity.

UK data similar to that available in the HELIUS Dietary Patterns study were not available. The HELIUS Dietary Patterns study provided detailed dietary intake data through ethnic-specific food frequency questionnaires, comprising approximately 200 food items,[200] for large samples of different ethnic groups. To my knowledge, dietary data currently available in UK multi-ethnic samples are more limited.

6.2.3 Generalisability

All of the research contained in this dissertation was conducted in a high-income, Western European country, specifically the UK or the Netherlands. Whilst some of my findings may be generalised to other settings, especially populations that are similar in terms of ethnic diversity and levels of poverty, other findings may be context specific. Similarities and differences observed across different settings may help us to understand the drivers of, and mechanisms behind, diet inequalities and food insecurity, and where and when they are most important. In this section, I discuss my findings in relation to findings from other settings.

In several Western countries, studies conducted to investigate the changes in magnitude of diet inequalities over time found that diet inequalities persisted and at times widened.[178–180,211,212] This suggests that the differential margin of resources social groups have to navigate their food environment has not narrowed, and many people living in Western countries still experience difficulties with achieving a good diet quality.

High prevalence of food insecurity has been reported in the US and Canada for decades.[351,352] In the UK, there were few food banks before the global financial crash in 2008 and food insecurity was not reported as a widespread problem prior to this.[196] The political and public attitudes to food insecurity may be dependent on the social and governmental context locally, but the consistency in associations with insufficient income, poor diet, and poor health points to the same drivers and consequences of food insecurity across different populations.

Some of my findings differed from the existing international literature. For example, in Chapter 5, I found no association between financial difficulties and diet in the Netherlands, but previous studies from the UK indicate that financial difficulties do negatively affect diet.[54,72,353] This association may differ between countries due to differences in food pricing or food environments, or differences in economic situation and welfare support, affecting the accessibility and affordability of food.

In the studies presented in Chapters 2 and 5, I found that ethnic minority groups tended to have better diet quality than the ethnic majority group in the UK and the Netherlands. In the US, ethnic minority groups tend to have poorer diet quality compared to the white majority.[82,319] However, the association is nuanced. When stratified, black participants usually have poorer diet compared to the white ethnic majority in the US, but Hispanic participants tend to have similar or better diet quality.[82,354] This has been called the 'Hispanic paradox', as Hispanic groups appear to have better health outcomes compared to the white ethnic majority in the US despite having lower socioeconomic position.[355,356] The 'healthy migrant' and 'salmon bias' hypotheses have been proposed to explain this 'paradox', suggesting that those who migrate are healthier than those who do not and that migrants tend to move back to their home country in old age and therefore lower the mortality reported, respectively.[356] These explanations relate to the selection and artefact explanations of inequalities. However, the healthy migrant hypothesis does not explain the differences observed between ethnic minority groups, and a study testing both hypotheses concluded that they did not explain the lower mortality among Hispanics.[357,358] Alternatively, better diet quality and family support have been suggested as explanations for the Hispanic paradox.[356,358] The diet and family support explanations relate to the cultural and social resources within Hispanic communities. The importance of cultural and social resources in achieving good diet quality, at times in spite of a lack of financial and material resources, is supported by the findings in this dissertation.

The differences identified between the UK, the Netherlands, the US, and Canada show that context matters. Studies need to be conducted across the globe to expand the evidence base that may help in our fundamental understanding of the drivers of diet and health inequalities, and to provide context-specific evidence for policy.

6.3 Drivers of persisting diet inequalities

Although this dissertation is made up of multiple independent pieces of work, and discussion points specific to each chapter are provided within the chapters themselves, there were some common themes. In the Introduction, I considered several theories that could explain why social characteristics are associated with dietary and health disadvantages. In this section, I reflect on how my work supports or challenges these theories.

6.3.1 Black report explanations of persisting diet inequalities

The Black report proposed four explanations of health inequalities: artefact, selection (natural or social), cultural/behavioural, and materialist or structuralist.[12]

Responses from food insecure individuals in the IFPS survey in Chapter 3 and the qualitative data from news articles in Chapter 4 point to diet inequalities among food

insecure adults being experienced in real-life, indicating that diet inequalities are not statistical artefacts.

The cross-sectional nature of the studies included in this dissertation means that causation between social identity/social standing and diet cannot be proven, but there is some indication of causality and suggestion that the relationship may be bi-directional. Quotes within news articles in Chapter 4 point to poor mental and physical health as both causes and consequences of food insecurity.

There do appear to be cultural and behavioural differences related to diet between population subgroups. The possession of cultural resources (such as healthier food preferences) and social resources (such as food sharing norms) could explain the better diet quality seen among ethnic minority groups residing in Western countries compared to the ethnic majority of those countries. Similarly, cultural and behaviour differences between the social classes and different social networks may explain and reinforce differences in diet quality across socioeconomic groups.

The studies within this dissertation provide strong evidence to support the materialist and structuralist explanation of diet inequalities. This will be covered in the next section.

6.3.2 Material explanations of persisting diet inequalities

Poverty and lack of material resources run throughout this dissertation as putative causes of poor diet and health. In Chapter 3, participants who reported difficulty making ends meet had around 20 times the adjusted odds of food insecurity compared to participants who reported that making ends meet was easy. One analysis has suggested that in England, households in the lowest income decile would have to spend a median of 74% of their disposable household income to meet the UK government's dietary guidelines.[54] For households in the second lowest income decile, this drops to a median of 28%, whilst households in the top income decile would need to spend a median of 6%.[54] Therefore, those in the lowest income group are experiencing difficulty with affording a healthy diet much more than those in other income groups, even when compared to people who have slightly more disposable income. This indicates that an absolute insufficiency of income is driving poor diet in the lowest income groups.

Resources and income are more likely to be insufficient if the cost of living is higher, which is dependent on the local economic environment. Limited income has to cover housing and fuel, and perhaps also transportation and childcare, the costs of which have all increased in the UK over the last decade.[252] The Joseph Rowntree Foundation calculates a Minimum Income Standard based on the necessities for an acceptable standard of living, including basic items and items necessary for social participation.[252] They reported that full-time earnings on the National Minimum Wage were not enough to reach this Minimum Income Standard in the UK in 2018.[252] Pressures on budgets come

from the increasing cost of basic necessities as well as the increasing cost of items that are seen as necessary for social participation within society.[252] Lack of material resources reduces social participation, and therefore, social capital.[132] A lack of material resources, such as adequate and permanent housing with sufficient cooking and food storage facilities, may also restrict diet quality through the lack of ability to prepare and store fresh food.[359]

With limited budget for food purchases, pricing differences between food options may be particularly powerful in influencing food choices in low-income groups. Previous research has shown that less healthy foods are cheaper per unit of energy than healthier foods in the UK.[74] In a financially constrained situation, purchasing cheaper and more energy-dense food may be a strategy to ensure hunger satiation, but has long-term consequences for health as these foods tend to be less nutrient-dense.[53] This is supported by the poorer diet quality observed in Chapters 2 and 3, and higher prevalence of obesity observed in Chapter 3, among food insecure participants compared to food secure participants. Low income families may also choose familiar and palatable foods that will not lead to waste of food, and therefore, resources.[360] Research indicates that children refuse unfamiliar foods between 8 to 15 times before accepting them.[361] Choosing familiar foods and foods that are innately preferred (those that are sweet or salty, and not bitter or sour) is a strategy that may reduce the economic risk of feeding one's family.[361] The lack of exposure to a variety of foods may in turn influence taste preference in adulthood.[362]

6.3.3 Psychosocial explanations of persisting diet inequalities

Besides material explanations, diet inequalities may be explained through psychosocial mechanisms. These mechanisms are based on people having different social standing within society. The social gradients observed across epidemiological research, whereby disadvantage is associated with poorer diet and health outcomes without a plateau beyond a certain threshold, support this explanation.[128,134] In this dissertation, socioeconomic gradients in diet quality were observed among ethnic Dutch participants in Chapter 5.

Low social standing can cause stress and low self-esteem, and can result in discrimination and lack of social participation. Quotes from food insecure individuals within new articles presented in Chapter 4 support this relationship. Low social standing may lead to feelings of inferiority,[123] affecting individual behaviour and interpersonal relationships. Research suggests that positive health behaviours may be low in priority for lower socioeconomic groups due to lower actual and perceived control of their own health, and higher belief in the role of chance, compared to higher socioeconomic groups.[140,363,364] Although this is sometimes used to explain socioeconomic inequality in diet, I found that ethnic minority groups that had lower socioeconomic position compare

to the ethnic majority group in fact had higher diet quality (see Chapter 5). This may be explained by differential community support, as without community and structural support for healthy behaviours, individual change may indeed be insignificant for health benefits.[364]

The stigma attached to low socioeconomic position may also contribute to the persistence of diet inequalities.[6] Stigma surrounding food insecurity and poverty may lead individuals to feel blamed for their circumstances and reluctant to seek help.[6] Perceived discrimination has been shown to be associated with poor self-rated health, especially ethnicity-, age-, disability-, and gender-based discrimination in Europe.[365] Previous work suggests that perceived racial discrimination is associated with less healthy eating and other poor health outcomes.[366]

The management of a low financial budget in an environment with high and increasing costs is stressful, especially for people who face stigma, discrimination, and a lack of job opportunities. Chapter 3 described higher stress among food insecure adults compared to food secure adults. Migration, and associated hardship such as language difficulties and unfamiliar surroundings and societal norms,[367] could also contribute to high stress in ethnic minority groups. The stress response could be a mechanism by which social disadvantage contributes to diet and health inequalities.[368] High stress can lead to poorer dietary choices through depleted self-control and executive function.[369] Stress may also lead people to make convenient food choices in order to direct resources and effort to other aspects of living. In the current food environment, convenient food choices are likely to be highly-processed, energy-dense, ready-to-eat foods.[52] The easiest food choices to make may also be dependent on the foods you are used to and the foods that people around you eat, which are influenced by your social identity, and social and cultural capital. Poor health may also result from high stress through physiological responses. Chronic stress is associated with the release of cortisol, which can stimulate appetite, heighten preference for foods high in sugar and fat, and increase accumulation of abdominal fat.[137] This, alongside the abundance of such foods, may be contributing to the increased consumption of energy-dense foods, and thus weight gain.[137]

The social standing explanation is related to income inequality. The UK has wide income inequality,[124] and the study presented in Chapter 2 suggests that diet inequalities have persisted throughout the period of wide income inequality, supporting the notion that income inequality contributes to diet inequalities.

6.3.4 Cultural explanations of persisting diet inequalities

Intuitively, cultural norms associated with ethnicity contribute to dietary differences between ethnic groups, and this is supported by research.[83,85] The ethnic differences in diet presented in this dissertation also supports this explanation. Less discussed is how

cultural norms associated with socioeconomic position may contribute to dietary differences between socioeconomic groups. Socioeconomic position may influence the importance people place on diet quality,[364] and the dietary habits and norms people are exposed to through their social networks.[154] Research suggests that diet may also be used as a marker of status and social identity, and to distinguish oneself from other social groups.[141] The expression of social identity through food might be especially important for those wanting to display their social standing, or for people who wish to retain their social identity, for example ethnic minority groups.[85] This social distinction could be unconscious through internalised taste preferences and attitudes adopted from norms within one's sociocultural surroundings.[370] This relates to cultural capital, which has been used to explain the persistence of health inequalities.[371]

6.3.5 Summary

In the introduction of this dissertation, I hypothesised that the unified theories of health inequalities would explain diet inequalities better than theories focusing on one domain - that social, cultural, and economic resources all help individuals, and groups of individuals, to achieve a healthy diet. The research in this dissertation supports the fundamental idea of interplay between economic, social, and physical factors that influence diet. The persistence of socioeconomic gradients in diet quality alongside wide income inequality in Western Europe supports the explanation that material resources are a key driver of socioeconomic inequality in diet. However, the better diet quality observed among ethnic minority groups compared to ethnic majority groups in Western Europe suggests that cultural and social capital can increase the margin of resources available to navigate the food environment and to eat a healthy diet, despite limited material resources. Diet quality among second generation ethnic minority participants was poorer than among first generation ethnic minority participants, suggesting that acculturation and the loss of social and cultural resources might be contributing to the deterioration of diet quality across generations.

6.4 Implications for policy

Policy can be used to attenuate risks of poor diet and reduce diet inequalities by supporting positive dietary behaviours and by creating environments where healthier diets are easier to achieve.[22] Interventions should aim to address the mechanisms thought to be driving social inequalities in diet: insufficient material, social, and cultural resources, and a poor food environment saturated with energy-dense and nutrient-poor foods. This could be by encouraging individual behaviour change, for example by increasing nutritional knowledge using mass media campaigns. Policies could also change the food environment so that existing behaviours lead to healthier outcomes, for example by reformulating products so that consumers can improve their diets without changing their behaviour. Support at all levels of the social ecological model simultaneously is

likely to be most effective in producing sustained improvements in population diet and reductions in social inequalities in diet.[175] Research indicates that population level interventions are more effective in achieving improvements in population diet and health than those that target high-risk groups.[372] However, targeted interventions for high-risk groups could also have a place in reducing harm to those who are most at risk of poor diet and health.

This section first explores past and present UK policies that have been enacted and then discusses the implications of my findings for future policies aiming to improve population diet and reduce social inequalities in diet.

6.4.1 Lessons from past and current policies

Reducing health inequalities has been a public health priority for decades.[12,373] The need to address diet inequalities is rarely mentioned specifically; however, some policy documents do mention poor diet as contributing to health inequalities.[13,14,184] In my exploration of past and current UK policies, I discuss health inequalities more broadly, in the absence of documentation explicitly about diet inequalities. Learning from the strengths and weaknesses of these policies may help to improve future endeavours.

6.4.1.1 The Black report recommendations

The Black report contained 37 recommendations to reduce health inequalities in the UK, a few of which related directly to diet.[12] One such recommendation was to develop a national food survey to allow nutritional surveillance and identification of high-risk groups. This led to the DNSBA in 1986-87 and subsequently the NDNS, which continues to be conducted today. Data from these surveys were used in the analyses reported in Chapter 2. Similar monitoring of dietary concerns, such as food insecurity, will allow similar academic analyses and surveillance. Free milk for infants is a scheme that has come in and out of existence since the Black Report. Universal free school meals have also been on the agenda since 1980, but only implemented in 2014,[374] which illustrates the long timeframe associated with policy changes. Many other recommendations within the Black report were related to childcare and welfare, showing recognition of the wider economic barriers to health 40 years ago. Childcare costs and welfare support remain crucial in the discussion of food insecurity as illustrated in Chapter 4.

6.4.1.2 Healthy Start vouchers and free school meals

The provision of Healthy Start vouchers and free school meals are government-led initiatives aiming to directly reduce income-related inequalities in diet. The Healthy Start scheme provides expectant mothers and mothers of children under 4 years on a low income with food vouchers.[280,375] These vouchers can be redeemed against fruits, vegetables, and milk. However, the uptake of vouchers is low and the real value of the vouchers has dropped due to inflation and increasing food prices.[280] One study also

showed that consumption of fruit and vegetables in families who were eligible for Healthy Start vouchers and families who were not eligible changed similarly over time.[376] The authors hypothesise that this could be due to vouchers, fully or partly, being used to purchase milk. A systematic review found that the Supplemental Nutrition Assistance Program, a similar programme in the US, was also ineffective in improving diet quality, but did reduce food insecurity.[377] The lack of effect on diet quality could be due to the low value of these vouchers relative to the high price of fruits and vegetables. Alternatively, recipients may be diverting money towards other purchases by retaining the same level of fruit and vegetable intake.

Universal free school meals are now provided for children in Reception to Year 2 (aged 5-8 years).[374] For children outside of this age range, free school meals are provided to children from low-income households. However, the stigma associated with receiving means-tested meals may have negative mental, social, and educational consequences.[378] As discussed in Chapter 4, low-income families also struggle to afford food during school holidays, when there is little-to-no assistance.

Focusing on children and their parents brings intervention earlier in the life course, which is beneficial as the negative effects of low socioeconomic position on diet and health are cumulative.[12] Interventions that target children also seem to be prioritised and more acceptable within policy, as suggested by the emergence of 'holiday hunger' as a major theme in the newspaper discussion of food insecurity in Chapter 4 and also by the political attention given to childhood obesity.[304,305] However, more government-led initiatives are needed and the uptake of existing schemes needs to be improved in order to further reduce diet inequalities. The uptake of means-tested free school meals and Healthy Start vouchers is low,[280,374] perhaps due to the complications with signing up and the stigma associated with claiming assistance. The uptake of free school meals increased among families who were previously eligible for means-tested free school meals when they were offered to all children, suggesting that offering free school meals universally reduced the associated stigma.[374]

6.4.1.3 Labour government strategy to reduce health inequalities

Between the years 1997 and 2010, the UK government had a strategy aiming to reduce socioeconomic inequalities in health by 10% in 10 years.[185,187] This strategy involved reallocating resources to the more deprived areas in the UK and aimed to tackle various drivers of health inequalities, including nutrition, health care, tobacco use, the built environment, and health promotion in schools.[185,187] A time trend analysis showed that this strategy reduced geographical inequalities in life expectancy, but that the trend reversed once the programme was removed with changes in government.[31] This indicates that addressing the wider determinants of health is effective in reducing health inequalities, but that such strategies have to be sustained for long-term benefits.

6.4.1.4 Salt, sugar, and calorie reduction

In the UK, the Salt Reduction Programme, introduced in 2003, and Soft Drinks Industry Levy, implemented in 2018, are strategies that have placed emphasis on reformulation by industry.[379,380] These low agency strategies could help to simultaneously improve dietary intake at the population level and reduce social inequalities in diet.[174] The Salt Reduction Programme was considered multi-dimensional as it brought together voluntary targets for the food industry to reduce salt content of products and a mass media campaign targeting consumers.[245] The multi-pronged nature of the programme was attributed to its success.[246] In Chapter 2, we saw greater improvement in overall adherence and reduction in social inequalities over time for salt, compared to the other dietary recommendations studied. This improvement was likely due the UK Salt Reduction Programme.[381]

Whilst voluntary agreements can be effective, they must be implemented and monitored appropriately.[382] The Public Health Responsibility Deal, launched in England in 2011, aimed to improve public health (with a focus on food, alcohol, health at work, and physical activity) by bringing together the government, businesses, the public sector, and non-governmental organisations in public-private partnerships.[383] This deal was based on voluntary pledges to improve public health and was found to have negligible nutritional benefits.[384,385] The Public Health Responsibility Deal was criticised for giving priority to corporate companies that were interested in protecting their profits over public health improvements, with limited accountability for non-compliance to pledges.[386] An evaluation of the food pledges found that the majority of pledges were related to information provision to the consumer, for example nutritional labelling, over more effective and equitable structural pledges, for example, food pricing strategies.[383] Moreover, most of the proposed pledges seemed to have been underway before the Public Health Responsibility Deal, suggesting little added benefit.[383]

The Soft Drinks Industry Levy taxes sugar-sweetened beverages with added sugar to incentivise manufacturers to reduce the sugar content of drinks through reformulation.[380] The Soft Drinks Industry Levy is part of the government's wider sugar reduction strategy and childhood obesity plan,[387] and these components may complement each other. Between 2015 and 2018, there was a 28.8% decrease in sugar content (sales-weighted average g per 100 ml) for drinks subject to the Soft Drinks Industry Levy, and some smaller reductions for other food categories included in the Sugar Reduction Programme.[387] There was also a 30% reduction in the sales of sugar from soft drinks, equivalent to 4.6 g per capita per day, between 2015 and 2018.[388] Evaluations of the equitability of the Soft Drinks Industry Levy and the Sugar Reduction Programme are yet to become available. However, a systematic review of evidence from other high-income countries that have implemented similar fiscal policies suggests similar or greater impact on consumption and body weight in low-income households,

compared to high-income households.[389] Whilst the international literature is encouraging, these taxes are unlike the UK tax, which is aiming to target industry and incentivise product reformulation rather than target consumers.[390]

Multi-dimensional strategies are likely to be most effective in enabling sustainable health benefits as they are aiming to change individual behaviour, the food environment, and social norms, and thus encourage change across the social ecological model.[175] Emphasis on changes to existing food products and the food environment might be especially effective in reducing inequalities, as no individual behaviour change is required.[174] The success of the Salt Reduction Programme and the preliminary results from the evaluation of the impact of the Soft Drinks Industry Levy are encouraging. The recently implemented multi-dimensional programmes for sugar reduction and calorie reduction,[248,249,387] may also be effective in reducing overall population intake of sugar and calories, and closing the socioeconomic gap in sugar intake and prevalence of overweight, both of which are higher in lower socioeconomic groups compared to higher socioeconomic groups.[59,67]

6.4.2 Considerations for future policies

It is clear that further intervention is needed to improve population diet, reduce diet inequalities, and reduce prevalence of food insecurity in the UK, and elsewhere. Government action and policies are essential to achieving this. The findings in this dissertation could have important implications for policy, and some considerations are discussed in this section. Although focused on the UK context, general learnings may be applicable to other regions and may help to inform policy-making in other countries.

6.4.2.1 Targeting at-risk groups

In this dissertation, we consistently observed poorer diet and health outcomes in low-income households, single-parent households, and among younger adults. These groups may have insufficient resources (material and social) necessary to meet their basic needs, including consuming a nutritious diet for healthy living. Although inequalities in diet were observed across the socioeconomic spectrum, it is important for policies to focus most effort in addressing poor diet and health in the most at-risk groups. Chapters 2 and 3 illustrate that diet and health inequalities between social groups in the UK are substantial, with no sign of diminishing and are possibly widening. Whilst the data in Chapter 2 do not point to an increase in daily energy intake over time, we have observed an increase in obesity prevalence in the UK and globally,[41,209] with greater prevalence of obesity among lower socioeconomic groups compared to higher socioeconomic groups in high-income countries.[67] Therefore, policies to improve population diet quality and reduce energy intake are needed, especially targeting those groups most at risk of poor diet and obesity.

The findings presented in Chapter 3 suggest a high prevalence of food insecurity in the UK, and found associations with poor diet and health outcomes, which were consistent with the associations found in other countries.[115,116] These findings help to refute the notion that food insecurity is not a problem in the UK, as was reportedly suggested by some politicians in news articles included in Chapter 4. My qualitative analysis of news articles also suggests that there was public support for governmental intervention to reduce food insecurity and its societal and health consequences.

6.4.2.2 Improving financial resources

Government policies could help to reduce the prevalence of poverty and ensure that individuals can afford the rising costs of living, including the cost of food and especially healthier foods.[74,252] Low-income households have to spend a large proportion of their disposable income in order to meet government dietary recommendations.[54] Welfare reform and benefit delays have been reported as causes of food insecurity and food bank use in the academic literature,[191,290] and by food insecure individuals and advocacy representatives in news articles analysed in Chapter 4. Welfare support needs to be revised in order to support good diet quality and health. Employment and wage-related policies must also be reviewed. Many UK adults who are food insecure are employed, as reported in Chapter 3. Low income security (for example, from zero-hour contracts) and low income (through jobs that pay the Minimum Wage but do not ensure that the Minimum Income Standard is met) mean that working people are increasingly unable to ensure that their costs of living can be met through their income.[252] In 2017, the Scottish government announced support for the piloting of a Basic Income.[391] This is an income sufficient to meet basic needs that would be paid unconditionally, to everyone. The feasibility and effectiveness this scheme is yet to be reported.

6.4.2.3 Considering community

Communities can shape dietary habits, especially in ethnic minority groups where expression of identity through food might be important.[313] In one qualitative study, Turkish and Moroccan participants revealed the pressure to host guests and offer traditional foods for family,[84] providing a social incentive to retain dietary customs from their home country. Retention of elements of their traditional diet could be beneficial to ethnic minority groups residing in Western Europe, and positive aspects of their diet and dietary practices may also be able to improve the diets of other groups through cultural interaction and exchange.

Chapter 4 illustrated that community was also important, and perceived as important, in relieving food insecure individuals in the UK from the immediate consequences of food insecurity, through food banks and other charitable food aid. Communities could be a way of redistributing resources and increasing social capital, which may help to support better diet quality across the whole population. Policies that harm community support

must be avoided, as without structural support for healthy living, this may be crucial support for some individuals in the interim.

6.4.2.4 Diversifying societies

The UK and many other countries are projected to become more ethnically diverse.[20] Household structures and gender roles are changing.[392] The population is ageing.[393] Work patterns and occupation types are evolving.[143] These changes are diversifying societies. Societal differences should be embraced and celebrated, and should not lead to unfair and avoidable differences in diet quality or health outcomes. Research into the understanding of how diet quality differs across population subgroups should acknowledge that different dietary behaviours and food preferences can be equally effective in promoting healthy eating, as demonstrated in Chapter 5. Policies also have to be mindful about keeping up with modern society and its needs.

6.4.2.5 Monitoring and surveillance

Nationwide surveillance of population diet is crucial in monitoring the health of a population and health inequalities. These data can also be linked with data from interventions to evaluate their effect on population diet. This is important to be able to understand the effects of wider social factors and policies on population diet. My studies were at times limited by the data available, and surveillance data will be important to our understanding of diet inequalities going forward. Globally, there is a need to recognise, monitor, and document the extent of diet inequalities within populations.

National studies often group ethnic minority groups together when ethnic minority representation within the sample is limited. The differential findings between ethnic minority groups in the study presented in Chapter 5 highlights the limitations of this approach. Different ethnic groups have different levels of social, cultural, and material resources and, therefore, may have different diet and health outcomes. This highlights the need to conduct research to understand ethnic differences in diet, specifically.

6.4.2.6 Food environment

An individual's response to their food environment may depend on their circumstances. In Chapter 3, food insecurity was associated with greater adjusted odds of overweight. This may be due to the interaction between low income and obesogenic food environments. Studies indicate that more deprived neighbourhoods, compared to less deprived neighbourhoods, have poorer access to fresh food and a higher density of fast food outlets.[136,394] An unhealthy food environment also has a stronger association with diet quality in more disadvantaged groups compared to less disadvantaged groups.[395,396] This means that improving the food environment could be very important in reducing socioeconomic inequalities in diet, as such interventions might be expected to have a greater positive effect on more disadvantaged groups.

The current food system, which is controlled by major corporate food companies,[52,53,397] is a major upstream driver of diet inequalities. The food industry prioritises marketing of energy-dense foods rather than fresh produce, as it is more profitable.[53] As obesity rates rise, especially in low income groups,[40] the imbalance in food prices between healthier and less healthy foods, and the abundance of cheap, energy-dense yet nutrient-poor foods are crucial to address.[52,74] The food environment could be improved by providing better physical and economic access to healthy foods, especially in more deprived areas, and a greater range of food choices. Taxation of unhealthy foods and subsidies for healthy foods for low-income individuals should be considered.[22,390] Such strategies may help individuals to consume healthier options and reduce socioeconomic inequalities in diet in a way that requires little personal resources.

6.4.2.7 Diet and health beyond public health

The social inequalities in diet discussed in this dissertation may need solutions beyond the powers of public health. Deterioration in living conditions due to political changes, such as austerity measures and benefit cuts, directly affect health outcomes and cannot be counteracted solely by community support and individual change.[174,398] Poverty, lack of opportunity, and systemic disadvantages that are hard for individuals to work against must be addressed. Governmental policies have the most wide-reaching ability to improve people's material resources and to regulate the food environment. Data presented in Chapter 4 highlight that governmental interventions are upstream of community and individual interventions, and suggest that there is public support for government interventions to reduce food insecurity. Welfare support is needed for good population diet and health, with more generous welfare regimes found to mitigate the influence of rising food prices and stagnant wages on food insecurity.[123,127] Whilst health policies that concentrate on reducing health inequalities are necessary, non-health policies should also consider their effect on health equality.[399] Health inequalities are linked to income inequalities.[124] As income inequality narrowed in the UK and US between the 1920s and 1970s, health inequalities declined also.[20] Since the 1980s, however, income and health inequalities have widened again.[400] Although nutritional survey data in the UK do not date back this far, my work showed that diet inequalities were and still are persistent through this period of high income inequality, adding to the evidence supporting this link.

6.4.2.8 Explicit mention of social inequalities in diet

Whilst almost all contemporary UK policy documents addressing public health note the need to reduce health inequalities, there are few that conclude with explicit policies to do so. As an example, the UK government's "Childhood obesity: a plan for action, chapter 2", outlines the need to reduce the gap in prevalence of obesity by deprivation in its introduction, but does not mention inequality or deprivation again until the concluding statement.[305] Whilst the goal was to half obesity prevalence by 2030, there was no

measurable goal for reducing social inequalities in obesity prevalence. In order to measure progress, reducing health inequalities needs to be a measured priority and not a side issue. Thought also needs to be given to how health inequalities can be reduced. As diet is one of the biggest contributors to poor health, there should be some policy focus on reducing diet inequalities in particular. However, policy documents do not mention diet inequalities specifically. Furthermore, policies should consider the different dimensions of social inequality, where historically, the focus has only been on socioeconomic inequalities. All PROGRESS-plus characteristics can influence diet and health,[25] and their interaction may alter the risk of poor diet and health.

6.4.2.9 Summary of policy considerations

Policies across the social ecological model are needed in order to create environments that are supportive of healthy diets in all social groups.[175] It is therefore likely that much more organised efforts are needed from a wide range of groups to improve population diet and reduce social inequalities in diet, using a mixture of low and high agency interventions, and ones that target specific high-risk groups as well as whole populations. Addressing the upstream, structural drivers of social inequalities in diet is especially necessary for long-term, sustainable solutions. For any large-scale intervention, most importantly, population diet needs to be prioritised on the political agenda, in view of the likely need for structural changes.

6.5 Future Research

Future research that considers intersecting social characteristics is needed, to account for the sometimes competing, and sometimes multiplicative, effects of different influences on diet. Longitudinal studies of food insecure individuals would be valuable to our understanding of the long-term implications of food insecurity and the uncertainty experienced by food insecurity individuals. A mixed-methods study could be conducted to quantitatively estimate prevalence of food insecurity and its fluctuation within households over time, alongside interviews with participants to explore the drivers and consequences of food insecurity. Including measurement of child food insecurity in such a study would be particularly useful. Chapter 4 indicated that child food insecurity was prevalent in the UK, but this could not be measured using the IFPS data. Child food insecurity also appeared to attract public and political interest, and may encourage policy action. Research into political attitudes and how to increase political will to reduce diet and health inequalities is also needed. Ultimately, these findings could help with designing interventions to reduce diet inequalities and prevent food insecurity. Research that monitors changes in magnitude of diet inequalities and prevalence of food insecurity is also needed, as are evaluations of interventions that intentionally and unintentionally change population diet quality.

6.6 Conclusions

Diet inequalities were observed according to various social characteristics: gender, age, socioeconomic position, and ethnicity. Whilst overall population diet appears to have improved over time, social inequalities in diet persist. Prevalence of individual-level food insecurity was estimated at 24% among UK adults aged 18-64 years. Poor diet and food insecurity tended to be more prevalent among social groups with insufficient access to material resources. However, in ethnic minority groups, diet quality was better in comparison to the ethnic majority group despite lower socioeconomic position. This could be because social and cultural resources mitigate the negative effect of low socioeconomic position on diet, and retention of elements of traditional diets may be protective against poor diet in these groups. The reasons for diet inequalities are therefore varied and complex. Various personal, social, cultural, and environmental factors may be competitive or multiplicative in their influence on diet, within population subgroups or within individuals. To reduce diet inequalities, it is likely that interventions at the individual, community, and structural levels are needed. Communities may help to support healthy eating behaviours, whilst structural changes are needed for sustainable reductions in social inequalities in diet. Government action is likely required to implement structural changes to improve the food environment, eliminate poverty, and improve welfare support and employment policies, to ensure that good diet quality and health can be achieved by all.

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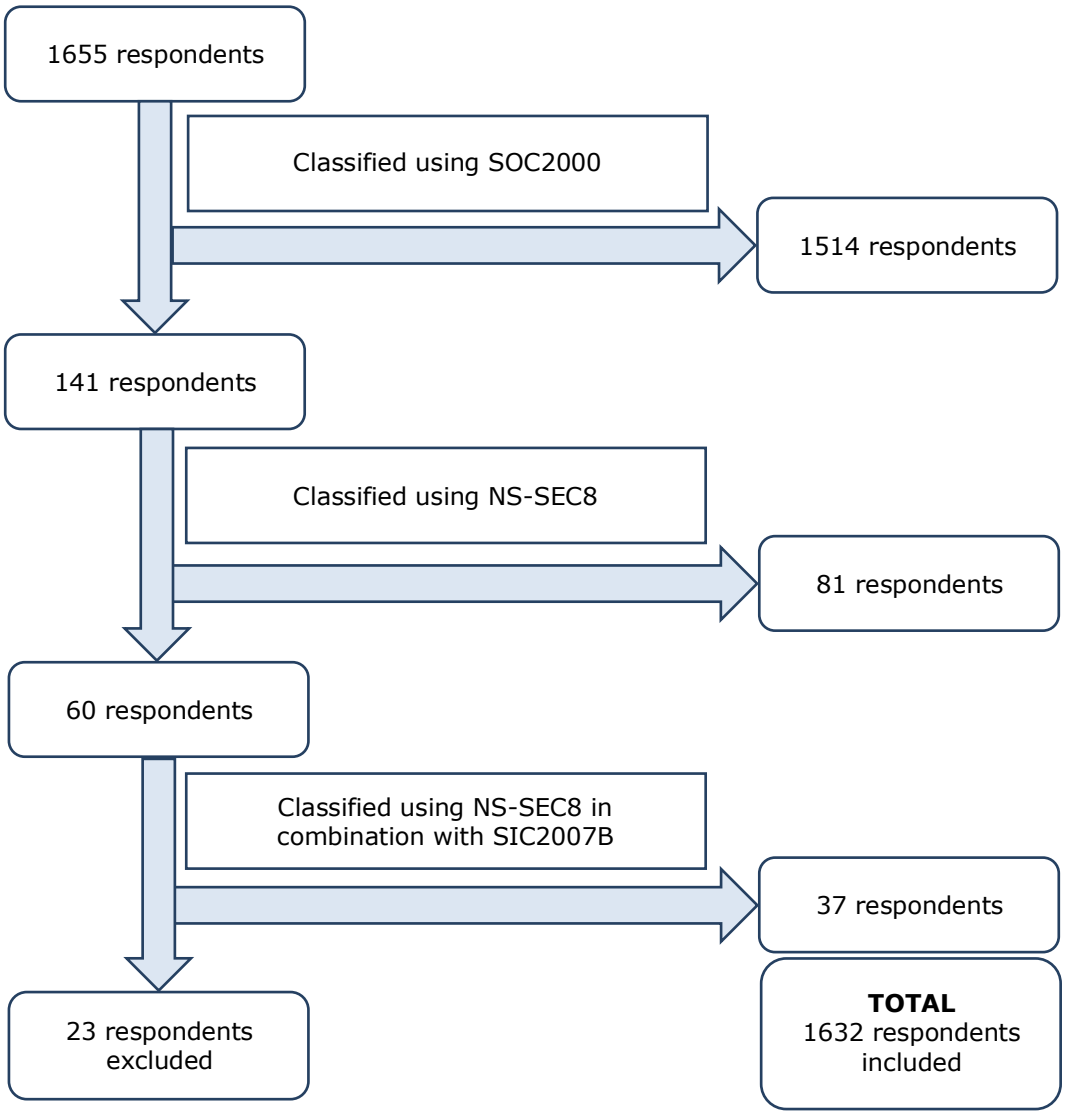
SUPPLEMENTARY MATERIAL

Appendix A: Supplementary material for chapter 2

Supplementary Figure A1. Flowchart for Registrar General's Social Class estimation for NDNS Rolling Programme respondents



There were 1655 respondents aged 19 to 64 years with 3 or 4 days of food diary records in 2008-12. Using information on the household reference person's employment status (whether s/he was self-employed or an employee, and whether s/he was working in an organisation with more or fewer than 25 people) and the Standard Occupational Classification (SOC) 2000, we were able to classify 1514 (91.5%) of respondents into the two Registrar General's Social Class (RGSC) categories: non-manual occupations and manual occupations. Of the remaining 141 respondents, 81 (4.9% of the original sample) were classified using their NS-SEC classification. This NS-SEC to RGSC estimation was based on the conversion table from National Statistic's documentation for 'continuity issues: SC, SEG and NS-SEC'.[222] A further 37 respondents (2.2%) were classified using NS-SEC combined with Standard Industrial Classification (SIC) 2007, which gave further details on the industry in which the household reference person worked. This resulted in 1632 (98.6%) respondents with estimated RGSC classifications, allowing comparison across surveys. We were unable to classify 8 (0.5%) respondents due to uncertainty regarding occupation. A further 15 respondents were excluded due to incomplete occupational data.

Supplementary Table A1. Weighted vs unweighted data: adjusted odds ratios (95% CIs) for adhering to dietary recommendations by sociodemographic characteristics

	1986-1987 (unweighted) OR (95% CI)	**2000-2001 (unweighted)** OR (95% CI)	**2000-2001 (weighted)** OR (95% CI)	**2008-2012 (unweighted)** OR (95% CI)	**2008-2012 (weighted)** OR (95% CI)
Sex (reference group: men)					
FV	0.86 (0.63, 1.19)	1.07 (0.82, 1.40)	1.08 (0.81, 1.44)	1.07 (0.84, 1.37)	0.97 (0.74, 1.27)
Salt	7.59 (6.07, 9.48)	7.18 (5.69, 9.07)	7.79 (6.02, 10.09)	4.76 (3.83, 5.91)	4.33 (3.39, 5.52)
Oily fish	0.50 (0.36, 0.69)	0.95 (0.73, 1.26)	1.01 (0.75, 1.36)	1.05 (0.81, 1.35)	1.09 (0.82, 1.46)
RPM	3.63 (2.95, 4.47)	3.20 (2.60, 3.93)	3.58 (2.86, 4.50)	2.22 (1.81, 2.73)	2.08 (1.65, 2.62)
Age (reference group: 19-40)					
FV	1.74 (1.26, 2.42)	2.98 (2.22, 4.00)	3.14 (2.30, 4.29)	2.02 (1.56, 2.62)	1.95 (1.46, 2.62)
Salt	1.07 (0.87, 1.31)	1.11 (0.89, 1.38)	1.10 (0.87, 1.40)	1.51 (1.21, 1.88)	1.60 (1.26, 2.03)
Oily fish	2.15 (1.55, 3.00)	2.15 (1.61, 2.87)	2.54 (1.86, 3.47)	1.71 (1.31, 2.23)	1.60 (1.19, 2.16)
RPM	1.07 (0.87, 1.30)	1.07 (0.88, 1.31)	1.09 (0.87, 1.36)	0.98 (0.80, 1.21)	1.02 (0.81, 1.28)
Socioeconomic position (reference group: manual)					
FV	3.21 (2.25, 4.58)	2.08 (1.56, 2.79)	2.10 (1.54, 2.87)	1.76 (1.35, 2.28)	1.60 (1.20, 2.62)
Salt	0.80 (0.65, 0.98)	0.77 (0.62, 0.96)	0.79 (0.62, 1.01)	1.08 (0.87, 1.35)	1.09 (0.85, 1.39)
Oily fish	1.92 (1.38, 2.66)	2.18 (1.61, 2.94)	2.18 (1.57, 3.03)	2.11 (1.59, 2.79)	1.99 (1.45, 2.73)
RPM	1.27 (1.04, 1.55)	1.43 (1.16, 1.75)	1.46 (1.16, 1.83)	1.16 (0.95, 1.43)	1.21 (0.96, 1.52)
Ethnicity (reference group: white)					
FV	2.66 (1.40, 5.03)	1.93 (1.16, 3.22)	1.79 (1.02, 3.14)	1.90 (1.30, 2.78)	2.18 (1.43, 3.33)
Salt	4.47 (2.65, 7.54)	3.47 (2.11, 5.72)	3.36 (2.08, 5.43)	1.90 (1.29, 2.80)	2.35 (1.44, 3.83)
Oily fish	0.81 (0.32, 2.06)	1.72 (1.01, 2.91)	1.71 (0.94, 3.11)	1.24 (0.81, 1.90)	1.09 (0.68, 1.75)
RPM	1.87 (1.15, 3.05)	2.03 (1.29, 3.18)	2.08 (1.28, 3.40)	1.80 (1.28, 2.53)	2.06 (1.41, 3.01)
FV, fruit and vegetables. RPM, red and processed meat. Odds ratios are adjusted for sex, age, socioeconomic position, and ethnicity.					

Supplementary Table A2. Weighted vs unweighted data: adjusted odds ratios (95% CIs) for adhering to dietary recommendations over time

Inequality			2000-01 vs 1986-87 (unweighted) OR (95% CI)	2000-01 vs 1986-87 (00-01 weighted) OR (95% CI)	2008-12 vs 2000-01 (unweighted) OR (95% CI)	2008-12 vs 2000-01 (weighted) OR (95% CI)
Sex	FV	Men	1.72 (1.27, 2.32)	1.67 (1.23, 2.27)	1.27 (0.96, 1.67)	1.35 (1.00, 1.82)
		Women	2.13 (1.59, 2.86)	2.13 (1.58, 2.88)	1.32 (1.04, 1.68)	1.26 (0.97, 1.64)
	Salt	Men	1.28 (0.98, 1.67)	1.57 (0.87, 1.54)	3.25 (2.54, 4.14)	3.62 (2.76, 4.76)
		Women	1.25 (1.04, 1.49)	1.23 (1.02, 1.48)	2.20 (1.80, 2.70)	2.08 (1.67, 2.60)
	OF	Men	1.31 (0.98, 1.74)	1.20 (0.90, 1.61)	1.21 (0.91, 1.60)	1.29 (0.95, 1.75)
		Women	2.47 (1.79, 3.41)	2.42 (1.74, 3.36)	1.30 (1.01, 1.67)	1.32 (1.00, 1.74)
	RPM	Men	1.90 (1.51, 2.39)	1.66 (1.30, 2.11)	1.07 (0.86, 1.35)	1.32 (1.02, 1.69)
		Women	1.70 (1.42, 2.04)	1.66 (1.38, 2.01)	0.77 (0.64, 0.93)	0.78 (0.64, 0.96)
Age	FV	19-40	1.35 (0.95, 1.92)	1.28 (0.89, 1.84)	1.66 (1.20, 2.30)	1.76 (1.23, 2.52)
		41-64	2.31 (1.78, 3.00)	2.34 (1.79, 3.07)	1.15 (0.92, 1.43)	1.11 (0.87, 1.40)
	Salt	19-40	1.25 (1.01, 1.54)	1.18 (0.95, 1.46)	2.15 (1.71, 2.71)	2.19 (1.70, 2.82)
		41-64	1.28 (1.04, 1.57)	1.20 (0.98, 1.48)	3.08 (2.49, 3.81)	3.28 (2.59, 4.14)
	OF	19-40	1.75 (1.23, 2.49)	1.47 (1.02, 2.12)	1.45 (1.05, 1.99)	1.69 (1.18, 2.42)
		41-64	1.72 (1.33, 2.24)	1.75 (1.34, 2.30)	1.17 (0.93, 1.47)	1.10 (0.86, 1.42)
	RPM	19-40	1.76 (1.44, 2.15)	1.63 (1.32, 2.01)	0.93 (0.75, 1.15)	1.05 (0.83, 1.34)
		41-64	1.76 (1.45, 2.15)	1.64 (1.34, 2.00)	0.85 (0.70, 1.03)	0.94 (0.76, 1.16)
Socioeconomic position	FV	NM	1.67 (1.30, 2.14)	1.63 (1.26, 2.11)	1.24 (1.00, 1.54)	1.20 (0.94, 1.52)
		M	2.52 (1.72, 3.71)	2.48 (1.67, 3.68)	1.46 (1.05, 2.02)	1.58 (1.11, 2.25)
	Salt	NM	1.24 (1.01, 1.52)	1.19 (0.97, 1.47)	3.03 (2.47, 3.72)	3.11 (2.49, 3.90)
		M	1.30 (1.05, 1.61)	1.21 (0.97, 1.51)	2.14 (1.68, 2.72)	2.20 (1.68, 2.87)
	OF	NM	1.81 (1.40, 2.35)	1.71 (1.31, 2.23)	1.25 (1.00, 1.56)	1.26 (0.99, 1.61)
		M	1.59 (1.11, 2.28)	1.51 (1.04, 2.19)	1.28 (0.90, 1.82)	1.39 (0.95, 2.05)
	RPM	NM	1.86 (1.54, 2.25)	1.72 (1.42, 2.09)	0.82 (0.68, 0.99)	0.93 (0.76, 1.15)
		M	1.65 (1.34, 1.99)	1.53 (1.22, 1.91)	0.97 (0.77, 1.22)	1.07 (0.83, 1.37)
Ethnicity	FV	White	1.94 (1.57, 2.41)	1.94 (1.55, 2.42)	1.30 (1.07, 1.57)	1.27 (1.03, 1.57)
		Non-white	1.52 (0.69, 3.34)	1.33 (0.58, 3.05)	1.31 (0.71, 2.41)	1.60 (0.82, 3.14)
	Salt	White	1.27 (1.09, 1.48)	1.21 (1.03, 1.41)	2.76 (2.35, 3.25)	2.82 (2.35, 3.37)
		Non-white	1.04 (0.54, 2.03)	0.98 (0.51, 1.88)	1.43 (0.80, 2.54)	1.72 (0.92, 3.21)
	OF	White	1.67 (1.35, 2.07)	1.58 (1.27, 1.98)	1.29 (1.06, 1.57)	1.34 (1.08, 1.66)
		Non-white	3.55 (1.24, 10.10)	3.32 (1.09, 10.16)	0.92 (0.48, 1.75)	0.90 (0.44, 1.82)
	RPM	White	1.76 (1.52, 2.03)	1.62 (1.40, 1.88)	0.88 (0.76, 1.02)	0.98 (0.83, 1.16)
		Non-white	2.03 (1.07, 3.85)	1.90 (0.98, 3.70)	0.82 (0.48, 1.42)	1.00 (0.56, 1.79)

FV, fruit and vegetables. OF, oily fish. RPM, red and processed meat. NM, non-manual. M, manual.
Odds ratios are adjusted for sex, age, socioeconomic position, and ethnicity.

Supplementary Table A3. Sex inequalities: *n* (%) adhering to dietary recommendations and adjusted odds ratios (95% CIs) for adherence

Dietary recommendation		1986-1987 (*n*=2018) *n* (%)	2000-2001 (*n*=1683) *n* (%)	2008-2012 (*n*=1632) *n* (%)	00-01 vs 86-87 08-12 vs 00-01 OR (95% CI)	χ2 ($P_{interaction}$)
Fruit and vegetables	Men	88 (8.9)	119 (15.8)	143 (20.3)	1.72 (1.27, 2.32) 1.27 (0.96, 1.67)	1.27 (0.53)
	Women	80 (7.8)	152 (16.3)	198 (21.4)	2.13 (1.59, 2.86) 1.32 (1.04, 1.68)	
Women vs men, OR (95% CI)		0.86 (0.63, 1.19)	1.07 (0.82, 1.40)	1.07 (0.84, 1.37)		
Salt	Men	138 (13.9)	131 (17.4)	292 (41.4)	1.28 (0.98, 1.67) 3.25 (2.54, 4.14)	9.30 (0.01)*
	Women	552 (53.8)	551 (59.3)	710 (76.6)	1.25 (1.04, 1.49) 2.20 (1.80, 2.70)	
Women vs men, OR (95% CI)		7.59 (6.07, 9.48)	7.18 (5.69, 9.07)	4.76 (3.83, 5.91)		
Oily fish	Men	110 (11.1)	115 (15.3)	128 (18.2)	1.31 (0.98, 1.74) 1.21 (0.91, 1.60)	13.76 (0.001)*
	Women	61 (5.9)	135 (14.5)	175 (18.9)	2.47 (1.69, 3.41) 1.30 (1.01, 1.67)	
Women vs men, OR (95% CI)		0.50 (0.36, 0.69)	0.95 (0.73, 1.26)	1.05 (0.81, 1.35)		
Red and processed meat	Men	168 (17.0)	217 (28.8)	222 (31.5)	1.90 (1.51, 2.39) 1.07 (0.86, 1.35)	11.52 (0.003)*
	Women	434 (42.3)	522 (56.1)	467 (50.4)	1.70 (1.42, 2.04) 0.77 (0.64, 0.93)	
Women vs men, OR (95% CI)		3.63 (2.95, 4.47)	3.20 (2.60, 3.93)	2.22 (1.81, 2.73)		

Odds ratios are adjusted for age, socioeconomic position, and ethnicity.
*$P \leq 0.05$

Supplementary Table A4. Age inequalities: *n* (%) adhering to dietary recommendations and adjusted odds ratios (95% CIs) for adherence

Dietary recommendation		1986-1987 (*n*=2018) *n* (%)	2000-2001 (*n*=1683) *n* (%)	2008-2012 (*n*=1632) *n* (%)	00-01 vs 86-87 08-12 vs 00-01 OR (95% CI)	χ2 ($P_{interaction}$)
Fruit and vegetables	19-40	67 (6.4)	70 (8.8)	109 (15.1)	1.35 (0.95, 1.92) 1.66 (1.20, 2.30)	6.58 (0.04)*
	41-64	101 (10.5)	201 (22.6)	232 (25.4)	2.31 (1.78, 3.00) 1.15 (0.92, 1.43)	
41-64 vs 19-40, OR (95% CI)		1.74 (1.26, 2.42)	2.98 (2.22, 4.00)	2.02 (1.56, 2.62)		
Salt	19-40	357 (33.8)	319 (40.2)	413 (57.4)	1.25 (1.01, 1.54) 2.15 (1.71, 2.71)	8.49 (0.01)*
	41-64	333 (34.6)	363 (40.8)	589 (64.6)	1.28 (1.04, 1.57) 3.08 (2.49, 3.81)	
41-64 vs 19-40, OR (95% CI)		1.07 (0.87, 1.31)	1.11 (0.89, 1.38)	1.51 (1.21, 1.88)		
Oily fish	19-40	60 (5.7)	78 (9.8)	103 (14.3)	1.75 (1.23, 2.49) 1.45 (1.05, 1.99)	1.62 (0.44)
	41-64	111 (11.5)	172 (19.3)	200 (21.9)	1.72 (1.33, 2.24) 1.17 (0.93, 1.47)	
41-64 vs 19-40, OR (95% CI)		2.15 (1.55, 3.00)	2.15 (1.61, 2.87)	1.71 (1.31, 2.23)		
Red and processed meat	19-40	308 (29.2)	343 (43.2)	310 (43.1)	1.76 (1.44, 2.15) 0.93 (0.75, 1.15)	0.43 (0.81)
	41-64	294 (30.5)	396 (44.5)	379 (41.6)	1.76 (1.45, 2.15) 0.85 (0.70, 1.03)	
41-64 vs 19-40, OR (95% CI)		1.07 (0.87, 1.30)	1.07 (0.88, 1.31)	0.98 (0.80, 1.21)		
Odds ratios are adjusted for sex, socioeconomic position, and ethnicity. *$P \leq 0.05$						

Supplementary Table A5. Socioeconomic inequalities: *n* (%) adhering to dietary recommendations and adjusted odds ratios (95% CIs) for adherence

Dietary recommendation		1986-1987 (*n*=2018) *n* (%)	2000-2001 (*n*=1683) *n* (%)	2008-2012 (*n*=1632) *n* (%)	00-01 vs 86-87 08-12 vs 00-01 OR (95% CI)	χ2 ($P_{interaction}$)
Fruit and vegetables	Non-manual	123 (12.6)	196 (20.2)	240 (24.3)	1.67 (1.30, 2.14) 1.24 (1.00, 1.54)	7.14 (0.03)*
	Manual	45 (4.3)	75 (10.5)	101 (15.7)	2.52 (1.72, 3.71) 1.46 (1.05, 2.02)	
NM vs M, OR (95% CI)		3.21 (2.25, 4.58)	2.08 (1.56, 2.79)	1.76 (1.35, 2.28)		
Salt	Non-manual	311 (32.0)	374 (38.6)	613 (62.1)	1.24 (1.01, 1.52) 3.03 (2.47, 3.72)	5.82 (0.05)*
	Manual	379 (36.3)	308 (43.2)	389 (60.3)	1.30 (1.05, 1.61) 2.14 (1.68, 2.72)	
NM vs M, OR (95% CI)		0.80 (0.65, 0.98)	0.77 (0.62, 0.96)	1.08 (0.87, 1.35)		
Oily fish	Non-manual	108 (11.1)	183 (18.9)	224 (22.7)	1.81 (1.40, 2.35) 1.25 (1.00, 1.56)	0.36 (0.84)
	Manual	63 (6.0)	67 (9.4)	79 (12.2)	1.59 (1.11, 2.28) 1.28 (0.90, 1.82)	
NM vs M, OR (95% CI)		1.92 (1.38, 2.66)	2.18 (1.61, 2.94)	2.11 (1.59, 2.79)		
Red and processed meat	Non-manual	313 (32.2)	460 (47.4)	430 (43.6)	1.67 (1.30, 2.14) 0.82 (0.68, 0.99)	1.82 (0.40)
	Manual	289 (27.7)	279 (39.1)	259 (40.2)	2.52 (1.72, 3.71) 0.97 (0.77, 1.22)	
NM vs M, OR (95% CI)		1.27 (1.04, 1.55)	1.43 (1.16, 1.75)	1.16 (0.95, 1.43)		

NM, non-manual. M, manual.
Odds ratios are adjusted for sex, age, and ethnicity.
*$P \leq 0.05$

Supplementary Table A6. Ethnic inequalities: *n* (%) adhering to dietary recommendations and adjusted odds ratios (95% CIs) for adherence

Dietary recommendation		1986-1987 (*n*=2018) *n* (%)	2000-2001 (*n*=1683) *n* (%)	2008-2012 (*n*=1632) *n* (%)	86-87 vs 00-01 86-87 vs 08-12 OR (95% CI)	χ2 ($P_{interaction}$)
Fruit and vegetables	White	155 (8.0)	248 (15.6)	296 (20.1)	1.94 (1.57, 2.41) 1.30 (1.07, 1.57)	0.85 (0.65)
	Non-White	13 (16.7)	23 (25.6)	45 (28.3)	1.52 (0.69, 3.34) 1.31 (0.71, 2.41)	
NW vs W, OR (95% CI)		2.66 (1.40, 5.03)	1.93 (1.16, 3.22)	1.90 (1.30, 2.78)		
Salt	White	643 (33.1)	624 (39.2)	889 (60.4)	1.27 (1.09, 1.48) 2.76 (2.35, 3.25)	7.52 (0.02)*
	Non-White	47 (60.3)	58 (64.4)	113 (71.1)	1.04 (0.54, 2.03) 1.43 (0.80, 2.54)	
NW vs W, OR (95% CI)		4.47 (2.65, 7.54)	3.47 (2.11, 5.72)	1.90 (1.29, 2.80)		
Oily fish	White	166 (8.6)	230 (14.4)	272 (18.5)	1.94 (1.57, 2.41) 1.29 (1.06, 1.57)	2.11 (0.35)
	Non-White	5 (6.4)	20 (22.2)	31 (19.5)	1.32 (0.69, 3.34) 0.92 (0.48, 1.75)	
NW vs W, OR (95% CI)		0.81 (0.32, 2.06)	1.72 (1.01, 2.91)	1.24 (0.81, 1.90)		
Red and processed meat	White	570 (29.4)	685 (43.0)	602 (40.9)	1.76 (1.52, 2.03) 0.88 (0.76, 1.02)	0.11 (0.95)
	Non-White	32 (41.0)	54 (60.0)	87 (54.7)	2.03 (1.07, 3.85) 0.82 (0.48, 1.42)	
NW vs W, OR (95% CI)		1.87 (1.15, 3.05)	2.03 (1.29, 3.18)	1.80 (1.28, 2.53)		

NW, non-white. W, white.
Odds ratios are adjusted for sex, age, and socioeconomic position.
*$P \leq 0.05$

Supplementary Table A7. Sociodemographic inequalities in meeting dietary recommendations (non-disaggregated vs. disaggregated data from NDNS Rolling Programme 2008-12)

Sociodemographic Characteristic	Fruit and vegetables		Oily fish		Red and processed meat	
	Non-disaggregated	Disaggregated	Non-disaggregated	Disaggregated	Non-disaggregated	Disaggregated
Overall	20.9	30.4	18.6	16.2	42.2	62.8
Men, %	20.3	28.9	18.2	16.6	31.5	47.8
Women, %	21.4	31.5	18.9	15.9	50.4	74.2
Women vs men, OR (95% CI)	1.07 (0.84, 1.37)	1.13 (0.91, 1.41)	1.05 (0.81, 1.35)	0.94 (0.72, 1.23)	2.22 (1.81, 2.73)	3.19 (2.59, 3.94)
19-40 y, %	15.1	23.9	14.3	12.1	43.1	63.8
41-64 y, %	25.4	35.5	21.9	19.4	41.6	62.1
41-64 y vs 19-40 y, OR (95% CI)	2.02 (1.56, 2.62)	1.84 (1.46, 2.30)	1.71 (1.31, 2.23)	1.77 (1.33, 2.34)	0.98 (0.80, 1.21)	0.98 (0.79, 1.21)
Non-manual, %	24.3	35.1	22.7	19.7	43.6	65.8
Manual, %	15.7	23.3	12.3	10.9	40.2	58.3
Non-manual vs manual, OR (95% CI)	1.76 (1.35, 2.28)	1.81 (1.43, 2.27)	2.11 (1.59, 2.79)	2.01 (1.50, 2.70)	1.16 (0.95, 1.43)	1.42 (1.15, 1.76)
White, %	20.1	29.6	18.5	16.2	40.9	61.4
Non-white, %	28.3	37.7	19.5	16.4	54.7	75.5
Non-white vs white, OR (95% CI)	1.90 (1.30, 2.78)	1.71 (1.21, 2.43)	1.24 (0.81, 1.90)	1.18 (0.75, 1.86)	1.80 (1.28, 2.53)	2.07 (1.40, 3.07)
Odds ratios are adjusted for sex, age, socioeconomic position, and ethnicity.						

Non-disaggregated and disaggregated average daily intake estimates were available for respondents in the NDNS Rolling Programme. Non-disaggregated estimates code 100% of a mixed dish by its meat/fish component, e.g. lamb stew is coded as 100% lamb. Disaggregated estimates separate a mixed dish into its individual ingredients, e.g. the same lamb stew could be 60% lamb, 10% onions, 5% carrots etc. We compared adherence to dietary recommendations for fruit and vegetables, oily fish, and red and processed meat using both methods of intake estimation, overall and across sociodemographic subgroups. The methods used for disaggregated data were the same as the methods used for the non-disaggregated data presented in the main report. Overall adherence to the recommendation was 10% higher for fruit and vegetables, 2% lower for oily fish, and 20% higher for red and processed meat, when using disaggregated estimates compared to non-disaggregated estimates. The inequalities observed were similar between the two intake estimation methods for the fruit and vegetables and oily fish recommendations. For red and processed meat, we saw greater sex and socioeconomic inequalities when using disaggregated data compared to non-disaggregated data, but similar odds ratios for age and ethnic inequalities.

Appendix B: Supplementary material for chapter 3

Supplementary Table B1. Questions used to assess food security status (adapted from USDA's Adult Food Security Survey Module)

	Question	Responses	Score
HH1	Which of these statements best describes the food eaten in your household in the last 12 months:	You and other household members always had enough of the kinds of foods you wanted to eat.	N/A
		You and other household members had enough to eat, but not always the kinds of food you wanted.	
		Sometimes you and other household members did not have enough to eat.	
		Often you and other household members didn't have enough to eat.	
		Don't know	
		Refuse to answer	
Now you will see several statements that may be used to describe the food situation for a household. Please indicate if the statement was often true, sometimes true, or never true for you and other household members IN THE PAST 12 MONTHS.			
HH2	You and other household members worried that food would run out before you got money to buy more.	Often true	1
		Sometimes true	1
		Never true	0
		Don't know	0
		Refuse to answer	N/A
HH3	The food that you and other household members bought just didn't last, and there wasn't any money to get more.	Often true	1
		Sometimes true	1
		Never true	0
		Don't know	0
		Refuse to answer	N/A
HH4	You and other household members couldn't afford to eat balanced meals.	Often true	1
		Sometimes true	1
		Never true	0
		Don't know	0
		Refuse to answer	N/A
If affirmative response (i.e., "often true" or "sometimes true") to one or more of questions HH2-HH4, OR, response "sometimes" or "often" to question HH1 (if administered), then continue to Adult Stage 2.			

	Question	Responses	Score
AD1	In the last 12 months, since last (name of current month), did you or other adults in your household ever reduce the size of your meals or skip meals because there wasn't enough money for food?	Yes	1
		No	0
		Don't know	0
		Refuse to answer	N/A
AD1a	How often did this happen—almost every month, some months but not every month, or in only 1 or 2 months?	Almost every month	1
		Some months but not every month	1
		Only 1 or 2 months	0
		Don't know	0
		Refuse to answer	N/A
AD2	In the last 12 months, did you ever eat less than you felt you should because there wasn't enough money for food?	Yes	1
		No	0
		Don't know	0
		Refuse to answer	N/A
AD3	In the last 12 months, were you ever hungry but didn't eat because there wasn't enough money for food?	Yes	1
		No	0
		Don't know	0
		Refuse to answer	N/A
AD4	In the last 12 months, did you lose weight because there wasn't enough money for food?	Yes	1
		No	0
		Don't know	0
		Refuse to answer	N/A
If affirmative response to one or more of questions AD1 through AD4, then continue to Adult Stage 3; otherwise skip to End of Food Security Module.			
AD5	In the last 12 months, did you or other adults in your household ever not eat for a whole day because there wasn't enough money for food?	Yes	1
		No	0
		Don't know	0
		Refuse to answer	N/A
AD5a	How often did this happen—almost every month, some months but not every month, or in only 1 or 2 months?	Almost every month	1
		Some months but not every month	1
		Only 1 or 2 months	0
		Don't know	0
		Refuse to answer	N/A

Supplementary Table B2. F statistic (*P*-value) for interactions between sociodemographic characteristics and food security status on dietary and health outcomes

Interaction	Fruit	Vegetables	Juice	Diet	General health	Mental health	Stress	BMI
AFI#Sex	1.40 (0.24)	9.50 (<0.0001)***	7.08 (0.0001)***	1.74 (0.16)	2.45 (0.06)	2.86 (0.04)	0.90 (0.44)	7.75 (<0.0001)***
AFI#Age	8.34 (<0.0001)***	2.58 (0.05)*	1.57 (0.19)	1.96 (0.12)	2.63 (0.05)*	11.84 (<0.0001)***	7.05 (0.0001)***	32.03 (<0.0001)***
AFI#Ethnicity	0.96 (0.48)	1.56 (0.11)	2.16 (0.01)**	1.62 (0.09)	1.17 (0.30)	1.06 (0.39)	0.67 (0.77)	1.02 (0.43)
AFI#Household Composition	0.85 (0.55)	1.15 (0.33)	1.45 (0.18)	0.55 (0.80)	1.29 (0.25)	3.33 (0.002)**	1.44 (0.18)	0.88 (0.53)

AFI, adult food insecurity. BMI, body mass index.
* P≤0.05, **P≤0.01, ***P≤0.001

Supplementary Table B3. Characteristics of the full analytical sample, BMI sub-sample, and the UK population

Characteristic	Overall sample	BMI sub-sample	Overall sample vs BMI sub-sample Pearson's F Statistic (*P*-Value)	UK population [source]
Food Insecurity, % (95% CI where available)				
Food Secure	75.7 (73.7, 77.6)	78.2 (76.0, 80.3)	2.74 (0.10)	92 [Food & You, 2017]
Food Insecure	24.3 (22.4, 26.3)	21.8 (19.7, 24.1)		8 [Food & You, 2017]
Sex, % (95% CI where available)				
Male	48.9 (46.7, 51.2)	51.3 (48.7, 53.9)	1.81 (0.18)	49.3 [2016 mid-year estimates]
Female	51.1 (48.8, 53.3)	48.7 (46.1, 51.3)		50.7 [2016 mid-year estimates]
Age, median (IQR)	44 (32, 54)	45 (32, 55)	1.80 (0.18)	41 (22, 53) [2016 mid-year estimates]
Ethnicity, % (95% CI where available)				
White British	85.2 (83.5, 86.7)	84.2 (82.2, 86.0)	0.34 (0.88)	80.5 [Census 2011]
White other	4.6 (3.8, 5.7)	5.2 (4.2, 6.4)		5.5 [Census 2011]
Mixed	2.5 (1.9, 3.3)	2.8 (2.1, 3.8)		2.2 [Census 2011]
Asian	4.1 (3.3, 5.1)	4.6 (3.7, 5.8)		7.5 [Census 2011]
Black	1.5 (1.1, 2.1)	1.3 (0.8, 1.9)		3.3 [Census 201]
Other & unknown	2.1 (1.5, 3.1)	1.9 (1.2, 3.1)		1.0 [Census 2011]
Household composition, % (95% CI where available)				
No other adults, no children	15.2 (13.6, 16.9)	16.1 (14.2, 18.1)	0.45 (0.72)	28.3 [Families and Households 2017]
Other adults, no children	52.0 (49.7, 54.2)	52.9 (50.3, 5.5)		31.8 [Families and Households 2017]
No other adults, with children	5.8 (4.8, 7.1)	5.3 (4.1, 6.7)		6.2 [Families and Households 2017]
Other adults, with children	27.0 (25.0, 29.1)	25.8 (23.6, 28.1)		30.1 [Families and Households 2017]
Employment, % (95% CI where available)				
Full time	57.2 (55.0, 59.4)	58.9 (56.3, 61.4)	0.63 (0.64)	74.5 [UK Labour Market Jan 2017[a]]
Part time	18.5 (16.8, 20.3)	18.2 (16.3, 20.3)		
Looking for work	4.7 (3.9, 5.7)	4.1 (3.2, 5.2)		4.8[b] [UK Labour Market Jan 2017]
Not looking for work	19.2 (17.5, 21.0)	18.6 (16.7, 20.7)		21.7[c] [UK Labour Market Jan 2017]
Unknown	0.4 (0.2, 0.9)	0.2 (0.04, 0.8)		N/A
Student status, % (95% CI where available)				
No	87.1 (85.6, 88.5)	87.5 (85.8, 89.0)	0.10 (0.95)	Data unavailable
Yes, full time	8.6 (7.5, 9.9)	8.5 (7.3, 10.0)		7 [Census 2011]
Yes, part time	4.1 (3.4, 5.1)	3.8 (3.0, 4.9)		2.3 [Universities UK 2015[d]]
Unknown	0.1 (0.03, 0.6)	0.2 (0.04, 0.8)		N/A

Characteristic	Overall sample	BMI sub-sample	Overall sample vs BMI sub-sample Pearson's F Statistic (*P*-Value)	UK population [source]
Making ends meet, % (95% CI where available)				
Difficult	22.1 (20.2, 24.1)	19.6 (17.6, 21.7)	1.93 (0.12)	12[e] [YouGov DebtTrack 2013[f]]
Neither easy nor difficult	33.4 (31.3, 35.6)	32.6 (30.2, 35.0)		40[g] [YouGov DebtTrack 2013]
Easy	44.0 (41.8, 46.3)	47.6 (45.0, 50.2)		43[h] [YouGov DebtTrack 2013]
Unknown	0.5 (0.3, 0.9)	0.3 (0.1, 0.8)		5 [YouGov DebtTrack 2013]
Education, % (95% CI where available)				
Low	29.0 (26.9, 31.1)	26.0 (23.8, 28.4)	1.95 (0.12)	49.7 [Census 2011]
Medium	27.2 (25.2, 29.3)	26.9 (24.6, 29.2)		12.2 [Census 2011]
High	43.4 (41.2, 45.6)	46.8 (44.3, 49.4)		28.6 [Census 2011]
Unknown	0.5 (0.2, 0.9)	0.3 (0.1, 0.6)		N/A
Body mass index, % (95% CI where available)				
Underweight	N/A	4.6 (3.7, 5.8)	N/A	2 [Health Survey for England 2016]
Normal	N/A	46.7 (44.1, 49.3)		37 [Health Survey for England 2016]
Overweight	N/A	31.3 (28.9, 33.8)		35 [Health Survey for England 2016]
Obese	N/A	17.4 (15.5, 19.5)		26 [Health Survey for England 2016]
Unknown	N/A	N/A		N/A

[a] ages 16-64 years included in the UK Labour Market January 2017
[b] unemployed
[c] inactive
[d] estimated from Patterns and Trends in UK Higher Education 2015, Universities UK: https://www.universitiesuk.ac.uk/policy-and-analysis/reports/Documents/2015/patterns-and-trends-2015.pdf
[e] Keeping up with bills and credit commitments is a heavy burden
[f] Subjective indicator of financial difficulties for Credit, Debt and Financial Difficulty in Britain 2012, Department for Business Innovation and Skills: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/208075/bis-13-p187-a-report-using-data-from-the-yougov-debttrack-survey.pdf
[g] Keeping up with bills and credit commitments is somewhat of a burden
[h] Keeping up with bills and credit commitments is not a burden at all

Supplementary Table B4. Odds ratio (95% CI) from adjusted logistic regression models for association between sociodemographic characteristics and diet and health outcomes

Sociodemographic characteristic		Fruit	Vegetable	Fruit juice	Healthiness of diet	General health	Mental health	Stress	BMI
Adult food insecurity	Food secure	REF	REF	REF	REF	REF	REF	REF	REF
	Food insecure	0.59 (0.47, 0.74) ***	0.68 (0.54, 0.86)**	1.39 (1.10, 1.75)**	1.65 (1.31, 2.09) ***	1.90 (1.50, 2.41) ***	2.10 (1.64, 2.69) ***	3.15 (2.42, 4.11) ***	1.32 (1.00, 1.75)*
Sex	Male	REF	REF	REF	REF	REF	REF	REF	REF
	Female	1.17 (0.97, 1.42)	1.53 (1.27, 1.84) ***	0.66 (0.54, 0.79)	0.99 (0.81, 1.20)	0.99 (0.81, 1.22)	1.39 (1.12, 1.74)**	1.17 (0.91, 1.50)	0.59 (0.48, 0.74) ***
Age		1.02 (1.01, 1.02) ***	1.00 (1.00, 1.01)	0.99 (0.99, 1.00)	0.99 (0.99, 1.00)	1.00 (1.00, 1.01)	0.98 (0.97, 0.99) ***	0.99 (0.98, 1.00)*	1.04 (1.03, 1.05) ***
Ethnicity	White British	REF	REF	REF	REF	REF	REF	REF	REF
	White other	1.28 (0.80, 2.05)	1.16 (0.73, 1.85)	1.31 (0.85, 2.01)	0.91 (0.56, 1.46)	0.54 (0.31, 0.96)*	0.67 (0.37, 1.20)	1.19 (0.68, 2.10)	1.15 (0.72, 1.84)
	Mixed	1.14 (0.65, 2.00)	0.91 (0.51, 1.63)	1.27 (0.70, 2.30)	0.65 (0.34, 1.26)	0.58 (0.29, 1.16)	0.99 (0.50, 1.93)	0.95 (0.43, 2.08)	1.71 (0.88, 3.30)
	Asian	1.10 (0.69, 1.75)	1.12 (0.69, 1.80)	1.04 (0.66, 1.64)	1.10 (0.69, 1.75)	0.99 (0.61, 1.60)	0.64 (0.38, 1.05)	0.69 (0.36, 1.31)	1.10 (0.65, 1.86)
	Black	0.97 (0.49, 1.94)	0.98 (0.49, 1.99)	1.11 (0.53, 2.34)	0.37 (0.15, 0.92)*	0.65 (0.28, 1.55)	0.39 (0.14, 1.09)	0.37 (0.14, 0.99)*	2.02 (0.77, 5.29)
	Other & unknown	0.95 (0.42, 2.14)	0.90 (0.44, 1.88)	1.10 (0.51, 2.38)	1.69 (0.75, 3.80)	1.21 (0.49, 3.00)	0.90 (0.28, 2.93)	0.71 (0.30, 1.67)	0.87 (0.29, 2.58)
Household composition	No other adults, no children	REF	REF	REF	REF	REF	REF	REF	REF
	Other adults, no children	1.21 (0.91, 1.61)	0.92 (0.71, 1.21)	1.16 (0.88, 1.53)	0.79 (0.59, 1.04)	0.70 (0.53, 0.93)*	0.57 (0.42, 0.78) ***	0.75 (0.52, 1.08)	1.12 (0.81, 1.54)
	No other adults, with children	1.55 (0.93, 2.57)	0.84 (0.53, 1.33)	1.11 (0.67, 1.82)	0.97 (0.59, 1.57)	0.72 (0.44, 1.20)	0.84 (0.50, 1.39)	1.22 (0.67, 2.20)	1.69 (0.93, 3.06)
	Other adults, with children	1.27 (0.93, 1.75)	0.79 (0.59, 1.07)	1.52 (1.12, 2.08)	0.82 (0.60, 1.13)	0.69 (0.50, 0.95) *	0.46 (0.32, 0.65) ***	0.85 (0.57, 1.27)	1.23 (0.86, 1.76)

N/A, not applicable. BMI, body mass index.
* P≤0.05, **P≤0.01, ***P≤0.001

Supplementary Table B5. Odds ratio (95% CI) from sensitivity analysis for adjusted logistic regression models looking at association between adult food insecurity and frequency of fruit, fruit juice, and vegetable intake with additional adjustment for socioeconomic variables

		Fruit (*n*=2551)	**Vegetable** (*n*=2551)	**Fruit Juice** (*n*=2551)
Adult food insecurity	Food secure	REF	REF	REF
	Food insecure	0.63 (0.48, 0.82)**	0.72 (0.54, 0.95)*	1.45 (1.11, 1.89)**
Sex	Male	REF	REF	REF
	Female	1.14 (0.93, 1.40)	1.50 (1.23, 1.82)***	0.70 (0.57, 0.86)**
Age		1.02 (1.01, 1.03)***	1.01 (1.00, 1.01)	1.00 (0.99, 1.01)
Ethnicity	White British	REF	REF	REF
	White other	1.23 (0.75, 2.00)	1.05 (0.65, 1.68)	1.25 (0.81, 1.93)
	Mixed	1.05 (0.59, 1.85)	0.83 (0.46, 1.05)	1.17 (0.64, 2.13)
	Asian	1.02 (0.63, 1.64)	0.99 (0.62, 1.59)	1.02 (0.65, 1.60)
	Black	0.96 (0.49, 1.89)	0.91 (0.41, 2.02)	1.05 (0.50, 2.24)
	Other & unknown	1.02 (0.41, 2.57)	0.92 (0.43, 1.99)	0.87 (0.35, 2.14)
Household composition	No other adults, no children	REF	REF	REF
	Other adults, no children	1.21 (0.91, 1.62)	0.93 (0.71, 1.23)	1.17 (0.88, 1.55)
	No other adults, with children	1.68 (1.00, 2.81)	0.94 (0.59, 1.48)	1.19 (0.72, 1.97)
	Other adults, with children	1.31 (0.95, 1.80)	0.81 (0.59, 1.10)	1.58 (1.16, 2.17)**
Employment status	Full time	REF	REF	REF
	Part time	1.22 (0.93, 1.59)	1.11 (0.86, 1.44)	0.82 (0.63, 1.07)
	Looking for work	1.02 (0.65, 1.60)	1.21 (0.78, 1.86)	0.77 (0.49, 1.21)
	Not looking for work	1.06 (0.81, 1.38)	1.14 (0.88, 1.48)	0.81 (0.63, 1.05)
Student status	No	REF	REF	REF
	Yes, full time	1.11 (0.77, 1.59)	1.23 (0.84, 1.80)	1.48 (1.04, 2.10)*
	Yes, part time	1.04 (0.65, 1.64)	1.42 (0.92, 2.20)	1.62 (1.03, 2.56)*
Making ends meet	Difficult	REF	REF	REF
	Neither easy nor difficult	0.84 (0.63, 1.12)	0.88 (0.66, 1.17)	1.03 (0.78, 1.37)
	Easy	1.01 (0.75, 1.35)	1.00 (0.74, 1.33)	1.23 (0.92, 1.65)
Education	Low	REF	REF	REF
	Medium	1.10 (0.85, 1.43)	1.32 (1.02, 1.71)*	0.81 (0.62, 1.04)
	High	1.58 (1.24, 2.01)***	1.88 (1.48, 2.38)***	0.97 (0.76, 1.23)

Logistic regression models mutually adjusted for sex, age, ethnicity, household composition, employment status, student status, ability, make ends meet, and educational level.
* P≤0.05, **P≤0.01, ***P≤0.001

Supplementary Table B6. Odds ratio (95%CI) from sensitivity analysis for adjusted logistic regression models looking at association between adult food insecurity and self-reported healthiness of diet and health with additional adjustment for socioeconomic variables

		Poor healthiness of diet (*n*=2551)	**Poor general health** (*n*=2551)	**Poor mental health** (*n*=2551)	**High stress** (*n*=2551)	**Overweight** (*n*=1949)
Adult food insecurity	Food secure	REF	REF	REF	REF	REF
	Food insecure	1.17 (0.89, 1.53)	1.15 (0.88, 1.51)	1.09 (0.83, 1.45)	2.16 (1.59, 2.95)***	1.28 (0.93, 1.77)
Sex	Male	REF	REF	REF	REF	REF
	Female	0.95 (0.77, 1.17)	0.86 (0.69, 1.07)	1.23 (0.98, 1.55)	1.30 (0.99, 1.69)	0.56 (0.45, 0.71)***
Age		0.99 (0.98, 1.00)**	1.00 (0.99, 1.00)	0.97 (0.97, 0.98)***	0.99 (0.98, 1.00)*	1.03 (1.02, 1.04)***
Ethnicity	White British	REF	REF	REF	REF	REF
	White other	1.01 (0.61, 1.67)	0.63 (0.36, 1.10)	0.80 (0.46, 1.42)	1.20 (0.68, 2,12)	1.15 (0.71, 1.84)
	Mixed	0.82 (0.44, 1.53)	0.75 (0.39, 1.45)	1.22 (0.64, 2.35)	1.07 (0.50, 2.28)	1.93 (0.99, 3.75)
	Asian	1.29 (0.81, 2.07)	1.20 (0.73, 1.96)	0.74 (0.44, 1.26)	0.70 (0.37, 1.32)	1.12 (0.65, 1.92)
	Black	0.39 (0.15, 1.01)	0.71 (0.29, 1.77)	0.37 (0.12, 1.17)	0.34 (0.12, 0.93)*	2.17 (0.77, 6.08)
	Other & unknown	2.30 (0.97, 5.44)	1.58 (0.60, 4.20)	1.36 (0.39, 4.78)	0.91 (0.37, 2.26)	0.65 (0.21, 2.02)
Household composition	No other adults, no children	REF	REF	REF	REF	REF
	Other adults, no children	0.83 (0.62, 1.11)	0.74 (0.54, 1.00)	0.57 (0.41, 0.78)***	0.79 (0.54, 1.16)	1.18 (0.85, 1.63)
	No other adults, with children	0.83 (0.50, 1.39)	0.60 (0.35, 1.03)	0.67 (0.39, 1.17)	1.20 (0.68, 2.13)	1.59 (0.87, 2.91)
	Other adults, with children	0.83 (0.60, 1.16)	0.73 (0.52, 1.03)	0.47 (0.32, 0.67)***	0.83 (0.54, 1.26)	1.25 (0.87, 1.79)
Employment status	Full time	REF	REF	REF	REF	REF
	Part time	0.94 (0.71, 1.24)	1.04 (0.78, 1.39)	1.08 (0.80, 1.46)	0.48 (0.34, 0.68)***	1.01 (0.74, 1.38)
	Looking for work	1.38 (0.88, 2.18)	1.74 (1.10, 2.78)*	1.81 (1.13, 2.91)*	0.71 (0.42, 1.19)	1.10 (0.62, 1.93)
	Not looking for work	1.26 (0.97, 1.64)	2.04 (1.56, 2.68)***	1.68 (1.26, 2.23)***	0.87 (0.63, 1.22)	1.43 (1.05, 1.94)*
Student status	No	REF	REF	REF	REF	REF
	Yes, full time	0.51 (0.35, 0.76)**	0.58 (0.38, 0.89)*	0.78 (0.51, 1.20)	0.98 (0.63, 1.54)	0.55 (0.36, 0.84)**
	Yes, part time	0.51 (0.31, 0.84)	0.67 (0.39, 1.13)	1.14 (0.69, 1.87)	1.06 (0.60, 1.87)	0.66 (0.38, 1.16)
Making ends meet	Difficult	REF	REF	REF	REF	REF
	Neither easy nor difficult	0.62 (0.47, 0.82)**	0.49 (0.37, 0.65)***	0.37 (0.28, 0.50)***	0.49 (0.35, 0.67)***	0.91 (0.65, 1.27)
	Easy	0.50 (0.37, 0.67)**	0.39 (0.29, 0.52)***	0.31 (0.23, 0.43)***	0.40 (0.28, 0.56)***	0.80 (0.57, 1.13)
Education	Low	REF	REF	REF	REF	REF
	Medium	0.73 (0.56, 0.95)*	0.74 (0.56, 0.97)*	0.65 (0.48, 0.88)**	0.98 (0.70, 1.39)	1.05 (0.77, 1.44)
	High	0.62 (0.49, 0.79)***	0.62 (0.48, 0.80)***	0.63 (0.48, 0.83)***	1.19 (0.88, 1.61)	0.88 (0.67, 1.16)

Logistic regression models adjusted for sex, age, ethnicity, household composition, employment status, student status, ability, make ends meet, and educational level.
* P≤0.05, **P≤0.01, ***P≤0.001

Appendix C: Supplementary material for chapter 4

Supplementary Table C1. Included articles by year and publication

Newspaper	2016	2017	2018	2019	Total
The Independent	20 (27.8)	58 (42.3)	33 (24.1)	20 (22.2)	131
The Guardian/The Observer	24 (33.3)	26 (20.0)	38 (27.7)	22 (24.4)	110
The Daily Mirror/Sunday Mirror	11 (15.2)	20 (14.6)	31 (22.6)	13 (14.4)	75
The Sun/Sunday Sun	4 (5.6)	11 (8.0)	13 (9.5)	12 (13.3)	40
The Times/Sunday Times	1 (1.4)	6 (4.4)	9 (6.6)	8 (8.9)	24
The Daily Express/The Daily Express	3 (4.2)	5 (3.6)	2 (1.5)	1 (1.1)	11
Financial Times	5 (6.9)	2 (1.5)	4 (2.9)	0 (0.0)	11
Daily Star	2 (2.8)	3 (2.2)	2 (1.5)	1 (1.1)	8
Sunday People	1 (1.4)	1 (0.8)	4 (2.9)	2 (2.2)	8
Morning Star	0 (0.0)	0 (0.0)	0 (0.0)	7 (7.8)	7
Daily Mail/Mail on Sunday	0 (0.0)	4 (2.9)	1 (0.8)	2 (2.2)	7
The Daily Telegraph	1 (1.4)	1 (0.8)	0 (0.0)	2 (2.2)	4
	72 (100.0)	137 (100.0)	137 (100.0)	90 (100.0)	436 (100.0)

Key (by year)
Newspaper with the highest number of articles
Newspaper with ≥10 articles
Newspaper with ≥5 articles
Newspaper with ≥3 articles
Newspaper with ≤3 articles

Appendix D: Supplementary material for chapter 5

Supplementary Table D1. DHD15-Index dietary components included in chapter 5

Dietary Component	Inclusion/Exclusion/Restriction	Recommendation	Threshold (0 point)	Cut-off (10 points)
Vegetables	**Included:** frozen and canned, peas, salad **Excluded:** legumes, potatoes	Increase consumption	0g/day	≥200g/day
Fruit	**Included:** fresh fruit **Excluded:** dried fruit, apple sauce, fruit juice	Increase consumption	0g/day	≥200g/day
Wholegrains*	**Included:** staple cereal products e.g. bread, couscous, muesli, pasta, rice **Excluded:** snack cereal products e.g. biscuits	Increase consumption	a) 0g/day	90g/day (5 points)
		Replace refined grains with wholegrains	b) wholegrain to refined grain ratio ≤0.7	wholegrain to refined grain ratio ≥11 (5 points)
Legumes	**Included:** pulses, lentils, beans, chickpeas **Excluded:** peas, peanuts	Increase consumption	0g/day	≥10g/day
Nuts & seeds	Nuts and seeds only	Increase consumption	0g/day	≥15g/day
Dairy	**Included:** milk, milk products, yoghurt, cheese, cream, custard, porridge prepared with dairy **Restricted:** Up to 40g/day of cheese was included	Maintain consumption within optimal range	0g/day (lower threshold)	300g/day-450g/day
			≥750g/day (upper threshold)	
Fish	**Included:** all oily fish **Restricted:** Up to 4g/day of lean fish and crustaceans/molluscs was included	Increase consumption	0g/day	≥15g/day
Tea	Black or green tea only	Increase consumption	0g/day	≥450g/day
Cooking fats & oils	**Solid:** butter, hard margarine **Liquid/soft:** oils, soft margarine, halvarine	Replace solid fats with liquid/soft fats	Liquid/soft to solid ratio ≤0.6	Liquid/soft to solid ratio ≥13
Red meat	**Included:** beef, pork, duck, pheasant, offal, game	Limit consumption	≥100g/day	≤45g/day
Processed meat	**Included:** red and white processed meat	Limit consumption	≥50g/day	0g/day
SSBs & fruit juices	**Included:** sugar-sweetened soft drinks, sugar-sweetened dairy drinks, fruit juice	Limit consumption	≥250g/day	0g/day
Alcohol		Limit consumption	Men: ≥30g ethanol/day Women: ≥20g ethanol/day	≤10g ethanol/day
DHD15-Index	Sum of all 13 food groups	N/A	Minimum score: 0	Maximum score: 130

SSBs, sugar-sweetened beverages. *products containing ≥25% wholegrain flour

Participants were scored between 0 and 10 for each component based on their estimated intake. The cut-off value was awarded 10 out of 10 and the threshold value was given 0 out of 10, with intakes in between scored proportionately. Most food groups use a maximum or minimum as the cut-off value and threshold value. However, for dairy, those who consumed 300g/day-450g/day achieved 10 out of 10, and those who ate less or more received a lower score. Some food items were limited in how much they could contribute to meeting a recommendation (lean fish, crustaceans/molluscs, and cheese).

Supplementary Table D2. Beta-coefficients (95% confidence intervals) from adjusted linear regression models for association between DHD15-Index and educational level in men

		Dutch β (95% CI)	**South-Asian Surinamese** β (95% CI)	**African Surinamese** β (95% CI)	**Turkish** β (95% CI)	**Moroccan** β (95% CI)
Model 1	Higher	REF	REF	REF	REF	REF
	Intermediate	-8.4 (-11.6, -5.2)***	3.3 (-0.5, 7.1)	0.9 (-3.9, 5.7)	-3.3 (-8.5, 1.8)	-1.6 (-6.7, 3.5)
	Lower	-10.3 (-14.3, -6.3)***	-2.5 (-6.3, 1.3)	-0.4 (-4.9, 4.1)	-6.6 (-11.7, -1.5)*	-2.7 (-8.3, 2.8)
	Elementary	-11.0 (-20.0, -2.0)*	-6.2 (-11.2, -1.1)*	-7.9 (-16.8, 0.9)	-7.3 (-13.2, -1.3)*	0.7 (-5.2, 6.5)
Model 2	Higher	REF	REF	REF	REF	REF
	Intermediate	-8.3 (-11.5, -5.0)***	3.3 (-0.5, 7.2)	0.8 (-4.0, 5.6)	-1.8 (-7.2, 3.5)	-1.8 (-6.9, 3.3)
	Lower	-10.3 (-14.3, -6.3)***	-2.5 (-6.3, 1.4)	-0.9 (-5.5, 3.6)	-5.9 (-11.1, -0.6)*	-2.9 (-8.5, 2.7)
	Elementary	-11.2 (-20.2, -2.2)*	-6.1 (-11.1, -1.0)*	-9.2 (-18.1, -0.3)*	-6.3 (-12.3, -0.3)*	0.4 (-5.5, 6.4)
Model 3	Higher	REF	REF	REF	REF	REF
	Intermediate	-7.6 (-10.8, -4.5)***	2.9 (-0.8, 6.6)	0.9 (-3.9, 5.6)	-1.1 (-6.3, 4.0)	2.8 (-7.9, 2.2)
	Lower	-9.5 (-13.4, -5.6)***	-1.7 (-5.6, 2.1)	-0.4 (-4.9, 4.1)	-5.3 (-10.4, -0.2)*	-2.8 (-8.3, 2.7)
	Elementary	-10.0 (-18.8, -1.3)*	-5.3 (-10.3, -0.3)*	-7.3 (-16.2, 1.5)	-5.3 (-11.2, 0.6)	0.4 (-5.4, 6.2)
Model 4	Higher	REF	REF	REF	REF	REF
	Intermediate	-6.8 (-10.0, -3.6)***	3.0 (-0.8, 6.7)	0.5 (-4.3, 5.2)	-0.8 (-6.1, 4.5)	-3.5 (-8.4, 1.5)
	Lower	-8.7 (-12.7, -4.8)***	-1.9 (-5.7, 2.0)	-1.1 (-5.6, 3.4)	-5.1 -10.3, 0.1)	-2.9 (-8.3, 2.5)
	Elementary	-8.0 (-16.9, 0.8)	-5.4 (-10.4, -0.4)*	-7.2 (-16.1, 1.6)	-5.0 (-11.1, 1.1)	-0.0 (-5.7, 5.6)
	P_{trend}	<0.0001***	0.01**	0.35	0.11	0.36

β, beta coefficient, CI, confidence interval.
Model 1 adjusted for age. Model 2: model 1 + adjusted for marital status, number of people in the household. Model 3: model 2 + adjusted for smoking status, physical activity, energy intake. Model 4: adjusted for model 3 + presence of one or more chronic disease, body mass index.
* $P \leq 0.05$, ** $P \leq 0.01$, *** $P \leq 0.001$

Supplementary Table D3. Beta-coefficients (95% confidence intervals) from adjusted linear regression models for association between DHD15-Index and educational level in women

		Dutch β (95% CI)	**South-Asian Surinamese** β (95% CI)	**African Surinamese** β (95% CI)	**Turkish** β (95% CI)	**Moroccan** β (95% CI)
Model 1	Higher	REF	REF	REF	REF	REF
	Intermediate	-4.8 (-7.5, -2.1)***	-1.7 (-5.2, 1.8)	-4.1 (-6.8, -1.3)**	-2.6 (-7.0, 1.8)	-4.7 (-8.6, -0.7)*
	Lower	-8.3 (-11.5, -5.0)***	-2.3 (-5.8, 1.2)	-5.9 (-8.8, -2.9)***	-4.4 (-9.4, 0.5)	-4.8 (-9.5, -0.1)*
	Elementary	-15.8 (-23.4, -8.1)***	-3.9 (-8.4, 0.6)	-5.4 (-12.0, 1.1)	-2.5 (-7.2, 2.2)	-4.4 (-9.1, 0.3)
Model 2	Higher	REF	REF	REF	REF	REF
	Intermediate	-4.7 (-7.4, -2.0)***	-1.5 (-5.1, 2.0)	-4.0 (-6.8, -1.3)**	-3.4 (-7.8, 1.1)	-5.1 (-9.1, -1.1)*
	Lower	-8.3 (-11.5, -5.0)***	-2.5 (-6.0, 1.0)	-6.0 (-8.9, -3.0)***	-5.4 (-10.4, -0.4)*	-5.8 (-10.6, -1.1)*
	Elementary	-15.8 (-23.4, -8.1)***	-3.7 (-8.2, 0.8)	-5.6 (-12.2, 1.0)	-3.6 (-8.3, 1.2)	-5.3 (-10.1, -0.5)*
Model 3	Higher	REF	REF	REF	REF	REF
	Intermediate	-3.9 (-6.6, -1.3)**	-2.3 (-5.8, 1.2)	-3.6 (-6.4, -0.8)*	-2.7 (-7.0, 1.7)	-5.4 (-9.4, -1.4)**
	Lower	-6.3 (-9.5, -3.1)***	-3.3 (-6.7, 0.1)	-5.4 (-8.4, -2.5)***	-3.8 (-8.8, 1.1)	-5.5 (-10.1, -0.8)*
	Elementary	-12.7 (-20.2, -5.2)***	-3.8 (-8.2, 0.6)	-5.2 (-11.8, 1.3)	-3.3 (-8.0, 1.3)	-5.4 (-10.1, -0.6)*
Model 4	Higher	REF	REF	REF	REF	REF
	Intermediate	-3.7 (-6.3, -1.0)**	-2.5 (-6.1, 1.0)	-3.7 (-6.4, -0.9)**	-2.0 (-6.5, 2.4)	-5.5 (-9.5, -1.6)**
	Lower	-5.7 (-8.9, -2.4)***	-3.6 (-7.0, -0.1)*	-5.7 (-8.7, -2.7)***	-2.8 (-7.9, 2.4)	-5.6 (-10.3, -0.9)*
	Elementary	-11.9 (-19.4, -4.4)**	-4.3 (-8.7, 0.1)	-5.6 (-12.1, 1.0)	-2.3 (-7.2, 2.6)	-5.7 (-10.6, -0.9)*
	P_{trend}	0.0001***	0.16	0.002**	0.72	0.04*

β, beta coefficient. CI, confidence interval.
Model 1 adjusted for age. Model 2: model 1 + adjusted for marital status, number of people in the household. Model 3: model 2 + adjusted for smoking status, physical activity, energy intake. Model 4: adjusted for model 3 + presence of one or more chronic disease, body mass index.
* $P \leq 0.05$, ** $P \leq 0.01$, *** $P \leq 0.001$

Supplementary Table D4. Beta-coefficients (95% confidence intervals) from adjusted linear regression models for association between DHD15-Index and occupational status in men

		Dutch β (95% CI)	**South-Asian Surinamese** β (95% CI)	**African Surinamese** β (95% CI)	**Turkish** β (95% CI)	**Moroccan** β (95% CI)
Model 1	Higher	REF	REF	REF	REF	REF
	Intermediate	-8.8 (-12.0, -5.6)***	0.7 (-3.3, 4.8)	0.8 (-4.4, 6.0)	-6.6 (-12.7, -0.4)*	1.1 (-4.7, 6.8)
	Elementary	-8.8 (-12.7, -4.8)***	-1.8 (-5.5, 1.9)	-1.2 (-5.8, 3.3)	-6.6 (-11.7. -1.4)*	-3.0 (-8.2, 2.1)
	Unknown/not in workforce	-6.1 (-13.0, 0.8)	-2.7 (-9.2, 3.9)	0.7 (-7.0, 8.5)	-8.2 (-16.8, 0.4)	-9.1 (-18.6, 0.5)
Model 2	Higher	REF	REF	REF	REF	REF
	Intermediate	-8.8 (-12.1, -5.6)***	0.9 (-3.2, 5.0)	0.9 (-4.3, 6.1)	-5.7 (-11.9. 0.6)	1.0 (-4.7, 6.7)
	Elementary	-8.4 (-12.4, -4.5)***	-1.7 (-5.5, 2.0)	-1.8 (-6.4, 2.8)	-5.7 (-11.0, -0.4)*	-3.2 (-8.4, 2.0)
	Unknown/not in workforce	-6.1 (-12.9, 0.8)	-2.6 (-9.2, 3.9)	1.0 (-6.7, 8.8)	-6.8 (-15.5, 1.9)	-8.9 (-18.5, 0.7)
Model 3	Higher	REF	REF	REF	REF	REF
	Intermediate	-9.0 (-12.1, -5.9)***	1.2 (-2.7, 5.2)	1.6 (-3.5, 6.7)	-4.5 (-10.6, 1.7)	-0.0 (-5.6, 5.6)
	Elementary	-8.7 (-12.6, -4.8)***	-1.5 (-5.2, 2.2)	-1.1 (-5.7, 3.4)	-4.8 (-10.0, 0.5)	-3.8 (-8.9, 1.3)
	Unknown	-6.7 (-13.4, -0.0)*	-2.7 (-9.0, 3.6)	0.6 (-7.0, 8.3)	-5.9 (-14.4, 2.6)	-9.4 (-18.8, 0.1)
Model 4	Higher	REF	REF	REF	REF	REF
	Intermediate	-8.3 (-11.4, -5.1)***	1.2 (2.8, 5.2)	1.2 (-3.9, 6.3)	-4.3 (-10.5, 1.9)	-0.8 (-6.4, 4.8)
	Elementary	-7.8 (-11.7, -3.9)***	-1.4 (-5.0, 2.3)	-1.7 (-6.2, 2.9)	-4.5 (-9.8, 0.8)	-4.0 (-9.0, 1.0)
	Unknown/not in workforce	-6.1 (-12.7, 0.6)	-2.9 (-9.2, 3.4)	-0.0 (-7.7, 7.6)	-5.9 (-14.4, 2.7)	-10.1 (-19.3, -0.8)*
	P_{trend}	<0.0001***	0.40	0.60	0.36	0.09

β, beta coefficient. CI, confidence interval.
Model 1 adjusted for age. Model 2: model 1 + adjusted for marital status, number of people in the household. Model 3: model 2 + adjusted for smoking status, physical activity, energy intake. Model 4: adjusted for model 3 + presence of one or more chronic disease, body mass index.
* $P \leq 0.05$, ** $P \leq 0.01$, *** $P \leq 0.001$

Supplementary Table D5. Beta-coefficients (95% confidence intervals) from adjusted linear regression models for association between DHD15-Index and occupational status in women

		Dutch β (95% CI)	**South-Asian Surinamese** β (95% CI)	**African Surinamese** β (95% CI)	**Turkish** β (95% CI)	**Moroccan** β (95% CI)
Model 1	Higher	REF	REF	REF	REF	REF
	Intermediate	-3.3 (-5.9, -0.6)*	-1.9 (-5.5, 1.7)	-2.0 (-4.9, 0.9)	-4.4 (-9.5, 0.8)	-5.6 (-10.0, -1.1)*
	Elementary	-8.0 (-11.1, -4.9)***	-4.8 (-8.2, -1.4)**	-4.6 (-7.7, -1.5)**	-5.0 (-9.6, -0.4)*	-8.6 (-12.8, -4.4)***
	Unknown/not in workforce	-8.4 (-13.3, -3.5)***	-4.9 (-10.2, 0.3)	-3.4 (-8.8, 2.0)	-2.2 (-7.3, 3.0)	-6.6 (-11.1, -2.2)**
Model 2	Higher	REF	REF	REF	REF	REF
	Intermediate	-3.3 (-5.9, -0.7)*	-1.9 (-5.5, 1.7)	-2.0 (-4.9, 0.9)	-4.8 (-9.9, 0.3)	-5.8 (-10.2, -1.4)**
	Elementary	-7.9 (-11.1, -4.8)***	-4.6 (-8.1, -1.2)**	-4.6 (-7.7, -1.5)**	-5.3 (-9.9, -0.7)*	-9.0 (13.2, -4.8)***
	Unknown/not in workforce	-8.5 (-13.5, -3.6)***	-4.6 (-9.9, 0.8)	-3.5 (-8.9, 1.9)	-2.4 (-7.6, 2.8)	-7.4 (-11.9, -2.9)***
Model 3	Higher	REF	REF	REF	REF	REF
	Intermediate	-2.7 (-5.2, -0.2)*	-2.6 (-6.1, 1.0)	-1.7 (-4.6, 1.2)	-3.8 (-8.8, 1.1)	-5.7 (-10.1, -1.3)*
	Elementary	-6.9 (-9.9, -3.8)***	-5.0 (-8.4, -1.6)**	-4.0 (-7.1, -1.0)**	-5.1 (-9.6, -0.6)*	-8.6 (-12.8, -4.5)***
	Unknown/not in workforce	-8.8 (-13.6, -4.1)***	-4.9 (-10.1, 0.3)	-3.0 (-8.3, 2.3)	-2.8 (-7.8, 2.3)	-7.1 (-11.5, -2.6)**
Model 4	Higher	REF	REF	REF	REF	REF
	Intermediate	-2.2 (-4.8, 0.3)	-2.7 (-6.2, 0.9)	-1.8 (-4.7, 1.1)	-2.9 (-8.1, 2.2)	-5.8 (-10.2, -1.4)**
	Elementary	-6.3 (-9.3, -3.2)***	-5.4 (-8.8, -2.0)**	-4.4 (-7.5, -1.3)**	-4.2 (-8.8, 0.5)	-8.8 (-12.9, -4.6)***
	Unknown/not in workforce	-8.7 (-13.5, -4.0)***	-5.4 (-10.6, -0.2)*	-3.3 (-8.6, 2.0)	-1.9 (-7.1, 3.3)	-7.4 (-11.9, -2.9)***
	P_{trend}	<0.0001***	0.01**	0.04*	0.33	0.001***

β, beta coefficient. CI, confidence interval.
Model 1 adjusted for age. Model 2: model 1 + adjusted for marital status, number of people in the household. Model 3: model 2 + adjusted for smoking status, physical activity, energy intake. Model 4: adjusted for model 3 + presence of one or more chronic disease, body mass index.
* $P \leq 0.05$, ** $P \leq 0.01$, *** $P \leq 0.001$

Supplementary Table D6. Beta-coefficients (95% confidence intervals) from adjusted linear regression models for association between DHD15-Index and financial difficulty status in men

		Dutch β (95% CI)	**South-Asian Surinamese** β (95% CI)	**African Surinamese** β (95% CI)	**Turkish** β (95% CI)	**Moroccan** β (95% CI)
Model 1	No	REF	REF	REF	REF	REF
	No, but careful	-1.8 (-4.7, 1.2)	1.3 (-2.1, 4.7)	3.4 (-1.1, 7.9)	2.3 (-3.4, 8.0)	1.5 (-3.6, 6.7)
	Yes	-3.0 (-7.2, 1.1)	-3.4 (-7.1, 0.2)	0.4 (-4.1, 4.9)	-0.3 (-5.4, 4.9)	-1.4 (-6.4, 3.6)
Model 2	No	REF	REF	REF	REF	REF
	No, but careful	-1.5 (-4.4, 1.5)	1.2 (-2.2, 4.7)	3.6 (-0.9, 8.1)	0.9 (-4.8, 6.7)	1.5 (-3.7, 6.7)
	Yes	-2.3 (-6.5, 2.0)	-3.4 (-7.2, 0.4)	-0.3 (-4.9, 4.2)	-0.5 (-5.6, 4.6)	-1.2 (-6.3, 3.8)
Model 3	No	REF	REF	REF	REF	REF
	No, but careful	-0.9 (-3.8, 2.1)	1.9 (-1.4, 5.2)	3.9 (-0.5, 8.4)	1.0 (-4.6, 6.6)	1.6 (-3.4, 6.7)
	Yes	-1.7 (-5.9, 2.4)	-3.4 (-7.1, 0.4)	0.6 (-3.9, 5.1)	-0.2 (-5.2, 4.7)	0.1 (-5.0, 5.1)
Model 4	No	REF	REF	REF	REF	REF
	No, but careful	-0.6 (-3.5, 2.3)	1.9 (-1.4, 5.2)	3.7 (-0.7, 8.1)	1.2 (-4.4, 6.8)	0.7 (-4.3, 5.7)
	Yes	-0.7 (-4.8, 3.5)	-3.6 (-7.4, 0.3)	0.2 (-4.3, 4.7)	0.1 (-4.9, 5.1)	-1.4 (-6.4, 3.6)
	P_{trend}	0.91	0.02*	0.14	0.86	0.61

β, beta coefficient. CI, confidence interval.
Model 1 adjusted for age. Model 2: model 1 + adjusted for marital status, number of people in the household. Model 3: model 2 + adjusted for smoking status, physical activity, energy intake. Model 4: adjusted for model 3 + presence of one or more chronic disease, body mass index.
* $P \leq 0.05$, ** $P \leq 0.01$, *** $P \leq 0.001$

Supplementary Table D7. Beta-coefficients (95% confidence intervals) from adjusted linear regression models for association between DHD15-Index and financial difficulty status in women

		Dutch β (95% CI)	**South-Asian Surinamese** β (95% CI)	**African Surinamese** β (95% CI)	**Turkish** β (95% CI)	**Moroccan** β (95% CI)
Model 1	No	REF	REF	REF	REF	REF
	No, but careful	-0.1 (-2.5, 2.3)	2.7 (-0.6, 6.1)	-0.1 (-3.2, 3.1)	-2.3 (-7.1, 2.5)	5.0 (1.2, 8.7)**
	Yes	-3.0 (-6.2, 0.1)	-1.6 (-4.9, 1.7)	-0.6 (-3.6, 2.5)	-4.6 (-8.9, -0.2)*	0.1 (-3.6, 3.9)
Model 2	No	REF	REF	REF	REF	REF
	No, but careful	-0.0 (-2.4, 2.3)	3.1 (-0.2, 6.4)	-0.0 (-3.2, 3.1)	-2.0 (-6.8, 2.7)	4.8 (1.0, 8.6)*
	Yes	-3.0 (-6.2, 0.2)	-0.7 (-4.0, 2.7)	-0.5 (-3.6, 2.6)	-4.0 (-8.4, 0.4)	0.2 (-3.6, 3.9)
Model 3	No	REF	REF	REF	REF	REF
	No, but careful	0.5 (-1.8, 2.8)	2.5 (-0.7, 5.8)	-0.1 (-3.2, 3.0)	-1.2 (-5.8, 3.5)	4.7 (0.9, 8.4)*
	Yes	-2.1 (-5.2, 1.0)	-0.5 (-3.8, 2.9)	-0.7 (-3.7, 2.4)	-3.0 (-7.3, 1.3)	0.3 (-3.4, 4.1)
Model 4	No	REF	REF	REF	REF	REF
	No, but careful	0.6 (-1.7, 2.9)	2.2 (-1.0, 5.5)	-0.2 (-3.3, 2.9)	-1.0 (-5.7, 3.7)	4.8 (1.1, 8.6)*
	Yes	-1.5 (-4.6, 1.7)	-1.0 (-4.4, 2.4)	-1.3 (-4.4, 1.9)	-2.2 (-6.6, 2.2)	0.3 (-3.6, 4.1)
	P_{trend}	0.41	0.08	0.64	0.58	0.01*

β, beta coefficient. CI, confidence interval.
Model 1 adjusted for age. Model 2: model 1 + marital status, number of people in the household. Model 3: model 2 + adjusted for smoking status, physical activity, energy intake. Model 4: adjusted for model 3 + presence of one or more chronic disease, body mass index.
* $P \leq 0.05$, ** $P \leq 0.01$, *** $P \leq 0.001$

Supplementary Table D8. Sensitivity analysis for association between educational level and DHD15-Index for men

		Dutch β (95% CI)	**South-Asian Surinamese** β (95% CI)	**African Surinamese** β (95% CI)	**Turkish** β (95% CI)	**Moroccan** β (95% CI)
Model 5	Higher	REF	REF	REF	REF	REF
	Intermediate	-5.3 (-8.7, -1.8)**	3.2 (-0.9, 7.4)	0.6 (-4.4, 5.5)	-0.1 (-5.8, 5.6)	-0.2 (-5.7, 5.3)
	Lower	-6.4 (-10.9, -2.0)**	-1.4 (-6.3, 3.5)	-0.8 (-6.2, 4.6)	-4.2 (-10.1, 1.8)	1.6 (-4.8, 8.0)
	Elementary	-5.1 (-14.3, 4.2)	-4.8 (-11.1, 1.5)	-6.9 (-16.4, 2.6)	-4.0 (-10.8. 2.9)	4.8 (-2.0, 11.7)
Model 6	Higher	REF	REF	REF	REF	REF
	Intermediate	-5.4 (-8.9, -1.9)**	3.3 (-0.9, 7.5)	0.6 (-4.4, 5.5)	-0.3 (-6.1, 5.4)	-0.1 (-5.7, 5.4)
	Lower	-6.6 (-11.0, -2.1)**	-1.3 (-6.2, 3.6)	-0.8 (-6.2, 4.6)	-4.4 (-10.4, 1.6)	1.7 (-4.7, 8.1)
	Elementary	-5.2 (-14.5, 4.1)	-4.7 (-11.0, 1.5)	-7.0 (-16.4, 2.6)	-4.4 (-11.4, 2.6)	5.0 (-1.9, 11.8)

β, beta coefficient. CI, confidence interval.
Model 5: adjusted for age, marital status, number of people in the household, smoking status, physical activity, energy intake, presence of one or more chronic disease, body mass index, occupational status.
Model 6: adjusted for age, marital status, number of people in the household, smoking status, physical activity, energy intake, presence of one or more chronic disease, body mass index, occupational status, financial difficulty status.
* $P \leq 0.05$, ** $P \leq 0.01$, *** $P \leq 0.001$

Supplementary Table D9. Sensitivity analysis for association between educational level and DHD15-Index for women

		Dutch β (95% CI)	**South-Asian Surinamese** β (95% CI)	**African Surinamese** β (95% CI)	**Turkish** β (95% CI)	**Moroccan** β (95% CI)
Model 5	Higher	REF	REF	REF	REF	REF
	Intermediate	-1.8 (-4.7, 1.1)	-0.9 (-4.7, 2.8)	-3.4 (-6.5, -0.4)*	-1.8 (-6.9, 3.2)	-3.8 (-8.1, 0.5)
	Lower	-2.4 (-6.3, 1.4)	-0.8 (-5.0, 3.5)	-5.3 (-8.9, -1.6)**	-2.5 (-8.5, 3.5)	-2.8 (-8.1, 2.6)
	Elementary	-7.8 (-15.8, 0.1)	-0.9 (-6.2, 4.5)	-5.1 (-12.1, 1.9)	-1.9 (-8.3, 4.5)	-2.4 (-8.1, 3.3)
Model 6	Higher	REF	REF	REF	REF	REF
	Intermediate	-1.9 (-4.8, 1.1)	-0.9 (-4.7, 3.0)	-3.4 (-6.4, -0.4)*	-1.6 (-6.7, 3.5)	-3.8 (-8.2, 0.6)
	Lower	-2.6 (-6.4, 1.3)	-0.6 (-4.9, 3.6)	-5.2 (-8.9, -1.6)**	-2.4 (-8.4, 3.6)	-2.8 (-8.3, 2.6)
	Elementary	-8.1 (-16.1, -0.0)*	-0.7 (-6.1, 4.7)	-5.0 (-12.0, 2.0)	-1.6 (-8.1, 4.8)	-2.5 (-8.2, 3.3)

β, beta coefficient. CI, confidence interval.
Model 5: adjusted for age, marital status, number of people in the household, smoking status, physical activity, energy intake, presence of one or more chronic disease, body mass index, occupational status.
Model 6: adjusted for age, marital status, number of people in the household, smoking status, physical activity, energy intake, presence of one or more chronic disease, body mass index, occupational status, financial difficulty status.
* $P \leq 0.05$, ** $P \leq 0.01$, *** $P \leq 0.001$

Supplementary Table D10. Sensitivity analysis for association between occupational status and DHD15-Index for men

		Dutch β (95% CI)	**South-Asian Surinamese** β (95% CI)	**African Surinamese** β (95% CI)	**Turkish** β (95% CI)	**Moroccan** β (95% CI)
Model 5	Higher	REF	REF	REF	REF	REF
	Intermediate	-5.9 (-9.6, -2.2)**	0.3 (-4.7, 5.3)	1.2 (-4.7, 7.1)	-3.3 (-10.2, 3.6)	0.0 (-7.0, 7.0)
	Elementary	-4.5 (-9.3, 0.4)	0.3 (-5.0, 5.6)	-0.8 (-7.1, 5.5)	-1.9 (-8.7, 4.8)	-4.8 (-11.9, 2.3)
	Unknown/not in workforce	-4.7 (-11.4, 2.0)	-1.7 (-8.7, 5.4)	0.6 (-7.3, 8.6)	-4.6 (-13.6, 4.3)	-9.9 (-20.0, 0.2)
Model 6	Higher	REF	REF	REF	REF	REF
	Intermediate	-5.9 (-9.6, -2.2)**	0.3 (-4.7, 5.3)	1.2 (-4.7, 7.1)	-3.3 (-10.3, 3.6)	0.2 (-6.9, 7.3)
	Elementary	-4.6 (-9.5, 0.3)	0.4 (-4.9, 5.8)	-0.9 (-7.2, 5.4)	-2.2 (-9.0, 4.7)	-4.5 (-11.7, 2.6)
	Unknown/not in workforce	-4.7 (-11.4, 2.1)	-1.2 (-8.3, 5.9)	0.6 (-7.4, 8.5)	-4.8 (-13.8, 4.2)	-9.8 (-19.9, 0.4)

β, beta coefficient. CI, confidence interval.
Model 5: adjusted for age, marital status, number of people in the household, smoking status, physical activity, energy intake, presence of one or more chronic disease, body mass index, educational level.
Model 6: adjusted for age, marital status, number of people in the household, smoking status, physical activity, energy intake, presence of one or more chronic disease, body mass index, educational level, financial difficulty status.
* $P \leq 0.05$, ** $P \leq 0.01$, *** $P \leq 0.001$

Supplementary Table D11. Sensitivity analysis for association between occupational status and DHD15-Index for women

		Dutch β (95% CI)	**South-Asian Surinamese** β (95% CI)	**African Surinamese** β (95% CI)	**Turkish** β (95% CI)	**Moroccan** β (95% CI)
Model 5	Higher	REF	REF	REF	REF	REF
	Intermediate	-0.5 (-3.7, 2.7)	-2.4 (-7.0, 2.2)	2.2 (-1.7, 6.2)	-2.8 (-9.5, 3.8)	-4.9 (-10.1, 0.3)
	Elementary	-3.8 (-7.8, 0.1)	-5.3 (-10.2, -0.4)*	0.7 (-3.9, 5.2)	-4.0 (-10.7, 2.7)	-8.6 (-14.1, -3.1)**
	Unknown/not in workforce	-6.9 (-11.9, -1.9)**	-5.3 (-11.3, 0.7)	-0.2 (-5.9, 5.4)	-1.8 (-8.9, 5.4)	-7.2 (-12.8, -1.6)*
Model 6	Higher	REF	REF	REF	REF	REF
	Intermediate	-0.6 (-3.8, 2.6)	-2.4 (-7.0, 2.2)	2.3 (-1.7, 6.2)	-2.8 (-9.4, 3.9)	-5.0 (-10.2, 0.2)
	Elementary	-3.9 (-7.8, 0.1)	-5.3 (-10.2, -0.3)*	0.7 (-3.8, 5.3)	-3.8 (-10.5, 3.0)	-8.6 (-14.1, -3.1)**
	Unknown/not in workforce	-6.9 (-11.9, -1.9)**	-5.3 (-11.3, 0.7)	-0.2 (-5.9, 5.4)	-1.6 (-8.7, 5.5)	-7.2 (-12.8, -1.6)*

β, beta coefficient. CI, confidence interval.
Model 5: adjusted for age, marital status, number of people in the household, smoking status, physical activity, energy intake, presence of one or more chronic disease, body mass index, educational level.
Model 6: adjusted for age, marital status, number of people in the household, smoking status, physical activity, energy intake, presence of one or more chronic disease, body mass index, educational level, financial difficulty status.
* $P \leq 0.05$, ** $P \leq 0.01$, *** $P \leq 0.001$

Supplementary Table D12. Sensitivity analysis for association between financial difficulty status and DHD15-Index for men

		Dutch β (95% CI)	**South-Asian Surinamese** β (95% CI)	**African Surinamese** β (95% CI)	**Turkish** β (95% CI)	**Moroccan** β (95% CI)
Model 5	No	REF	REF	REF	REF	REF
	No, but careful	0.5 (-2.4. 3.3)	1.9 (-1.3, 5.2)	3.6 (-0.8, 8.1)	1.9 (-3.8. 7.7)	1.1 (-3.9, 6.1)
	Yes	0.9 (-3.2, 5.0)	-3.2 (-7.0, 0.6)	0.7 (-3.9, 5.3)	1.6 (-3.6, 6.9)	-1.2 (-6.2, 3.9)
Model 6	No	REF	REF	REF	REF	REF
	No, but careful	0.7 (-2.1, 3.6)	1.9 (-1.3, 5.2)	3.7 (-0.8, 8.2)	2.0 (-3.8, 7.7)	1.0 (-4.0, 6.0)
	Yes	1.0 (-3.0, 5.1)	-3.2 (-7.0, 0.6)	0.7 (-3.9, 5.4)	1.9 (-3.4, 7.2)	-0.9 (-5.8, 4.1)

β, beta coefficient. CI, confidence interval.
Model 5: adjusted for age, marital status, number of people in the household, smoking status, physical activity, energy intake, presence of one or more chronic disease, body mass index, educational level.
Model 6: adjusted for age, marital status, number of people in the household, smoking status, physical activity, energy intake, presence of one or more chronic disease, body mass index, educational level, occupational status.
* $P \leq 0.05$, ** $P \leq 0.01$, *** $P \leq 0.001$

Supplementary Table D13. Sensitivity analysis for association between financial difficulty status and DHD15-Index for women

		Dutch β (95% CI)	**South-Asian Surinamese** β (95% CI)	**African Surinamese** β (95% CI)	**Turkish** β (95% CI)	**Moroccan** β (95% CI)
Model 5	No	REF	REF	REF	REF	REF
	No, but careful	1.6 (-0.7, 3.9)	2.3 (-0.9, 5.6)	0.0 (-3.1, 3.1)	-1.1 (-5.9, 3.6)	5.0 (1.3, 8.8)**
	Yes	-0.2 (-3.3, 3.0)	-0.5 (-3.9, 3.0)	-0.3 (-3.5, 2.9)	-2.1 (-6.5, 2.4)	1.3 (-2.6, 5.2)
Model 6	No	REF	REF	REF	REF	REF
	No, but careful	1.7 (-0.6, 4.0)	2.4 (-0.9, 5.6)	-0.0 (-3.1, 3.1)	-1.1 (-5.9, 3.6)	4.9 (1.1, 8.6)*
	Yes	0.1 (-3.1, 3.2)	-0.4 (-3.9, 3.0)	-0.3 (-3.5, 2.9)	-2.0 (-6.5, 2.5)	1.2 (-2.7, 5.0)

β, beta coefficient. CI, confidence interval.
Model 5: adjusted for age, marital status, number of people in the household, smoking status, physical activity, energy intake, presence of one or more chronic disease, body mass index, educational level.
Model 6: adjusted for age, marital status, number of people in the household, smoking status, physical activity, energy intake, presence of one or more chronic disease, body mass index, educational level, occupational status.
* $P \leq 0.05$, ** $P \leq 0.01$, *** $P \leq 0.001$

Supplementary Table D14. Age-adjusted median (lower quartile, upper quartile) DHD15-Index by ethnicity in men

Dietary Component	Dutch (*n*=633)	South-Asian Surinamese (*n*=395)	African Surinamese (*n*=298)	Turkish (*n*=273)	Moroccan (*n*=258)	Pearson's F Statistic (*P*-value)
Vegetables	7.7 (5.2, 9.8)	5.7 (3.2, 8.9)	6.6 (4.0, 9.7)	6.5 (3.8, 9.8)	5.5 (2.6, 9.3)	9.51 (<0.0001)***
Fruit	5.1 (1.9, 10.0)	5.9 (2.6, 10.0)	6.0 (2.6, 10.0)	8.1 (3.4, 10.0)	8.0 (4.0, 10.0)	12.46 (<0.0001)***
Wholegrains	5.6 (5.1, 6.8)	4.9 (2.6, 5.0)	4.6 (1.6, 5.0)	5.2 (4.2, 6.0)	5.4 (5.0, 6.3)	20.65 (<0.0001)***
Legumes	10.0 (2.9, 10.0)	10.0 (3.6, 10.0)	9.4 (3.4, 10.0)	10.0 (9.9, 10.0)	10.0 (9.5, 10.0)	4.45 (0.001)***
Nuts & seeds	8.8 (3.5, 10.0)	8.6 (2.3, 10.0)	9.2 (2.5, 10.0)	7.3 (3.1, 10.0)	7.3 (2.5. 10.0)	1.83 (0.12)
Dairy	6.5 (3.1, 9.0)	4.5 (1.6, 8.1)	4.4 (1.9, 7.4)	5.3 (2.3, 8.6)	6.1 (2.6, 9.4)	9.18 (<0.0001)***
Fish	5.3 (2.7, 9.6)	7.9 (2.7, 10.0)	4.9 (2.7, 10.0)	2.9 (1.4, 8.0)	4.3 (2.7, 10.0)	10.19 (<0.0001)***
Tea	3.5 (0.6, 9.8)	4.1 (0.8, 7.6)	3.2 (1.0, 7.5)	8.0 (3.8, 10.0)	6.0 (1.8, 9.8)	16.56 (<0.0001)***
Cooking fats & oils	10.0 (1.3, 10.0)	10.0 (9.9, 10.0)	10.0 (2.3, 10.0)	3.9 (1.4, 10.0)	10.0 (5.1, 10.0)	74.36 (<0.0001)***
Red meat	8.8 (3.2, 10.0)	10.0 (9.6, 10.0)	10.0 (7.2, 10.0)	6.0 (0.3, 10.0)	8.8 (0.5, 10.0)	18.64 (<0.0001)***
Processed meat	6.3 (3.2, 8.6)	9.2 (7.4, 10.0)	9.2 (7.1, 10.0)	9.4 (8.0, 10.0)	9.9 (9.0, 10.0)	122.69 (<0.0001)***
SSBs & fruit juices	4.7 (0.0, 8.4)	3.3 (0.0, 7.4)	1.0 (0.0, 5.9)	7.6 (1.3, 9.2)	5.3 (0.0, 8.8)	26.04 (<0.0001)***
Alcohol	7.7 (1.3, 10.0)	10.0 (10.0, 10.0)	10.0 (9.9, 10.0)	10.0 (10.0, 10.0)	10.0 (10.0, 10.0)	34.72 (<0.0001)***

SSBs, sugar sweetened beverages.
* $P \leq 0.05$, ** $P \leq 0.01$, *** $P \leq 0.001$

Supplementary Table D15. Age-adjusted median (lower quartile, upper quartile) DHD15-Index by ethnicity in women

Dietary Component	Dutch (*n*=789)	South-Asian Surinamese (*n*=576)	African Surinamese (*n*=646)	Turkish (*n*=305)	Moroccan (*n*=429)	Pearson's F Statistic (*P*-value)
Vegetables	8.6 (5.8, 10.0)	7.0 (4.4, 10.0)	7.7 (4.8, 8.2)	8.8 (5.8, 10.0)	7.4 (4.2, 10.0)	10.39 (<0.0001)***
Fruit	7.5 (3.5, 10.0)	7.9 (3.8, 10.0)	8.0 (3.3, 10.0)	8.5 (4.8, 10.0)	8.3 (4.4, 10.0)	1.11 (0.35)
Wholegrains	5.6 (5.0, 6.9)	4.4 (2.6, 5.1)	3.8 (1.7, 5.0)	5.3 (3.7, 6.0)	5.3 (4.3, 5.9)	79.86 (<0.0001)***
Legumes	10.0 (2.8, 10.0)	10.0 (3.5, 10.0)	9.4 (2.5, 10.0)	10.0 (10.0, 10.0)	10.0 (8.0, 10.0)	1.31 (0.27)
Nuts & seeds	7.1 (2.8, 10.0)	6.3 (2.3, 10.0)	4.6 (1.4, 10.0)	5.3 (2.0, 10.0)	4.9 (1.7, 1.0)	7.86 (<0.0001)***
Dairy	6.2 (3.2, 9.1)	4.5 (1.8, 8.3)	4.1 (1.4, 7.6)	4.7 (2.3, 8.1)	5.5 (2.4, 8.7)	13.50 (<0.0001)***
Fish	5.0 (2.7, 8.4)	7.7 (2.7, 10.0)	5.3 (2.7, 10.0)	3.1 (0.0, 7.1)	3.5 (2.7, 8.4)	22.32 (<0.0001)***
Tea	10.0 (3.8, 10.0)	7.6 (2.2, 10.0)	7.6 (2.7, 10.0)	8.1 (5.4, 10.0)	6.5 (2.2, 10.0)	21.46 (<0.0001)***
Cooking fats & oils	10.0 (1.2, 10.0)	10.0 (9.9, 10.0)	10.0 (3.3, 10.0)	4.1 (1.2, 10.0)	10.0 (9.0, 10.0)	55.44 (<0.0001)***
Red meat	10.0 (8.6, 10.0)	10.0 (10.0, 10.0)	10.0 (10.0, 10.0)	10.0 (2.3, 10.0)	10.0 (6.4, 10.0)	0.00 (1.00)
Processed meat	8.3 (6.3, 9.5)	9.8 (8.7, 10.0)	9.5 (7.9, 10.0)	9.7 (9.2, 10.0)	10.0 (9.6, 10.0)	118.39 (<0.0001)***
SSBs & fruit juice	6.9 (2.5, 9.0)	6.4 (1.8, 8.9)	4.3 (0.2, 8.4)	8.7 (6.1, 9.8)	7.9 (3.2, 9.7)	24.35 (<0.0001)***
Alcohol	10.0 (1.4, 10.0)	10.0 (10.0, 10.0)	10.0 (10.0, 10.0)	10.0 (10.0, 10.0)	10.0 (10.0, 10.0)	0.00 (1.00)

SSBs, sugar sweetened beverages.
* $P \leq 0.05$, ** $P \leq 0.01$, *** $P \leq 0.001$