UNIVERSITY OF SOUTHAMPTON

FACULTY OF MEDICINE

Division of Human Development and Health

The relative association between the local food environment, psychosocial factors and dietary inequalities among mothers in Hampshire

by

Christina Augusta Vogel (nee Black)

Thesis for the degree of Doctor of Philosophy

September 2014

ABSTRACT

FACULTY OF MEDICINE

Public Health Nutrition

Thesis for the degree of Doctor of Philosophy

THE RELATIVE ASSOCIATION BETWEEN THE LOCAL FOOD ENVIRONMENT, PSYCHOSOCIAL FACTORS AND DIETARY INEQUALITIES AMONG MOTHERS IN HAMPSHIRE

Christina Augusta Vogel (nee Black)

The poor dietary behaviours of mothers with low educational attainment are of particular concern not only for their own health, but also for the short and long term health of their children. Better psychosocial attitudes towards healthy eating are known determinants of better dietary behaviours, but knowledge of local environmental factors and their interaction with individual determinants is more limited, particularly in the UK. This study addressed a gap in the literature by examining associations between the local food environment, individual factors and dietary behaviours, and determining whether these associations varied by level of educational attainment.

921 mothers with young children from Hampshire completed a cross-sectional survey about their dietary behaviours, demographic and psychosocial characteristics, and activity space locations. Novel measures characterised the in-store environment of mothers' main food stores, density and variety of food outlets in mothers' activity spaces, and the nutrition environment of mothers' Sure Start Children's Centres using observational and self-report data. A conceptual model predicting dietary behaviours of mothers with young children was tested using structural equation modelling.

The results showed that the in-store environment of mothers' main food stores was indirectly associated with dietary behaviour through psychological and perceived food affordability factors, with the latter a more important predictor among mothers with low educational attainment. The dietary behaviours of mothers with low educational attainment tended to vary in accordance with the quality of the environments they were exposed to. In contrast, the dietary quality of mothers with higher educational attainment showed less susceptibility to poorer local food environment exposures.

These findings suggest that a multi-component intervention to improve the in-store environment of the least healthful supermarkets and mothers' psychological and cost-related attitudes towards healthy eating could enhance the dietary behaviours of mothers and their families, particularly if the most disadvantaged families are targeted.

"You forget that the fruits belong to all and the land belongs to no-one"

Jean Jacques Rousseau

"Equality of opportunity is not enough……When some people have to run a 100 metre race with sandbags on their legs, the fact that no one is allowed to have a head start does not make the race fair. Equality of opportunity is absolutely necessary but not sufficient in building a genuinely fair and efficient society."

Ha-Joon Chang

Acknowledgements

Many thanks to the mothers, store managers and Sure Start Children's Centre staff who participated in our surveys. Without your generous time and energy this research would not have been possible.

Thanks to Ross, Hayley, Beatrice and Ilse for your help with data collection and cleaning, and piloting the audit tools. Together we have written five theses! A particular thanks to Jamie Lawrence. You were my true pal when it came to trawling the supermarkets and convenience stores. Your persistence and bubbly personality made it so much more enjoyable!

Thank you Professor Steve Cummins, Dr Daniel Lewis, Professor Kylie Ball and Dr Gavin Abbott. I am so very appreciative of how generous you have been with your time and expertise. And, many thanks to Dr Ilona Box for your keen editorial eye.

Thank you to all my colleagues at the MRC Lifecourse Epidemiology Unit. I feel very lucky to be surrounded by such kind, fun and clever people. Thank you to the Southampton Initiative for Health team and the Unit yoginis for our chats and Aums – they've kept me sane. Special thanks to Professor Hazel Inskip and Ms Georgia Ntani, your statistical expertise have been utterly invaluable.

A massive thank you to my fabulous supervisors, Dr Janis Baird, Professor Graham Moon and Professor Cyrus Cooper. It has been an amazing journey with your ongoing encouragement. Thank you Cyrus for giving my project idea a chance and supporting its development. Thank you Graham for your help on my very green geographical path. I have learnt so much about health geography. A particular thank you to Janis, for being with me every step of the way. You have given me independence, and shown me guidance and friendship. I am so very grateful.

To my wonderful family and friends. Thank you for being there for me. Special thanks to my big sisters for your moral support, and to Meg and Millie for your comradeship, your big ears and warm hugs. Thank you to my amazing Ma and Pa for bestowing upon me the values of social justice and equality, and for giving me so many opportunities in life, and your love.

And to my darling Jamie, thank you. You have let me witter on and on about my thesis and our wedding, and given me a prod when it was needed. You continue to teach me about what is important in life. I love you so much and can't wait to be your wife!

Table of contents

List of Tables

List of Figures

List of Appendices

List of Abbreviations

Adjusted Goodness of Fit Index (AGFI)

Advance Level (A-level)

Comparative Fit Index (CFI)

English Index of Deprivation (ID)

English Index of Multiple Deprivation (IMD)

European Union (EU)

Food Environment Scores (FES)

Food Frequency Questionnaire (FFQ)

Geographic Information Software (GIS)

General Certificate of Secondary Education (GCSE)

Global Positioning Systems (GPS)

Goodness of Fit Index (GFI)

Higher National Diploma (HND)

Local Authority Enforcement Monitoring System (LAEMS)

Low-Income Diet and Nutrition Survey (LNDS)

Lower Super Output Areas (LSOAs)

Middle Super Output Area (MSOA)

National Health Service (NHS)

National Institute for Health and Care Excellence (NICE)

Nutrition Environment Measures Survey in Stores (NEMS-S)

Ordnance Survey Integrated Transport Network (OS ITN)

Retail Food Environment Index (RFEI)

Root Mean Square Error of Approximation (RMSEA)

standardised Root Mean Square Residual (sRMR)

Structural Equation Modelling (SEM)

Supplemental Nutrition Assistance Program (SNAP)

United Kingdom (UK)

United States (US)

DECLARATION OF AUTHORSHIP

I, Christina Augusta Vogel (nee Black) declare that this thesis and the work presented in it are my own and have been generated by me as the result of my own original research.

THE RELATIVE INFLUENCE OF THE LOCAL FOOD ENVIRONMENT AND PSYCHOSOCIAL FACTORS ON DIETARY INEQUALITIES AMONG WOMEN IN HAMPSHIRE

I confirm that:

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

Signed:...

Date:..

Declaration of tasks

I have undertaken the following tasks for this research project:

- intellectualised this work and the conceptual model
- developed the literature search strategy and conducted a literature review
- cleaned and manipulated the raw data collected as part of this research *(in collaboration with the MRC LEU data management team and Georgia Ntani)*
- completed the statistical analyses for each data chapter *(with assistance from Hazel Inskip, Georgia Ntani, Camille Parsons and Gavin Abbott)*
- wrote this thesis
- created the first draft of all published papers arising from this research *(manuscripts were edited after consultation with co-authors)*

For the Southampton Initiative for Health follow-up survey

- identified additional questions for inclusion: individual geographical locations, fast food consumption, mode of transport to main grocery store and perceptions of the local food environment
- assisted with recruitment and data collection
- geocoded all information about geographical locations

For the community nutrition environment work

- developed the food outlet categorisation system
- identified food outlets from secondary data sources *(with assistance from Jamie Lawrence and Emily Boardman)*
- conceptualised proximity and density measures *(in collaboration with Graham Moon, Janis Baird, Steve Cummins and Daniel Lewis)*
- completed the proximity and density analyses in ArcGIS *(after advice from Daniel Lewis and Julian Leyland)*

For the consumer nutrition environment work

- developed the consumer nutrition environment tool and protocols
- piloted the consumer nutrition environment tool *(with assistance from Ross Kenny and Megan Jarman)*
- completed the consumer nutrition environment survey *(with assistance from Ross Kenny, Tannaze Tinati and Jamie Lawrence in Southampton, Hayley Woodward in Havant and Jamie Lawrence in Eastleigh, Fareham and Portsmouth)*

- conceptualised a composite measure of healthfulness for the consumer nutrition environment *(in collaboration with Georgia Ntani, Hazel Inskip and Janis Baird)*

For the organisational nutrition environment work

- developed the organisational nutrition environment tool and protocols *(with assistance from Beatrice Paganini and Janis Baird)*
- piloted the consumer nutrition environment tool *(in collaboration with Beatrice Paganini)*
- completed the organisational nutrition environment survey *(in collaboration with Beatrice Paganini)*
- theorised the development of four scores to represent the nutrition environment of Sure Start Children's Centres
- created four nutrition environment scores for each Sure Start Children's Centre in the study area *(in collaboration with Hazel Inskip and Ilse Bloom)*

Structural equation model

- developed the conceptual model to be tested using structural equation modelling *(with assistance from Kylie Ball and Gavin Abbott)*
- completed data preparation, tested goodness of fit and developed measurement and structural models *(with assistance from Kylie Ball, Gavin Abbott and Georgia Ntani)*

Tasks undertaken by others (with my collaboration):

- Janis Baird and Mary Barker created the Southampton Initiative for Health follow-up questionnaire, associated paperwork and ethics application
- three employed field workers collected the Southampton Initiative for Health follow-up survey data with assistance from Megan Jarman, Ruifa Begum, Tannaze Tinati, Wendy Lawrence and myself
- raw data collected as part of this research was computerised by the MRC LEU data management team
- Daniel Lewis provided ArcGIS expertise and created the Python scripts for the density analyses
- Georgia Ntani created the Stata script to manipulate the raw consumer nutrition environment data into nine variables and create store healthfulness scores.

Outputs from this study

Awards

I was awarded a National Institute for Health Research, Doctoral Research Fellowship of £285,716 for three years in 2011.

I was awarded a University of Southampton, 3 year PhD scholarship of £21,000 in 2010.

I was awarded first prize for poster presentations at the Postgraduate Population Studies 'PopFest' conference in 2013.

I was awarded second prize for oral presentations at the University of Southampton Translational Research conference in 2010.

Collaborations

A formal collaboration was established with Professor Steve Cummins, London School Hygiene and Tropical Medicine. Through regular meetings, Professor Cummins has provided valuable guidance on the methodological design and analyses techniques of the consumer and community nutrition environment chapters. His team, particularly Dr Daniel Lewis, provided instrumental expertise with the Geographical Information System analyses.

A formal collaboration was also established with Professor Kylie Ball, Deakin University, Melbourne, Australia. A fundamental component of this collaboration was a four-week research visit to Deakin University in November 2013. Professor Ball and her team have offered useful guidance with structural equation modelling and the community nutrition environment analyses.

Publications

<u>Publications from this PhD thesis study</u>

Black C, Ntani G, Inskip H, Cooper C, Cummins S, Moon G, Baird J. Measuring the healthfulness of food retail stores: variations by store type and neighbourhood deprivation. *International Journal of Behavioral Nutrition and Physical Activity* 2014;11:69.

Black C, Moon G, Baird J. Dietary inequalities: What is the evidence for the effect of the neighbourhood food environment? *Health Place* 2014;27C:229-42.

Black C, Ntani G, Kenny R, Tinati T, Jarman M, Lawrence W, Barker M, Inskip H, Cooper C, Moon G, Baird J. Variety and quality of healthy foods differ according to neighbourhood deprivation. *Health Place* 2012;18(6):1292–99.

Publications from the Southampton Initiative for Health

Black C, Lawrence W, Cradock S, Ntani G, Tinati T, Jarman M, Begum R, Inskip H, Cooper C, Barker M, Baird J. Healthy conversation skills: increasing competence and confidence in front-line staff. *Public Health Nutrition* 2014;17(3):700–7.

Lawrence W, **Black C**, Tinati T, Cradock S, Begum R, Jarman M, Pease A, Margetts B, Davies J, Inskip H, Cooper C, Baird J, Barker M. 'Making every contact count': Evaluation of the impact of an intervention to train health and social care practitioners in skills to support health behaviour change. *Journal of Health Psychology* 2014;Apr 8.

Baird J, Jarman M, Lawrence W, **Black C**, Davies J, Tinati T, Begum R, Mortimore A, Robinson S, Margetts B, Cooper C, Barker M, Inskip H. What is the effect of a behaviour change intervention on the diets and physical activity levels of women attending Sure Start Children's Centres in Southampton? Findings from a non-randomised controlled trial. BMJ Open (In Press).

Tinati T, Lawrence W, Ntani G, **Black C**, Cradock S, Jarman M, Pease A, Begum R, Inskip H, Cooper C, Baird J, Barker M. Implementation of new Healthy Conversation Skills to support lifestyle changes – what helps and what hinders? Experiences of Sure Start Children's Centre staff. *Health and Social Care in the Community* 2012;20(4):430–7.

Jarman M, Lawrence W, Ntani G, Tinati T, Pease A, **Black C**, Baird J, Barker M, S. I. H. Study Group. Low levels of food involvement and negative affect reduce the quality of diet in women of lower educational attainment. *Journal of Human Nutrition and Dietetics* 2012;25(5):444–52.

Barker M, Baird J, Lawrence W, Jarman M, **Black C**, Barnard K, Cradock S, Davies J, Margetts B, Inskip H, Cooper C. The Southampton Initiative for Health: a complex intervention to improve the diets and increase the physical activity levels of women from disadvantaged communities. *Journal of Health Psychology* 2011;16(1):178–91.

Presentations

Translational Research conference 2010, Southampton, UK: How does the food environment influence the quality of diet of women of childbearing age? – oral presentation

ISBNPA 2011, Melbourne, Australia: How do choice and quality of healthy foods differ by neighbourhood deprivation? – oral presentation

DOHaD 2011, Portland, US: Dietary quality of young women: choice and quality of healthy foods differ according to neighbourhood deprivation – oral presentation

PHSRN 2012, Birmingham, UK: Dietary quality of women of childbearing age; do grocery stores have an influence? – oral presentation

WPHNA *WorldNutrition* 2012, Rio, Brazil: Dietary quality of women of childbearing age; do grocery stores have an influence? – oral presentation

ENRGHI 2012, London, UK: Does size make a difference; measure of overall healthfulness of grocery stores? – poster presentation

ISBNPA 2013, Ghent, Belgium: The relationship between the healthfulness of mother's main grocery stores and their quality of diet – oral presentation

Postgraduate Population Studies 'PopFest' 2013, Southampton, UK: The relationship between the healthfulness of mother's main grocery stores and their quality of diet – poster presentation

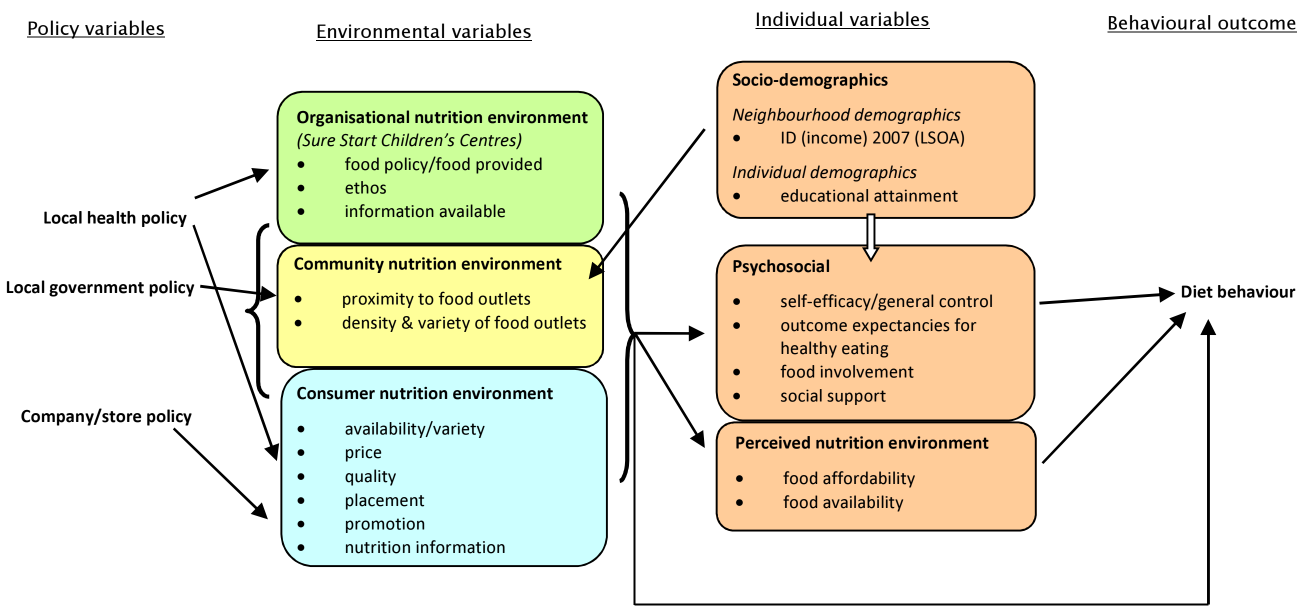
ESRC Frontiers in Population Health 2014, Southampton, UK: The local food environment and its association with the dietary quality of mothers – short plenary oral presentation

ENRGHI 2014, Portsmouth, UK: The relationship between mothers' accessibility to food outlets and their dietary quality differs by educational attainment – oral presentation

Thesis overview

This study is the first in the United Kingdom (UK) to comprehensively assess the relationships between the local food environment, individual factors and diet. Guided by a widely used conceptual model,[1] this study determined the relationships between three components of the local food environment and the dietary behaviour of mothers with young children. The mediating role of psychosocial and environmental perception factors, and differences according to mothers' levels of education were also investigated. There is strong evidence that good maternal nutrition leads to healthy babies, children and adults and that mothers from disadvantaged backgrounds make poor dietary choices. Education is a marker of disadvantage and mothers with low educational attainment report more environmental and psychosocial barriers to making healthier food choices than mothers with higher educational attainment. There is political will to help disadvantaged mothers improve their own and their families' diets. Further evidence is needed to identify target points for interventions that are most likely to be effective.

Conceptual model



Chapter 1 describes the persistent inequalities in health and dietary status in the UK, their cost to society, and the political imperative to improve the diets of young women from disadvantaged backgrounds to enhance health in the next generation. The determinants of maternal diet are reviewed and the need for additional evidence about the role of environmental factors is highlighted.

Chapter 2 is a review of the evidence for *i)* socioeconomic area-based differences in local food environment exposures, and *ii)* associations between local food environment exposures and diet. The conceptual framework upon which the literature review has been structured is described, including a definition of the three components of the local food environment: *community, consumer* and *organisational nutrition environments*. The need for advances in research methods and simultaneous assessment of the relative relationship between the three components of the local food environment and diet is highlighted. Further evidence about the mediating role of psychosocial factors is also required, thus providing the rationale for this study.

Chapter 3 outlines the conceptual framework upon which the four research hypotheses are based. The framework is informed by previous theory and evidence of the determinants of dietary quality and inequalities, particularly among mothers. The four hypotheses to be tested are specified and the study design described. The study covers six neighbouring local council areas and includes three samples. The first sample is a population-based sample of mothers with young children. The second sample covers all food retail and takeaway outlets, including data about the in-store environment of supermarkets and convenience stores, in the study area. The third sample refers to the environment of Sure Start Children's Centres within the study area. Data collection methods and exposure, covariate and outcome variables are introduced, with detailed descriptions provided in each data chapter (Chapter 4 to 8).

Chapter 4 describes the dietary behaviours, demographic, psychosocial and perceived environmental characteristics of the sample of mothers. Several psychosocial factors, including perceived control and belief in the benefits of healthy eating, were positively associated with dietary quality, while perceptions of food affordability were negatively related. Educational disparities in dietary quality, psychosocial and environmental perceptions were observed. In particular, dietary health beliefs were a greater predictor of dietary quality among mothers who left school at 16 years than among mothers with higher educational attainment. Additionally, mothers with lower educational attainment who experienced periods of not being able to afford food had poorer quality diets. The mediating role of psychosocial and environmental perception variables in the relationship between the local food environment and dietary behaviour is explored in Chapter 8.

Chapter 5 explores three community nutrition environment exposures (density, proximity and variety) to determine whether the geographical accessibility of food outlets differed by neighbourhood deprivation and related to mothers' dietary quality. The density of healthy and less healthy food outlets increased with area deprivation, such that more affluent areas had healthier food environments overall. There was some evidence that greater access to healthier food outlets was related to better dietary quality. However, greater access to less healthy outlets was also weakly associated with better dietary quality. Relationships between community nutrition environment exposures and dietary quality were shown to differ according to mothers' levels of educational attainment, with those with degrees being less susceptible to poorer food outlet exposures.

Chapter 6 examined the consumer nutrition environment of almost all supermarkets and convenience stores across the study area. A novel composite measure of the consumer nutrition environment, incorporating the interplay of nine in-store factors that can influence food choices, was shown to discriminate between store types. There was some evidence that more deprived neighbourhoods had less healthful in-store environments than more affluent neighbourhoods. Mothers who shopped at stores where healthy foods were cheaper relative to less healthy products had better quality diets. The consumer nutrition environment of mothers' main stores related to their dietary quality differently according to their level of educational attainment; those who left school at 16 years had the greatest vulnerability to poorer in-store exposures.

Chapter 7 investigated the nutrition environment of Sure Start Children's Centres in the study area. Sure Start Children's Centres were selected as the target organisational nutrition environment because mothers with children under the age of five years frequently visit these centres. A novel overall score including four domains of the organisational nutrition environment (food policy, healthy eating ethos, healthy eating information, and barriers to promoting healthy eating) was calculated for each centre. Staff working in centres in the most deprived neighbourhoods reported the most barriers to promoting healthy eating, but the overall nutrition environment did not differ by neighbourhood deprivation. Surprisingly, healthier overall nutrition environments were associated with poorer dietary quality. However, stratified analysis showed this association was only apparent among mothers with high educational attainment.

Chapter 8 used structural equation modelling (SEM) to test the hypothesised relationships of the conceptual model that guided this study. SEM is more advantageous than other multivariate analysis techniques because it enables simultaneous assessment of multiple interdependent relationships and uses latent constructs to estimate relationships free of measurement error. Assessment of the relative relationships between environmental and individual factors, and dietary behaviour indicated that the in-store environment of mothers' main food stores is indirectly associated with diet through psychological and perceived food affordability factors. Furthermore, a direct association between more healthful in-store environments and better dietary behaviours was observed among mothers with low educational attainment.

Chapter 9 reflects on the work that has been completed. The study findings are summarised in relation to the four hypotheses. The design of a future intervention study and a framework for policy initiatives that governments could enact to improve dietary inequalities are described. More specifically, the results of this study suggest that a future intervention which aims to *i)* improve the in-store environment of the least healthful supermarkets, and *ii)* enhance psychological and cost-related attitudes towards healthy eating, is likely to improve the dietary behaviours of mothers and their families, particularly if the most disadvantaged families are targeted. Additionally, policy actions by local and national governments could improve the imbalance of healthy and less healthy food outlets in more deprived neighbourhoods through planning restrictions and increase the value of Healthy Start subsidies to provide conditions that make healthier food choices easier for disadvantaged families.

Chapter 1 Dietary inequalities, maternal diet and the local food environment

The greatest burden of chronic illnesses, such as obesity and diabetes, fall upon those most disadvantaged and their poorer dietary patterns are an important determinant of this burden. There are political, social and economic imperatives to improving these health and dietary inequalities, particularly among young mothers from disadvantaged backgrounds. This chapter describes why mothers are an important population to study and reviews the psychological and environmental determinants of maternal diet. The concept of the local food environment is highlighted as an area needing further research.

1.1 Dietary inequalities

Health inequality describes differences in health status or in the distribution of health determinants, such as dietary quality, between different populations, including socioeconomic groups.[2] Socioeconomic inequalities in health remain a crucial public health issue in England.[3] On average, people living in the poorest neighbourhoods die seven years earlier than people living in the richest neighbourhoods, and the difference in disability-free life expectancy is 17 years.[4] The rates of long-standing illnesses are also greatest among the most disadvantaged with obesity levels 10-15% higher[5] and non-insulin dependent diabetes prevalence more than double[6] that of the most affluent. A recent review of health inequalities across European Union (EU) member states showed the prevalence of obesity among women was highest in England at 23%, with the greatest burden falling upon those with a low educational attainment.[7]

Premature deaths and long-standing illnesses may be avoided by improving lifestyle behaviours including dietary behaviours.[3] Good quality diets are characterised by high intakes of fruit, vegetables and fibre, low intakes of salt and saturated fat, and include a wide variety of different foods.[8] Healthier dietary patterns are associated with a healthy body weight, and lower risks of cardiovascular disease, non-insulin dependent diabetes and cancer.[9] Estimates from the European Union have shown that low fruit and vegetable consumption contributed 4.4% to the estimated burden of disease, and that overweight and obesity added a further 7.8%.[10] Together these factors were greater than the impact of tobacco or alcohol.

In England, population dietary intakes are not aligned with governmental recommendations. The majority of adults consume more than the recommended maximum six grams of salt per day, eat too much saturated fat and added sugar, and do not meet the recommended five daily portions of fruit and vegetables.[11] Results from the Low-Income Diet and Nutrition Survey (LNDS) showed that dietary trends among low-income groups mirrored the pattern of the general UK population but were more extreme.[12] These findings suggest that inequalities in diet are contributing to the health inequalities seen across England.

1.1.1 Dietary inequalities: a political priority

Inequalities in nutritional status have long been acknowledged by UK governments. In 1998, a report by Donald Acheson emphasised the role governments could play in improving access and affordability of healthy food to reduce nutrition-related health inequalities.[13] The government at the time responded by introducing free fruit for younger children in schools, a minimum wage and Sure Start Children's Centres to support vulnerable families with young children to adopt healthier lifestyle behaviours.[14] Subsequent government initiatives also highlighted the importance of addressing dietary inequalities. However, their public health white papers focused on encouraging individual responsibility for healthy eating and strategies were based on universal educational initiatives, such as *Five-a-day* and *Change for Life* social marketing campaigns, and front-of-pack food labelling.[13 15]

Despite concerted policy action to address health inequalities in England, the magnitude of disparity in four important lifestyle behaviours has worsened.[16] Overall, the proportion of adults smoking, drinking alcohol excessively, being physically inactive and having low fruit and vegetable intake decreased from 33% in 2003 to 25% in 2008. However, these reductions were seen mainly among those with high levels of education. In 2003, adults with the lowest educational attainment were three times more likely to engage in these unhealthy behaviours than those with high educational attainment. By 2008, this trend had strengthened to a fivefold greater risk. These findings demonstrate that universal education strategies risk increasing inequalities and highlight the need for more intensive action among the most disadvantaged to alter their lifestyle behaviours.[7]

In 2010, the review of health inequalities in England, *Fair Society, Healthy Lives,*[4] highlighted the economic and social burden of health disparities. Each year, inequality in illness accounts for £31 to 33 billion in productivity losses and £20 to 31 billion in tax losses and higher welfare payments. The report stated that closing the gap between the most and least advantaged is a matter of social justice and is vital for the economy, particularly in an austere financial climate. It urged governments to deliver six key policy objectives, including creating healthy places to live, giving every child the best start in life and prioritising prevention of long-standing illnesses, such as obesity.

The current public health white paper *Healthy Lives, Healthy People*[17] responded to this inequalities review and pledged government commitment to improving the health of the poorest. The current government's priorities for public health include improving maternal health to give children a better start and fostering local solutions to the wider social and environmental determinants of inequalities. Improving the health of women before, during and after pregnancy is fundamental to giving children a healthy start in life and laying the foundation for good health later in life. A particular priority action by the present government was to support young women from disadvantaged backgrounds to address health concerns like obesity.

1.2 The importance of maternal diet

Mothers are an important target group to study. There is strong evidence that maternal nutritional status influences fetal and infant health, and has subsequent implications for risk of chronic illnesses later in the child's life.[18 19] Women also remain primarily responsible for domestic food tasks,[20] and have considerable influence over family food-related decisions.

1.2.1 Maternal diet and lifetime health of her child

A mother's social, biological and genetic factors accumulate to influence the lifetime health of her baby.[17] Maternal health before, during and after pregnancy lays the foundation for healthy fetal development, as well as a child's physical and emotional health. The finding that children who were small at birth and during infancy have a significantly higher risk of developing coronary heart disease, stroke, non-insulin dependent diabetes and adiposity in adult life has been extensively replicated.[18 21 22] In the UK, a large proportion of first time mothers reported that their pregnancies were unplanned.[23] This finding suggests that many women may not have had time to adapt their diet according to guidelines for healthy eating during pregnancy. The Scientific Advisory Committee on Nutrition has expressed concern over the dietary quality of women and the impact that energy-dense diets of low micronutrient value have on their babies.[3] In obese women where the energy supply to their fetus is in excess, offspring are at greater risk of developing metabolic disorders, such as diabetes, as adults or even during childhood.[24]

A woman's ability to nourish herself and her baby is critically important to protect growth, optimise health and reduce the risk of disease in her children, and even her grandchildren.[24 25] This intergenerational transfer of nutritional status is of particular concern for public health in the UK. If a mother has a poor quality of diet and poor dietary patterns are continued in her child's adult life, transgenerational amplification of chronic disease risk may unfold in the mother's grandchildren.[24 25] Thus, the social gradient in health and dietary quality may be amplified with each generation.

A higher level of educational attainment was strongly correlated with better dietary quality in a large cohort of women of childbearing age.[26] Follow-up surveys of mother-child pairs revealed a strong link between mother's quality of diet and the diet of her growing child.[27] With evidence that dietary habits developed during childhood track into adulthood,[28] and that a socioeconomic gradient in dietary patterns persists, the need to improve the dietary quality of mothers from deprived backgrounds is clear.

1.2.2 Maternal dominance in domestic food work

Mothers are also an important target group of research to improve diet because they still do much of the domestic food work involved in feeding the family.[20] Domestic food work involves a complex combination of tasks, including preparing meals, shopping, planning, preparing ingredients, serving and washing dishes.[29] Research in the UK showed that 68% of women cook every day compared with 18% of men,[30] and that substantially more women are responsible for food shopping and preparation.[31]

Unlike men, a woman's contribution to food work does not vary according to her level of interest in food nor is there variation by socioeconomic status.[20] It has been suggested that women's domination of food work in families may relate to the perception in society that women are more skilled in food-related tasks and more knowledgeable about nutrition.[31] The vast majority of women report learning to cook from their mother,[30] thus confirming the significant role a mother can have over future generations' food choices and their cooking skills. In order to support mothers to choose healthier foods and preparation methods it is important to consider the determinants of maternal dietary quality.

1.3 Determinants of maternal food choice

Individual markers of deprivation, including low educational attainment, lower income and manual occupation, have been consistently associated with poorer dietary patterns.[26 32-34] Associations between level of neighbourhood deprivation and dietary patterns have also been shown in the literature. Residents of disadvantaged neighbourhoods have poorer quality diets than those living in more advantaged neighbourhoods, independent of their personal characteristics.[35-37] There is evidence to suggest that several psychosocial and environmental factors are linked to this relationship between deprivation and diet.

1.3.1 Psychosocial determinants of maternal dietary quality

A review investigating the association of psychosocial factors with fruit and vegetable intake in adults identified strong evidence in the literature for positive effects of social support, self-efficacy (i.e. confidence in choosing healthy foods) and nutrition knowledge.[38] There was also some evidence that understanding diet-disease associations increased fruit and vegetable intake.

Qualitative and quantitative research with women of childbearing age in Southampton showed that mothers with low educational attainment received little support from family members in their attempts to feed them a healthier diet.[39] These mothers also felt a lack of control over family food choices stating that their children's and partner's preferences determined which foods were bought.[40 41] Mothers with low educational attainment reported having few opportunities to learn positive food skills, such as cooking or trying a variety of foods. Furthermore, these mothers expressed less interest in and invested less time into food-related activities,[42] and had poorer knowledge of diet-related diseases than mothers with higher educational attainment.[39] Research in the United States (US) found similar results. In low-income households, mothers favoured buying convenience foods that were easy to prepare, and children's food preferences heavily influenced the foods purchased.[43]

This literature suggests that several psychosocial factors, namely social support, control over and interest in food-related activities, and comprehension of diet-disease relationships are associated with disparities in maternal dietary quality.

1.3.2 Environmental determinants of maternal dietary quality

A recent systematic review of food prices revealed that on average, healthier dietary patterns were more expensive than less healthy patterns by up to $1.50 US dollars per day.[44] Healthy meat options were also dearer than less healthy options, and grain and sugar food groups were cheaper than fruit and vegetables.[45] In the UK, qualitative research with lower educated mothers identified several price related barriers to healthy eating including cost of healthier foods, good value of price promotions on less healthy foods and not wasting money on foods that would not be eaten.[39 40] These price differentials may help to explain why energy dense, nutrient poor foods are associated with disadvantage[46] and why mothers on limited incomes use strategies, such as relying on discount stores and price promotions.[43]

Disparities in access to healthy and affordable food have been identified in the US,[47-49] though studies in other high-income countries are more limited and equivocal.[49] There is also evidence that low-income neighbourhoods have limited variety and poorer quality fruit and vegetables.[50 51] In the US, disparities in food access have been linked to the dietary quality of pregnant women; those living more than four miles from a supermarket were twice as likely to have poor dietary quality as those within two miles.[52]

Favourable self-reported perceptions of healthy food access have also been associated with better dietary patterns.[53 54] Among participants of the US Food Stamp Program, self-reported easy access to supermarkets was associated with higher fruit intake.[55] Similarly in Australia, low-income women who perceived greater healthy food availability in their neighbourhood were more likely to be high fruit and vegetable consumers.[56]

A number of environmental factors may be contributing to dietary inequalities including healthy food cost and availability, as well as objective and perceived access to stores selling healthy foods. Consensus on the need to adapt local food environments to make healthy choices easier is increasing, particularly for individuals from disadvantaged backgrounds.[5 17]

1.4 The local food environment

The local food environment describes the access, availability, price and promotion of food where people live. The United Nations recommend that member states create health-promoting environments that empower families and communities to make healthy dietary choices as a strategy to reduce non-communicable diseases.[57] The need for equitable access and availability of healthy foods and discouraging the promotion of less healthy foods was highlighted. The World Health Organisation also acknowledges the need for pricing, marketing and labelling initiatives that promote healthy products and recommends further research into behavioural and environmental factors affecting dietary choices.[58]

Furthermore, Foresight's obesity report noted that the evidence for environmental influences on diet in the UK is limited, and called for further research including studies using postcode-mapping technologies.[5] With the current UK public health White Paper championing the implementation of community-based initiatives to support healthy lifestyle behaviours, it is pertinent that interventions are based on evidence and that gaps in knowledge are addressed.

1.5 Conclusion

This chapter highlights that inequalities in health remain an important public health issue in the UK. The greatest burden of chronic illnesses, such as obesity and diabetes, fall upon those most disadvantaged and their poorer dietary patterns is an important determinant of this burden. Improving the health of women before, during and after pregnancy is fundamental to the short and long term health of the next generation. Supporting young women, particularly those from disadvantaged backgrounds, to make healthier dietary choices for themselves and their families is a current political priority. Initiatives to achieve this political imperative are more likely to be successful if they are based on evidence. While much is known about psychosocial determinants of dietary inequalities, quantitative assessment of environmental determinants is more limited. Chapter 2 reviews the literature on local environmental factors, inequalities and diet among adults.

Chapter 2 The local food environment

The literature examining associations between local environmental factors and dietary outcomes has grown in recent years.[59] Previous reviews of the evidence have demonstrated that the vast majority of studies exploring the local food environment have been conducted in the US.[59 60] Leading academics in the food environment field have cited a need for research to apply conceptual models that theorise and test the mechanisms by which specific environmental exposures interact with individual factors to influence health behaviours.[61–63]

This chapter presents the findings of a literature review that assessed the evidence for: *i)* differences in local food environment exposures by area level deprivation and, *ii)* associations between local food environment factors and diet or dietary inequalities. Gaps in the evidence that require further investigation are also highlighted. Initially the chapter examines the theoretical basis of food environment research and identifies a conceptual framework upon which the literature review has been structured. Three environmental components of this conceptual model, the *community, consumer* and *organisational nutrition environments* (sections 2.2.1 to 2.2.3), will collectively be termed the local food environment throughout this thesis.

2.1 Determinants of health

The health of individuals and populations is influenced by a range of factors both within and outside an individual's control.[64] These determinants have been theorised into models that aim to describe their pathways of operation. One widely used model is the Dahlgren and Whitehead Policy Rainbow (Figure 2-1) which identifies the layers of influence on an individual's potential for health.[64] This model explains that some determinants, such as age, gender and genetics, are fixed, while others are potentially modifiable. The modifiable determinants are expressed as a series of layers of influence including individual lifestyle factors, social and community networks, and broader socioeconomic, cultural and environmental conditions.

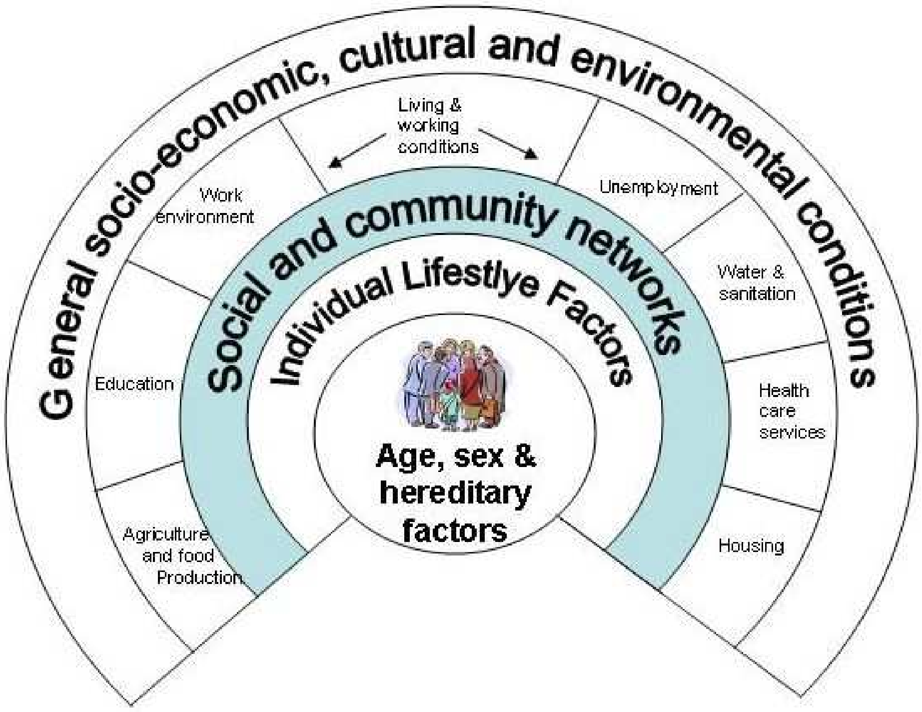


Figure 2-1 The determinants of health model by Dahlgren and Whitehead[64]

Models describing the determinants of health in wider society follow an ecological approach to health. They provide a conceptual framework for researchers to construct hypotheses about the individual, social and environmental determinants of health, and explore the relative influence and interaction of these determinants on outcomes.[65] The ecological approach was first applied to public health in the 1980s. It was adopted from the field of ecology which focuses on life settings and patterns of exchange between organisms and their environment and enabled public health to move beyond individually-focused theory.[66] Leading academics in the field of health inequalities state that:

"the common causes of the ill health that affects populations are environmental: they come and go far more quickly than the slow pace of genetic change because they reflect the changes in the way we live".[67 p10]

There has been resurgence in the use of the ecological approach in recent years. Current policy documents (sections 1.1 and 1.4) acknowledging the persistent social gradient in health highlight the need to address wider social and environmental determinants of health.[66] Innovative research methods, such as multilevel and spatial analyses, have adapted to an ecological approach and new ecological models that theorise specific public health issues, such as diet have been developed.[66]

2.2 Conceptual framework: dietary patterns

Leading academics in the food environment field have cited a need for research to apply conceptual models that theorise and test the mechanisms by which specific environmental exposures interact with individual factors to influence health behaviours.[61-63] A key conceptual framework, published by Glanz et al in 2005, is called the model of nutrition environments (Figure 2-2). Another conceptual framework theorising fruit and vegetable intake among low-income African Americans was also identified. However, this model may not be suitable for research outside the US because of the specific population.[68] The model by Glanz et al refers to a broader population and is more generalisable.

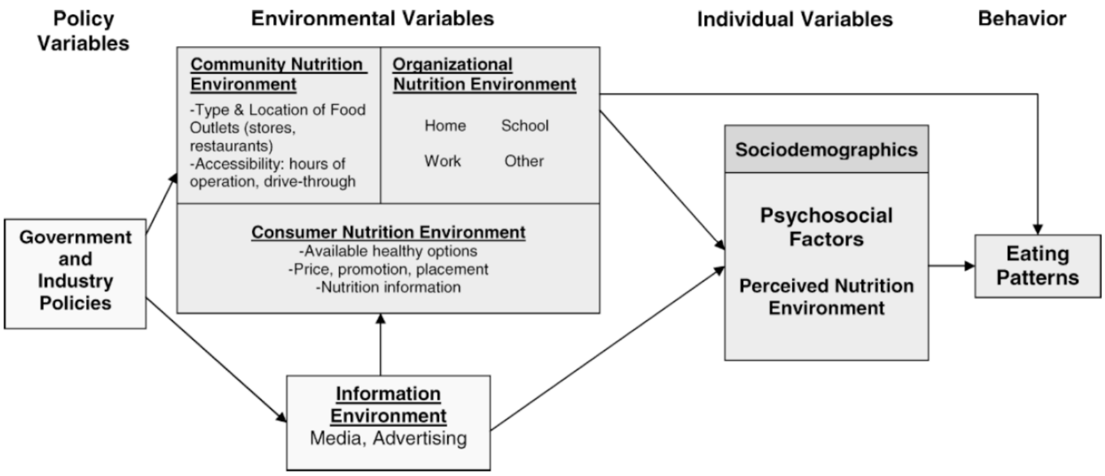


Figure 2-2 Model of nutrition environments[1]

The model of nutrition environments is based on an ecological approach to health and covers the policy, environmental, social and psychological determinants of diet.[1] The model also incorporates constructs found, or hypothesised, to be related to dietary quality from the fields of public health, health psychology, consumer psychology and urban planning. The focal points are the four nutrition food environments that are identified as key settings for environmental research. These four nutrition environments are shown to have two pathways of influence on dietary quality: *i)* direct effect and *ii)* indirect effect.

The four environments and their hypothesised direct effects on diet are described in more detail below (sections 2.2.1 to 2.2.4). The indirect pathway of influence was not explained by the authors. However, the ecological approach of the model implies that demographic, psychosocial and perception factors are likely to filter the influence of the food environments on dietary quality through the process of moderation or mediation. Moderating factors are known to affect the direction and/or strength of the relationship between predictor and outcome variables by interacting with the predictor variable.[69] Mediating factors however, account for the relationship between the predictor and outcome variables. Variations in the predictor, lead to variations in the mediator, which cascade to changes in the outcome.

The next four sections describe the environmental components of the model of nutrition environments in detail.

2.2.1 Community nutrition environment

The community nutrition environment considers the geographical accessibility of food outlets.[1] The conceptual basis of accessibility proposes that greater locational access to neighbourhood features can improve or worsen health-related behaviours.[70] For example, proximate access to large supermarkets which sell a range of healthy products can better enable healthy dietary patterns while proximate access to fast food outlets can promote consumption of less healthy foods at levels damaging to health. The accessibility of food outlets has been typically measured in the context of residential neighbourhoods. Geographic Information Software (GIS) or other methods are used to determine the geospatial location and accessibility of food outlets in terms of proximity, density and to a lesser extent variety.[71 72] Proximity generally assesses the minimum distance between food and residence or proxy location, using road network, Euclidean distance (straight line) or travel time. Density quantifies the availability of different types of food outlets within a specified area, such as census tract or buffer zones around a centroid, home or food outlet. Density calculations can include total count, count per population, per square area or kernel density estimation (density calculation weighted by distance from origin). Variety is a measure of choice rather than a measure of quantity, for example the number of choices of fast food outlets.[73] Having a wider choice of outlets may increase the likelihood of tastes and/or budgets being matched which could influence dietary intake.

2.2.2 Consumer nutrition environment

The consumer nutrition environment has been conceptualised as in-store factors that influence food shopping habits, such as the availability, variety, quality, price, promotions, placement of and nutrition information on food products.[1] Assessment of the in-store environment has typically involved observational audits using a checklist or market basket tool.[72] Several such tools have been developed where the majority measure product availability and price. A smaller number of tools consider additional factors, such as product quality and variety,[60] or product placement and promotion.[74] Fewer studies have explored consumer nutrition environment factors probably due to the time and financial costs associated with collecting and analysing such data.[75]

2.2.3 Organisational nutrition environment

The organisational nutrition environment refers to specific institutional settings where defined groups of people consume food or can learn about healthy eating, such as workplaces, early childhood facilities and churches.[1] The nutrition environment of these institutions has long been identified as an important determinant of health whereby the ethos, policies and practices of the setting can heavily influence an individual's beliefs and behaviours including food choices.[76] These settings can play an important role in an individual's daily life and are increasingly being recognised as part of the local food environment.

The home is also considered part of the organisational nutrition environment. Foods within the home are usually affected by food available from other food sources. In addition, social interactions between the primary food preparer and other family members are likely to play an important role in determining food availability within the home. The home is a complex and dynamic nutrition setting, and not considered in this review.[1]

2.2.4 Information environment

The information environment comprises media and advertising that can affect the attitudes of consumers and the appeal of certain foods or food outlets.[1] The information environment can operate on a national, regional, county and city level but has a more distal effect on food choice than the physical settings of the community, consumer and organisational nutrition environments.[77] For these reasons the information environment is not considered part of the local food environment and has not been included in this review.

2.3 Literature review methods

Using the model by Glanz et al, this study will define the **local food environment** as a **collective term to include the community, consumer** and **organisational nutrition environments.**

A literature review identifying the evidence for an association between dietary inequalities and the local food environment was completed. As the community and consumer nutrition environments are closely related these two environments were reviewed concurrently. The review of the literature on the community and consumer nutrition environments was restricted to research conducted in high-income nations, permanent food sources and on adults aged 18-60 years. The organisational nutrition environment was reviewed separately and was restricted to literature from high-income countries and settings where adults frequent including workplaces, churches and early childhood facilities. The aims of this review were to:

1. Summarise the evidence for neighbourhood disparities in community and consumer nutrition environments from previous review articles
2. Assess the evidence for the effects of the community and consumer nutrition environments on dietary intake
3. Summarise the evidence for the effect of the organisational nutrition environment in workplaces, churches and early childhood facilities on adult dietary intake

Aim 1: Previous semi-systematic and systematic review articles assessing neighbourhood disparities in community and consumer nutrition environments were identified and synthesised. A literature search for reviews was completed in January 2013 using Medline and Web of Science databases and the search terms ‘review’ and ‘food environment’. A total of 123 articles were identified. After screening and analysis, a total of ten papers were found to have reviewed the findings of studies investigating neighbourhood disparities in the community and consumer nutrition environments. Review papers that described methods for assessing the food environment were excluded. These ten review articles considered research on the community and consumer nutrition environment up to early 2011. Additional primary research papers published after this date were also considered to present examples of more recent evidence.

Aim 2: To assess the evidence for an effect of the community and consumer nutrition environments on dietary intake a literature search was performed in November 2012 and again in September 2013 using Medline, Embase, AMED and PsycArticles, and Web of Science databases. Both free text and MeSH terms were applied including 'environmental medicine' (MeSH), 'food stores', food outlet', 'food price', 'food availability', 'food promotions', 'food habits' (MeSH), 'diet', 'consumption' and 'intake'. A total of 3943 articles were identified in November 2012. After screening abstracts and removing duplicates 59 original research articles and two review articles were identified. A further 33 articles were excluded because they did not assess the direct relationship between objective measures of permanent food outlets and dietary outcomes in adults aged 18-60 years. An additional 21 articles were identified from the bibliographies of relevant papers and through contact with experts in the field of food environment research. In September 2013, nine new studies that met the inclusion criteria were identified. A schematic representation of this search is shown in Figure 2-3.

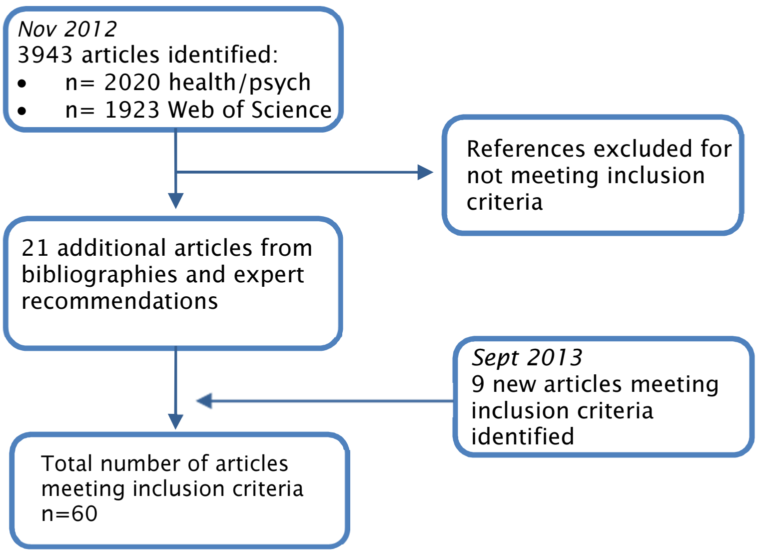


Figure 2-3 Literature search strategy Aim 2

Due to the heterogeneity of the exposure and outcome variables used in these original research papers a meta-analysis could not be performed. As an alternative, exposure measurements were tallied according to the direction of their relationship with three common dietary outcomes: dietary quality, fruit and vegetable intake or fast food intake. Several exposure measures from a single article may have been included in the count. Exposure measures were grouped by store type and key environmental variables including density, proximity, availability, price, quality and variety. The final results were presented in tables or graphs. Similar methods were used to summarise studies that investigated relationships between environmental variables and diet in disadvantaged populations.

Aim 3: A literature search for reviews was completed in January 2014 using Medline and Web of Science databases and the search terms 'workplace*', 'community centre*', 'church', 'childcare*', 'child* centre', 'sure start', 'early years', 'diet', intake', 'consumption', 'review'. A total of 160 were initially identified. After screening titles and content 17 articles were maintained: eight reviewed workplace nutrition interventions, four included reviews of nutrition interventions in church settings and six assessed the nutrition environment of early childhood facilities. In workplace settings, articles that only reviewed the evidence for anthropometric outcomes (weight, waist, BMI) were excluded. This exclusion was not applied to church settings because of the limited literature. However, none of the literature from early childhood settings reported adult dietary or weight outcomes. Therefore, articles that examined the quality of the nutrition environment in early childhood facilities or measured child dietary outcomes were included in this literature analysis. Due to the small number of review articles covering early childhood settings additional original research papers, not included in the reviews, were also summarised.

All identified literature was reviewed by only one reviewer. Grey literature papers identified from the bibliographies of relevant papers were included in this review. However, the grey literature was not systematically reviewed. The findings from the first and second aims of this literature review have been published in a peer-review journal[78] (Appendix A).

2.4 Literature review results

2.4.1 AIM 1: Community and consumer nutrition environment disparities

A total of ten published reviews have assessed studies investigating differences in neighbourhood deprivation or ethnicity of the community nutrition environment and/or the consumer nutrition environment.[47-49 60 79-84] Three articles were described as systematic reviews[49 60 80] however only one review, by Beaulac et al., articulated that two independent authors reviewed the search results. These reviews considered 102 original research papers from five high-income countries, which were published from 1966 to 2011. Four of the ten review articles assessed literature solely from the US, where the bulk of the research in this field has been conducted.[47 48 81 84] The six remaining reviews took an international perspective but were limited to research from high-income nations and papers published in English.

Of the 102 studies reviewed, 70 were from the US, 12 from the UK, 11 from Canada, seven from Australia and two from New Zealand. Approximately half of the studies (47%) focused on assessing neighbourhood disparities in the community nutrition environment, 34% on the consumer nutrition environment and 19% included measures of both these nutrition environments. There was much overlap in the original research papers reviewed, with 41% of studies featuring in more than one review article.

The reviews considered heterogeneity in measurements of the community and consumer nutrition environments to be a major challenge in interpreting the literature. A variety of definitions of neighbourhood and food outlets had been used and a range of analyses applied for measures of food outlet density or proximity and the availability and price of food within stores. This heterogeneity inhibited the performance of a meta-analysis. Table 2-1 provides a summary of the ten review articles and a brief report on their main findings are described in sections 2.4.1.1 and 2.4.1.2.

Table 2-1 Summary of review articles and key findings relevant to neighbourhood inequalities in the community nutrition environment and consumer nutrition environment

Author, year	**Review aim and methods**	**Number of papers reviewed**	**Geographical coverage**	**Key findings** – Community nutrition environment	**Key findings** – Consumer nutrition environment
Hilmers et al, 2012 American Journal of Public Health	Examine socioeconomic/ethnic disparities in neighbourhood access to fast food outlets and convenience stores. Reviewed literature from 2000 to 2011.	24 in total, all relevant to this review. 14 ecological design.	Australia Canada New Zealand UK US	14 of 18 studies identified fast food access favoured more deprived areas. 5 of 9 studies found fast food access was greater in predominantly ethnic areas. All 8 studies found higher density of convenience stores in areas of higher deprivation/ethnicity.	Not applicable
Gustafson et al, 2012 Journal of Community Health	Systematic review of the literature on food availability in stores and neighbourhood characteristics, diet, weight and food prices. Reviewed literature between 2000 and 2011.	56 in total. 30 relevant to this review, all cross-sectional design.	Australia UK US	Not applicable	Inconsistent evidence for less availability of healthy food (6 of 10) and F&V (7 of 11) in poorer/ethnic areas. Prices of healthy foods (2 of 8) rarely differed by area deprivation. All 8 studies showed quality of healthy foods was poorer in more deprived areas.

Author, year	Review aim and methods	Number of papers reviewed	Geographical coverage	**Key findings** – Community nutrition environment	**Key findings** – Consumer nutrition environment
Fleischhacker et al, 2010 Obesity Reviews	Systematic review to examine the evidence on fast food access and its associations with ethnicity, socioeconomic status, obesity and other health behaviours/outcomes. Reviewed literature between 1998 and 2008. Described as systematic review.	40 in total. 17 relevant to this review. 3 cross-sectional design and 14 ecological design.	Australia Canada New Zealand UK US	Only 3 of 15 studies did not find fast food outlets were more prevalent in low-income areas (all non-US). 7 of 9 studies found fast food outlets were more prevalent in high ethnic minority areas.	Not applicable
Fraser et al, 2010 International Journal of Environmental Research & Public Health	Summarise the literature regarding fast food outlet location by area deprivation, dietary intake and weight. Reviewed literature between 1990 and 2009.	33 in total. 12 relevant to this review, all ecological design.	Australia Canada New Zealand UK US	10 out of 11 studies showed associations between increasing area deprivation and access to fast food outlets. The 2 studies identified showed a positive association between area ethnicity and access to fast food outlets.	Not applicable
Walker et al, 2010 Health & Place	To review the literature on healthy food access in the US. Reviewed literature up to January 2010.	31 in total. 20 relevant to this review. 8 cross-sectional design and 12 ecological design.	US	Evidence indicates that disparities in supermarket access exist with ethnic minority and low-income neighbourhoods being disproportionately affected. Non-chain grocery stores are more likely to be located in poor areas. Supermarkets are more prevalent in more affluent areas.	Chain supermarkets have lower prices and better availability and quality of healthy food than smaller non-chain stores. Residents of neighbourhoods with no supermarket pay more for food and have poorer quality food.

Author, year	Review aim and methods	Number of papers reviewed	Geographical coverage	**Key findings** – Community nutrition environment	**Key findings** – Consumer nutrition environment
Beaulac et al, 2009 Preventing Chronic Disease	Systematic review to determine whether access to healthy, affordable food in retails stores varies by area, specifically disadvantaged areas. Reviewed literature up to 2007. Two independent authors reviewed the search results.	52 in total, all relevant to this review. 32 cross-sectional design and 20 ecological design.	Australia Canada New Zealand UK US	18 out of 19 US studies showed low-income/black American areas were underserved by grocery stores compared with more advantaged areas. In other developed countries, 1 out of 6 studies found that low-income areas had poorer access to grocery stores while 2 studies showed low-income areas had better access.	5 of 9 US studies found poorer availability and quality of foods in disadvantaged areas. 6 of 9 nine studies in other developed countries found no difference in availability, variety or quality of healthy foods by area deprivation. In all countries findings for price were mixed and complex. From a total of 23 studies, 3 found higher prices in poorer areas, 4 found lower prices in poorer areas and 16 found mixed or no association.
Larson et al, 2009 American Journal of Preventive Medicine	To comprehensively review disparities across the US according to neighbourhood access to more and less healthy foods and obesity and dietary outcomes. Reviewed literature between 1985 and 2008.	54 in total. 26 relevant to this review. 14 cross-sectional design and12 ecological design.	US	14 of 17 studies showed low-income and ethnic neighbourhoods were more often affected by poor access to supermarkets than more affluent areas. 4 of 6 studies showed access to fast food outlets was greater in low-income and minority areas.	8 of 10 studies showed the availability of healthy food was poorer in more disadvantaged areas. 2 of 2 studies showed restaurants in more affluent areas off more health menu options than low-income areas.

Author, year	**Review aim and methods**	**Number of papers reviewed**	**Geographical coverage**	**Key findings** – Community nutrition environment	**Key findings** – Consumer nutrition environment
Lovasi et al, 2009 Epidemiologic Reviews	To evaluate whether built environments might explain ethnic and socioeconomic disparities in obesity. Reviewed literature between 1995 and 2009.	45 in total. 15 relevant to this review. 8 cross-sectional design and 7 ecological design.	US	10 of 15 studies found disadvantaged areas had fewer supermarkets than more affluent areas. 5 of 8 studies found higher proportions of fast food outlets in more disadvantaged areas.	Not applicable
Ford and Dzewaltowski, 2008 Nutrition Reviews	To provide preliminary evidence to assess: (a) geographical disparities in the retail food environment, (b) disadvantaged areas have poor-quality retail food environment (c) individuals exposed to poor-quality retail food environments have poorer quality diets and higher obesity rates. Reviewed literature from 1992 to 2007.	13 in total, all relevant to this review. 7 cross-sectional design and 6 ecological design.	US	8 of 9 studies found lower access to supermarkets in more deprived and ethnic areas compared to more affluent and white neighbourhoods.	5 of 5 studies found poorer availability or quality of healthy foods is more disadvantaged areas. 2 of 2 studies found no difference in price of products by area deprivation or ethnicity.

Author, year	Review aim and methods	Number of papers reviewed	Geographical coverage	**Key findings** – Community nutrition environment	**Key findings** – Consumer nutrition environment
Black and Macinko, 2007 Nutrition Reviews	Comprehensively assess the neighbourhood determinants of obesity in high-income countries. Reviewed literature from 2005 to 2007.	90 in total. 18 relevant to this review. 5 cross-sectional and 13 ecological.	Australia Canada UK US	9 US studies showed access to stores selling healthy food is worse for low-income neighbourhoods. 3 studies from Canada, Australia and UK did not identify differences in grocery store access by area deprivation. 2 studies found more food retailers in low-income areas. 4 studies from the US, UK and Australia showed low-income and ethnic neighbourhoods had greater exposure to fast food outlets.	2 studies showed low-income and ethnic areas had fewer healthy choices in local restaurants.

2.4.1.1 Community nutrition environment inequity

There was consensus across the nine articles reviewing the community nutrition environment of sufficient evidence that residents of low-income or ethnic minority neighbourhoods in the US have disproportionally poorer access to healthy foods[47-49 79] and greater access to food outlets selling less healthy foods[48 79 80 82 83] than residents of more affluent neighbourhoods. One review concluded that the strongest evidence for environmental influences for socioeconomic and ethnic disparities in obesity is the unequal access to food stores (along with access to exercise facilities and neighbourhood safety).[84] The evidence for differences in access to healthy food by level of area deprivation from other developed nations including Canada, Australia and the UK was equivocal.[49 79] However, there was more consistent evidence for disparities in access to fast food outlets in these countries, with greater access in more deprived neighbourhoods.[79 80 82 83]

The five review articles that assessed the evidence for neighbourhood differences in fast food access found that, across high-income countries, the vast majority of studies showed greater access to fast food outlets in neighbourhoods with higher levels of deprivation and minority populations.[48 79 80 82 83]

The United States: The four review articles which assessed the evidence for spatial disparities in grocery store access found consistent trends for low-income and ethnic communities in the US having fewer supermarkets per capita and farther distances to travel to the closest store than more affluent communities.[47-49 79] For example, research assessing the national distribution of supermarkets by zip codes showed that residents in low-income neighbourhoods had only 75% as many chain supermarkets as middle income neighbourhoods.[85] There were also differences in access according to ethnicity, with the availability of chain supermarkets in neighbourhoods with higher proportions of black residents roughly half that in predominantly white neighbourhoods. Similarly, research from Detroit, which investigated distance to closest supermarket from census tracts centroid, showed the nearest supermarket was at a significantly greater distance from people's homes in the most impoverished areas (>17% in poverty) compared with the least impoverished areas (<5% in poverty).[86] Furthermore the most impoverished black areas were 1.1 miles further from the closest supermarket than the most impoverished white areas. A more recent study in a Texan county, however, found that proportion of residents who were Latino in the neighbourhood was not associated with access to supermarkets, grocery stores or specialty stores but there was an association with exposure to convenience stores.[87] This brief summary suggests, as noted in one review,[79] that there is evidence that in the US neighbourhood environmental factors may inhibit residents of disadvantaged communities from making health dietary choices.

In the United States a national study that examined the distribution of food service outlets in more than 28,000 zip codes, found lower income neighbourhoods had 1.2 and 1.3 times the number of full service and fast food outlets of higher income neighbourhoods respectively.[88] These disparities were observed after adjustment for population density, urbanisation and region. Research from New York City highlights how black communities are disproportionally affected by fast food access with results showing that the prevalence of fast food outlets was positively associated with percentage of black residents.[89] This association was stronger than the association with median household income such that high-income black neighbourhoods had similar exposure to fast food outlets as low-income black neighbourhoods. A more recent study, included in one review article[83], applied a novel approach to assessing food outlet accessibility by creating an index that considered density of supermarkets, convenience stores selling healthy foods and fast food outlets in census blocks.[90] Results showed that predominantly black neighbourhoods had poorer food access scores while predominantly Latino and white neighbourhoods had better food access scores. Additionally, neighbourhoods with the highest median income had better food access scores compared with the lowest income neighbourhoods.

Other high-income nations: Grocery store access studies from other high-income nations including Australia, Canada and the UK have not consistently identified disparities in access to supermarkets and grocery stores among neighbourhoods of varied socioeconomic status[49,79] and very few studies have reported differences by the ethnic composition. For example, research from Melbourne, Australia, has shown that geographical access to supermarkets and fruit and vegetable stores was better for those living in more advantaged neighbourhoods.[91] This finding was consistent across three measures of access: count within a two kilometre buffer of home, density per 10,000 residents and closest proximity via road network. Another study from Melbourne, however, found that although more advantaged areas had closer access to supermarkets, most residents (>80%) lived within an 8-10 minute car journey of a major supermarket suggesting most people had good access to healthy food.[92] Similarly, research in Brisbane, Australia, demonstrated no differences in shopping infrastructure according to the socioeconomic status of census districts.[93]

In Edmonton, Canada, research revealed few differences in supermarket access across neighbourhoods of differing socioeconomic status or proportion of Aboriginal residents.[94] Furthermore, research in British Columbia and Quebec has shown that supermarkets predominated low-income neighbourhoods[95 96], while in Ontario, convenience stores were more prevalent in lower income neighbourhoods.[97]

The evidence from the UK is also mixed. Assessment of the community nutrition environment in Wales and Northern England has shown poorer access to supermarkets in poorer areas.[98] Research in Glasgow, however, has shown little difference by neighbourhood deprivation[99] or better access to supermarkets in more deprived neighbourhoods.[100]

Nation-wide research in Sweden, that was not included in the review articles, revealed that neighbourhoods of high deprivation have a greater prevalence of supermarkets and grocery stores than less deprived neighbourhoods.[101] These results provide further indication that food access issues, which appear to be important predictors of inequalities in the US, may be less apparent in other developed countries.

Socioeconomic trends in fast food access in other developed countries have been reasonably consistent with trends observed in the US.[79] Only three studies, from Canada and the UK, have shown no association between level of neighbourhood deprivation and fast food access.[80 82] In Melbourne, Australia for example, research has shown that residents of the poorest neighbourhoods lived closer, and had up to 2.5 times more exposure to fast food outlets, than people living in wealthier neighbourhoods.[92 102] In Edmonton, Canada, poorer neighbourhoods, as well as those with higher percentages of Aboriginal residents, had greater access to fast food outlets than more affluent neighbourhoods.[94] This association remained after adjusting for supermarket proximity to residents' homes. Research from the UK has shown a positive linear relationship between the density per 1000 population of McDonald's and other chain fast food outlets and neighbourhood deprivation such that fast food outlets were more prevalent in poorer areas.[103 104] However, investigations including all out-of-home eating outlets in Glasgow showed the density was highest in neighbourhoods of the second most affluent quintile.[105] A more recent study assessing facilities across Sweden revealed results consistent with the international trend showing higher prevalence of fast food outlets in more deprived neighbourhoods.[101]

2.4.1.2 Consumer nutrition environment inequity

Six review articles appraised neighbourhood disparities in the consumer nutrition environment literature, three with an international perspective,[49 60 79] and three focused on literature from the US.[47 48 81] Ford and Dzewaltowski concluded that consumer nutrition environment studies revealed weaker associations between in-store variables and area deprivation than community nutrition environment studies that used store type as a proxy for healthy food (larger stores having greater availability and cheaper prices). However, the authors also stated that consumer nutrition environment studies are important because they allow for critical differences in availability, price and quality to be observed.

The United States: There is some evidence for neighbourhood disparities in the availability of healthier foods in the United States but the evidence for price is less robust.[47-49 81] For example, results from in-store surveys in two socioeconomic and ethnically contrasting cities in Alabama revealed that the more disadvantaged city had a dominance of convenience stores which stocked few healthy foods. The more affluent city had no convenience stores and several chain supermarkets which offered a large variety of healthy food options and lower price ranges for some fruit and vegetables.[106] In contrast, survey results from grocery stores in two socioeconomically and ethnically contrasting cities in Chicago showed that store prices were cheaper in the poorer community.[107]

Other high-income countries: In other high-income countries the evidence is equivocal.[49 60] In Australia, research in Brisbane showed no differences in fruit and vegetable price or availability by level of neighbourhood deprivation.[108] In-store surveys in Melbourne however, revealed that fruit and vegetable availability slightly favoured more affluent neighbourhoods but food prices were cheaper in more deprived neighbourhoods.[91] Cheaper food prices in poorer areas have also been observed in Canada[97] and the UK.[100 109]

Although limited and reviewed in only one article, evidence has consistently shown poorer quality produce in more deprived neighbourhoods.[60] A recent study from the UK revealed that residents of the most deprived neighbourhoods had 69-76% greater risk of poor quality fruit and vegetables than residents of more affluent neighbourhoods.[110] The small body of evidence assessing the consumer nutrition environment in food service outlets, reviewed in only one article, revealed that restaurants in more affluent areas offer healthier menu options than low-income areas.[48] The current evidence for socioeconomic neighbourhood differences in the consumer nutrition environment suggests that the relationship between the availability and price of healthy food and area deprivation is complex and context dependent.[81] Variations in the foods assessed in stores and exclusion of in-store factors, such as marketing and product placement, limits the ability of the current body of evidence to determine whether neighbourhood differences in the consumer nutrition environment contribute to dietary inequalities.[60]

2.4.2 AIM 2: Community and consumer nutrition environments and dietary quality

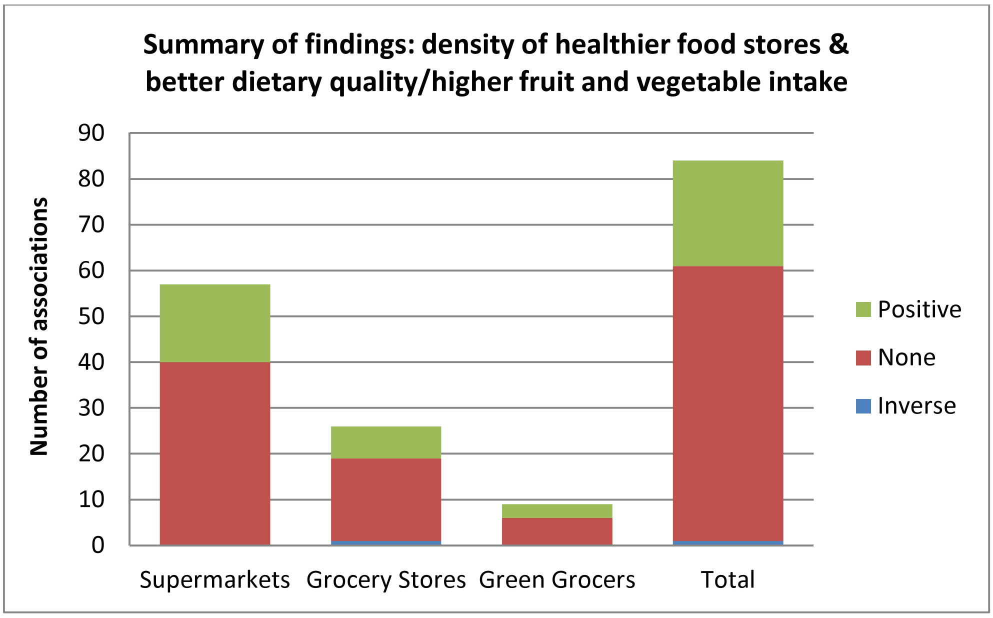
In the search for evidence of a relationship between the community and consumer nutrition environments and dietary outcomes, two systematic reviews were identified. Caspi et al[59] completed a systematic review of articles published prior to March 2011 that investigated a relationship between neighbourhood food environment exposures and diet. A total of 38 empirical studies were identified, 26 of which measured the relationship between objective community or consumer nutrition environment exposures and dietary outcomes in adults aged 18-60 years. More than two-thirds of the articles (n=26) used geographical exposure data to measure community nutrition environment against dietary outcomes. Gustafson et al[60] systematically reviewed literature investigating the consumer nutrition environment of food stores from 2000 to 2011. A total of six articles that assessed the relationship between objective consumer nutrition environment exposures and diet in adults aged 18-60 years were identified. An additional article,[111] not identified by Caspi et al, has not been included here because multiple community and consumer nutrition environment variables were combined in a model, making it difficult to directly compare with other research papers.

The literature search for this thesis identified a further 27 articles[53 112–137] in addition to those identified by Caspi et al and Gustafson et al. Key findings from the two systematic reviews and original research papers investigating the neighbourhood food environment and dietary outcomes are provided below for the community and consumer nutrition environments respectively.

2.4.2.1 Community nutrition environment and dietary quality

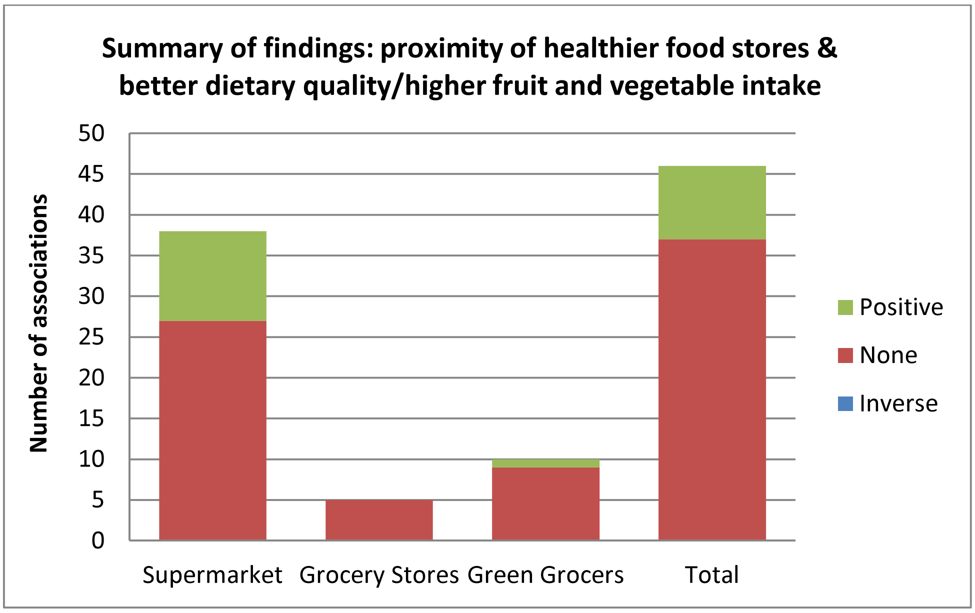
A total of 31 articles, involving adults aged 18–60 years, measured access to food stores using measures of density. These studies tested whether (a) increased access to food stores selling healthy foods, such as supermarkets/greengrocers, is associated with better dietary outcomes and/or (b) increased access to outlets selling less healthy foods, like fast food outlets, is associated with poorer dietary outcomes. The majority of these studies (n=20) identified at least one significant association between geographical density and their diet in the expected direction. Two studies assessed the ratio of number of healthy food outlets to less healthy food outlets (Retail Food Environment Index) within a specified boundary but found no association between overall retail exposure and diet.[134 137] A total of 24 articles, involving adults aged 18–60 years, examined distance to nearest food outlet from participant's home or proxy location. Thirteen of these papers revealed no association between proximity and diet. One study investigated fast food chain variety and showed that increased numbers of different fast food outlets was linked with higher fast food intake.[73]

Figure 2-4 to Figure 2-7 present the findings from the 42 original research papers investigating a relationship between community nutrition environment exposures and diet. Around a quarter of the density findings provide evidence for expected associations: food stores selling healthy foods (supermarkets, grocery stores and green grocers) related to better dietary outcomes (27%) and less healthy food stores related to poorer dietary outcomes (22%). Approximately one fifth of the proximity findings provide evidence for an association between healthier food stores and better dietary outcomes (20%) and even fewer show an association between less healthy food outlets and poorer dietary intakes (13%).



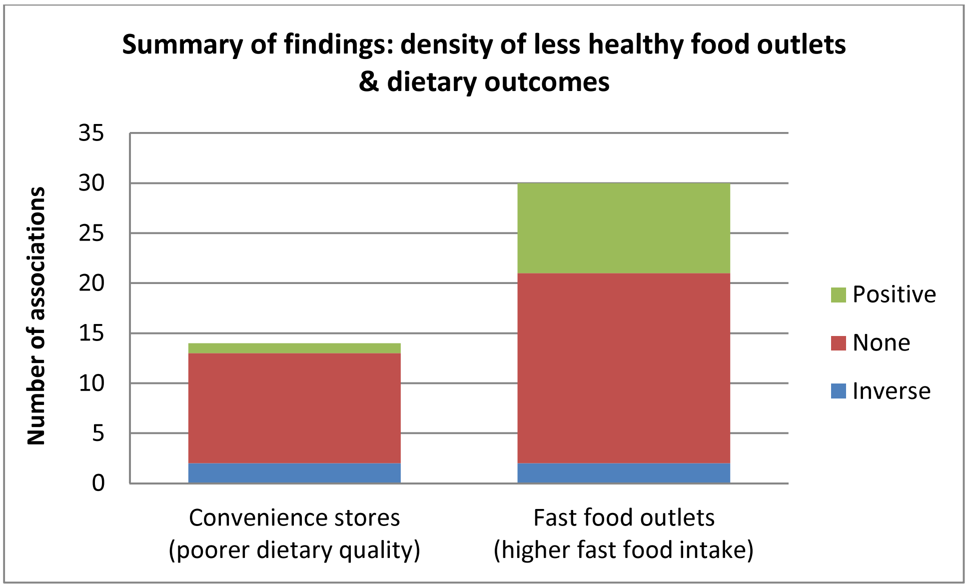
* Across 42 different exposure measures, 17 studies and 21 papers.

Figure 2-4 Summary of findings relating density of healthier food stores to better dietary quality or higher fruit and vegetable intake



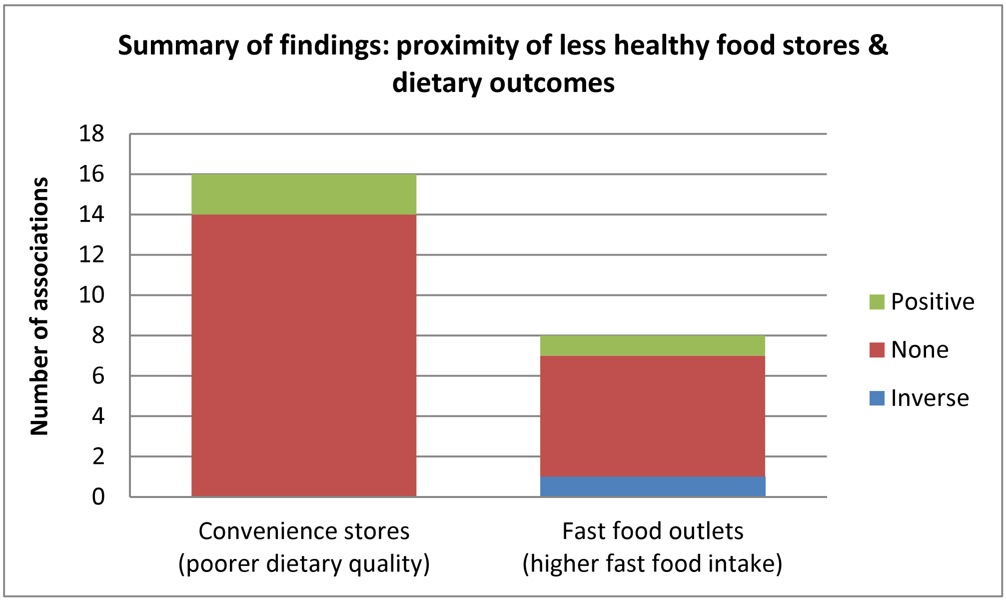
* Across 11 different exposure measures, 16 studies and 18 papers.

Figure 2-5 Summary of findings relating proximity of healthier food stores to better dietary quality/fruit and vegetable intake



* Across 10 different exposure measures for convenience stores, 7 studies and 7 papers.
* Across 12 different exposure measures for fast food outlets, 8 studies and 9 papers.
(2 studies were excluded from convenience store calculations because different outcome measures were used and 5 studies were excluded from fast food outlet calculations because different outcome measures were used.)

Figure 2-6 Summary of findings relating density of less healthy food stores to poorer dietary outcome



* Across 5 different exposure measures for convenience stores, 7 studies and 7 papers.
* Across 1 different exposure measures for fast food outlets, 4 studies and 5 papers.
(1 study was not included in the convenience store calculation because different outcome measures were used and 1 study was not included in the fast food outlet calculation because different outcome measures were used.)

Figure 2-7 Summary of findings relating proximity of less healthy stores to poorer dietary outcomes

Very similar trends were observed in the few studies (n=9) that focused analyses on disadvantaged populations. More than a quarter of the density findings showed an association between density of healthier food stores and better dietary outcomes while, nearly a fifth showed evidence of an association between closer proximity to healthier food stores and better dietary outcomes. No relationships were observed between proximity of convenience stores and diet in disadvantaged populations, however, proximity to fast food outlets was associated with higher fast food intake in the one study identified.[118]

The evidence for the community nutrition environment shows a trend toward expected associations of healthier environments and better dietary behaviours. However, the majority of findings reported no association. There is some variation by global regions which is discussed further below.

The United States: The majority of studies have been conducted in the US (n=24). This literature provides the strongest evidence of all regions for a relationship between community nutrition environment exposures and dietary outcomes with almost two thirds of studies showing significant associations ($p<0.05$) in the expected direction. Better access to supermarkets and green grocers was associated with healthier dietary behaviours in ten studies. However, a further eleven studies revealed no significant associations. Two studies revealed negative associations between fruit and vegetable intake and the density of small grocery stores and convenience stores which are known to offer poorer availability of healthy foods.[138 139] For example, Powell et al[139] showed that each additional grocery store per 10,000 capita was associated with an approximate 3% decrease in weekly fruit and vegetable consumption ($p=0.05$). This study by Powell et al also showed that each additional fast food outlet per 10,000 capita was associated with an approximate 5% decrease in fruit and vegetable consumption. However, the evidence for a relationship between fast food access and fast food intake in the US is mixed with four of the nine studies showing mixed results and three returning null or unexpected findings. Results from a longitudinal study stratifying the sample by gender found no association between fast food outlet density and fast food consumption in women. For males however, 1% increase in access to fast food outlets within a 1km and 1-3km radius from home corresponded with modest increases in monthly fast food intake of 0.13% and 0.34% respectively.[115] The evidence suggests that while some inconsistency exists in the literature there is weak evidence for a relationship between community nutrition environment exposures and dietary outcomes in the US.

Canada: One comprehensive study in Ontario, Canada, has assessed the relationship between food access and diet.[134] This study measured multiple aspects of the community nutrition environment including road network distance to nearest grocery store, convenience store and fast food outlet, total store and restaurant density within one kilometre of home, and the ratio of healthy to unhealthy stores and restaurants. Analyses were stratified by gender and results revealed no significant relationships. The lack of significant findings suggests that in Canada dietary quality is not influenced by access to food stores and restaurants although conclusions cannot be drawn from a single study.

Australasia: A total of eight articles were identified from the Australasia region: four from Australia, two from New Zealand and two from Japan. The findings of these papers are largely equivocal, with several studies revealing mixed results. For example, the SESAW study from Australia found that density of supermarkets per 10,000 residents[114] and within 2km radius of low-income women's homes[56] was not associated with fruit and vegetable consumption. Higher supermarket density within 3 km radius of residence, however, was associated with increased vegetable consumption of the full sample of women.[140] In New Zealand, research by Pearce et al[141 142] found no association between supermarket access and fruit and vegetable consumption. However, this study did show that residents with the worst access to fast food outlets were up to 17% *more* likely to consume the recommended intake of vegetables and those with the best access to convenience stores were up to 25% *less* likely to.

Europe: Across Europe, nine articles written in English were identified: eight from the UK (five in England and three in Scotland), and one from the republic of Ireland. This literature revealed many inconsistencies with several studies reporting conflicting findings. In the UK, Burgoine et al[117] showed no association between fruit and vegetable consumption and density of supermarkets or convenience stores. They also found an unexpected association between elevated vegetable consumption and higher density of food service outlets. These outlets included restaurants as well as takeaway outlets and the authors postulated that residents might not always be making unhealthy choices if they are eating-out within their neighbourhood. Two natural experiments exploring the effects of opening a new supermarket have been conducted in the UK. In northern England, consumers who switched supermarkets or lived within 500 meters of the new store had increased fruit and vegetable consumption after the new supermarket had opened.[143] In Glasgow, however, no positive effect on the fruit and vegetable intake of neighbourhood residents was identified even though 30% of the sample reported switching to the new supermarket.[144] The single non-UK study revealed a weak effect for supermarket access on dietary quality in the republic of Ireland: each additional supermarket within a two kilometre radius from home was associated with a 2.5% increase in dietary quality score which represented a healthier dietary pattern.[120] These studies from Europe demonstrate inconsistent associations between the community nutrition environment and diet, and the effect sizes observed have been relatively small. The body of literature is also limited, particularly outside the UK, and there is a need for methodological improvements to enhance the quality of the evidence.[59 71]

2.4.2.2 Consumer nutrition environment and dietary quality

A total of 20 studies used in-store audit tools to measure consumer nutrition environment exposures and dietary outcomes in adults aged 18-60 years. These studies tested whether (a) better availability, variety and quality of healthy foods is associated with healthier dietary intakes and/or (b) lower costs of healthy food and higher costs of less healthy food are associated with healthier dietary outcomes.

Different in-store audit tools were used across most studies and few studies reported the psychometric properties of reliability. Ten assessed product availability, six of which identified at least one positive association with diet. The eight studies that assessed price found either null associations or unexpected associations where better dietary patterns were associated with higher prices. The two longitudinal studies,[128 129] however, showed that price increases on less healthy foods were associated with lower energy or fast food intake. Few studies measured the variety or quality of products (n=4) and results were mixed.

Table 2-2 summaries of the findings from the 20 original research papers investigating a relationship between consumer nutrition environment exposures and diet. Almost a quarter of findings (24%) regarding the availability of healthy products revealed that better availability was associated with better dietary outcomes. For price, one fifth of studies showed that lower prices of healthy and less healthy products increased consumption of these foods. However, almost half of the findings regarding price showed that higher prices of healthy foods were associated with better dietary outcomes. Few studies (n=5) investigated the effect of produce variety or quality on dietary outcomes and the evidence is currently equivocal.

Table 2-2 Summary of findings relating consumer nutrition environment exposures to better dietary quality/higher fruit and vegetable intake

Direction of relationship	Number of findings			
	Availability	**Price**	**Variety**	**Quality**
Inverse (unexpected)	2	11	0	0
None	27	12	3	4
Positive	9	5	1	1
Number of exposure measures	20	13	3	4
Number of papers	11	10	3	4
Number of studies	11	10	3	4

The United States: A total of 16 studies from the United States have investigated links between factors within food stores and dietary outcomes. This region has the largest body of research on this topic and provides moderate evidence to support the hypothesis that the consumer nutrition environment influences diet. Of the ten studies investigating the relationship between product availability and dietary outcomes, six showed at least one significant association in the expected direction, with better availability of healthy food related to healthier dietary intakes. Four studies using the Nutrition Environment Measures Survey in Stores (NEMS-S) market basket tool showed mixed results: lower availability of healthier foods was associated with dietary patterns of poorer quality[145] and better availability of healthier foods was associated with higher odds of eating at least one serving of vegetables a day,[112] but associations between higher dietary quality and lower availability of healthier foods have also been found.[127]

Five of the nine studies investigating the effect of price on dietary outcomes found at least one significant association in the expected direction, higher prices and lower intake of less healthy items or lower prices and increased intakes of healthy items. A longitudinal price study showed a strong relationship between weekly fast food consumption and prices of soda and weaker associations for takeaway burger prices.[129] These relationships were differentiated by ethnicity and income. The strongest association, seen in black men, showed a 20% increase in the price of soda was associated with a 0.25 reduction in number of days eating fast food per week. Two recent cross-sectional studies using published price data revealed negative associations between total diet cost and dietary quality such that better quality diets were more costly[131] and diet cost mediated the relationship between socioeconomic position and dietary quality.[130]

Other high-income nations: Four studies have investigated product availability or price and diet outside the US: two from the UK and one each from Canada and Australia. This small body of literature revealed inconsistent findings that can largely be considered inconclusive.

2.4.3 AIM 3: Organisational nutrition environments and dietary quality

The literature search for evidence that nutrition environments in workplaces, churches and early childhood centres have an effect on adult dietary intake identified adequate literature only for workplace settings. A very small number of studies measured adult dietary outcomes of interventions in church settings. No studies assessing the nutrition environment of early childhood settings measured parental dietary intake because the focus has been on childhood obesity and childcare centres where parents leave their children. However, early childhood settings could also affect the dietary choices of parents, particularly in children's development centres where parents attend with their children. This literature review identified that, across the three settings, common areas were targeted when assessing or altering the organisational nutrition environment. The next three sections describe the findings from workplaces, churches and early childhood settings (sections 2.4.3.1, 2.4.3.2 and 2.4.3.3 respectively).

2.4.3.1 Workplaces

Eight published reviews have assessed the effectiveness of nutrition-related intervention studies in workplaces.[146-153] Five of these articles were systematic reviews where at least two authors independently assess the content of the search results.[146 147 149 150 153] One systematic review conducted a meta-analysis of the effectiveness of dietary interventions that used educational or counselling strategies.[147] Other review articles cited heterogeneity in study design as a barrier to completing a meta-analysis. These reviews covered 65 original research papers published from 1988 to 2011. Seven of these review articles covered studies from across the globe, while one focused solely on literature from Europe.[149] The majority of the research reviewed was conducted in high-income countries and no review articles reported on differences between intervention effects by employee's level of educational attainment. There was some overlap in original research papers reviewed, with 28% of studies featuring in more than one review article. Table 2-3 provides a summary of each of the eight review articles.

There was consensus across the eight review articles of moderate evidence for a small positive effect of dietary-related interventions in the workplace on employee dietary behaviours. Intervention results generally showed consistent positive effects on fruit and vegetable intake, but results were more equivocal for fat consumption. Intervention effect sizes were consistently reported as being small. The single meta-analysis identified a small to medium effect size (Cohen's d=0.4) for motivational enhancement strategies, such as motivational interviewing.[147] But found that effect sizes for educational and social influence strategies were rather small (d<0.2). Narrative reviews also reported that improvements in fruit and vegetable consumption were small and equated to less than one additional serving each day.[146 150 152]

According to the eight review articles strategies employed to improve dietary behaviours in workplaces can be grouped into four approaches: *i)* education/information, *ii)* policy/environmental, *iii)* socio-cultural or *iv)* multi-component. Educational strategies included nutrition displays, posters and information sheets, educational email alters, diet plan examples or individual/group counselling. Environmental strategies included point-of-purchase nutrition labelling, increased availability of healthy foods in cafeterias or vending machines or healthier catering policies for meetings and events. Socio-cultural approaches include active involvement and role-modelling by management and inclusion of employees in development of new policies and activities to facilitate change in social-norms. Multi-component interventions included at least two of these three approaches.

Most of the original research papers reviewed included education only or multi-component interventions. Studies including only environmental strategies tended to have poorer study designs and provided weaker evidence of effectiveness. Few studies included socio-cultural strategies. One randomised controlled trial illustrated that socio-cultural strategies, including actively engaging management, can improve access to healthy foods at work and enhance employee perceptions of the support they receive from management and co-workers for healthy eating.[154]

It was argued in two reviews that inclusion of environmental/policy and socio-cultural strategies in multi-component workplace interventions is advantageous because they reach a large number of employees, are low-cost and are likely to be sustainable.[148,152] Another review concluded that even modest effect sizes can be important for improvements in health outcomes if employee participation and reach is high.[149] Furthermore, workplace health programs can have knock-on effects, such as improving firm productivity or the dietary behaviours of employee's families.[152] The small but consistently positive findings of these review articles therefore suggest that multi-component interventions in the workplace can be effective at supporting employees to adopt healthier dietary attitudes and behaviours, and may improve productivity and have wider societal benefits.

Table 2-3 Summary and key findings of review articles assessing nutrition focused interventions in workplaces

Author, year	**Review aim and methods**	**Number of papers reviewed**	**Geographical coverage**	**Key findings** – Workplaces
Geaney et al, 2013 Preventive Medicine	Systematic review of the effectiveness of controlled workplace dietary modification interventions longer than three months. Dietary modifications included changes in food available or portion size. Three authors screened and evaluated identified papers.	6 studies (12 articles) were identified.	Belgium, Brazil, Netherlands, US	Five out of six studies included dietary modification and educational strategies in their intervention. Four of five studies found small (<1 serve/day) positive effects for fruit and vegetable intake. One of three studies showed reduced dietary fat intake. There is some evidence that workplace dietary modification interventions improve dietary behaviours but quality research is limited.
Hutchinson and Wilson, 2012 Health Promotion International	Systematic review and meta-analysis of workplace dietary and physical activity interventions. Identify conceptual frameworks for effective interventions. Reviewed literature from 1999 to 2009. Two authors identified and assessed identified papers.	29 articles identified: 7 measured dietary behaviour outcomes.	International	Consistent evidence for small positive effect of all intervention types on dietary behaviours. The largest effect sizes were observed for motivation enhancement strategies, then educational strategies. Greater effect sizes were observed for studies with a single focus (diet or physical activity) and randomised control trials.
Kahn-Marshall and Gallant, 2012 Health Education & Behavior	Review the effectiveness of workplace health promotion programs that included environmental strategies. Reviewed literature from 1995 to 2010. Environmental strategies included point-of-sale information, availability of healthier foods, healthier catering policies.	9 articles with a dietary element identified: 4 environment only, 10 multi-component.	Canada, Chile, Netherlands, New Zealand, US	All four studies with nutrition-related environmental or policy interventions found a positive effect on dietary-related outcomes. However methodological concerns limit the conclusiveness of the evidence. Two thirds of multi-component studies found modest improvements in fruit and vegetable intake. There was also some evidence for reduced fat intake and lower absenteeism levels in individual studies.

Author, year	Review aim and methods	Number of papers reviewed	Geographical coverage	Key findings – Workplaces
Maes et al, 2012 European Journal of Public Health	Review the effectiveness of workplace health eating and physical activity interventions in Europe. Reviewed literature from 1990 to 2010. Articles identified by one author and evaluated by four authors.	17 articles with a dietary focus identified: 8 education only 1 environment only 8 multi-component.	North and west Europe	Three quarters of educational and multicomponent studies moderate evidence for a positive effect on dietary behaviours. Evidence of environmental interventions is inconclusive due to the limited research. Studies were moderate to weak in design.
Osilla et al, 2012 American Journal of Management Care	Systematic review of workplace wellness programmes impact on behaviours, absenteeism and healthcare costs. Reviewed literature from 2000 to 2011. Articles were independently evaluated by two authors.	33 articles identified: 12 measuring dietary outcomes.	International	Half of the dietary intervention studies found improvements in diet. However, overall effect sizes were small for example 0.7 increase in fruit and vegetable serves/day. The most common intervention strategy included self-help and educational materials. Observational designs were more likely to show dietary improvements than randomised controlled trials.
Jensen, 2011 Perspectives in Public Health	Review of potential productivity effects of dietary workplace interventions. Reviewed literature from 1988 to 2010.	30 articles identified: 14 measured dietary behaviour outcomes.	Canada, Denmark, Netherlands, Sweden	11 out of 14 articles found beneficial effects of dietary workplace interventions of dietary outcomes. Positive effects on diet were observed for educational, environmental and multi-component interventions.

Author, year	Review aim and methods	Number of papers reviewed	Geographical coverage	**Key findings** – Workplaces
Ni Murhchu et al, 2010 BMC Public Health	Review of effectiveness of workplace interventions on diet. Reviewed literature from 1995 to 2009.	16 articles identified: 8 education only 2 environment only 6 multi-component.	Europe, US	Three quarters of the articles measured changes in fruit and vegetable intake, and half measured changes in total fat intake. These articles generally showed positive intervention effects on dietary outcomes but small effect sizes. Individual education/counselling interventions found slightly greater effect sizes than environmental interventions.
Engbers et al, 2005 American Journal of Preventive Medicine	Systematic review of effectiveness of workplace health programs with environmental modifications on dietary intake, physical activity or health risk indicators. Reviewed literature from 1985 to 2004. Two authors independently assessed identified articles.	13 articles identified: 4 had high quality methodology.	International	Half of the articles measured fruit and vegetable intake and all found positive intervention effects. Half of the articles measured fat intake and almost all found interventions reduced fat intake. Good evidence for the effectiveness for workplace health interventions with environmental modifications on dietary intake. However, the body of literature is small and methodological quality was mostly poor.

2.4.3.2 Church settings

Four review articles included assessment of health and obesity focused interventions in church settings (Table 2-4).[155-158] All four reviews covered literature only from the US. The two oldest articles, both published in 2004, reported on studies that measured dietary outcomes but one of these articles grouped dietary findings with weight-related outcomes.[157] The two more recent reviews reported on the evidence for weight outcomes in obesity interventions in minority populations, namely Latinos[155] and African Americans.[156] All four reviews identified some evidence for the effectiveness of church-based nutrition or weight-management programmes in reducing weight and/or increasing fruit and vegetable consumption. Most interventions included educational, information or motivational strategies. The two studies included in the review by Glanz and Yaroch[158] reported good effect sizes for interventions that included environmental strategies, such as serving more fruit and vegetables at church events. An increase of approximately one additional serving of fruit and vegetables each day was observed in the intervention groups. These results however need to be viewed with caution because the body of evidence is small.

DeHaven et al[157] suggested that church-based health programmes are likely to be under evaluated and under reported. Authors from all four review articles highlighted the important role the church setting can have on supporting health lifestyle behaviours, particularly with vulnerable populations. Churches act as familiar community-based institutions, offering a comfortable environment where messages about health and lifestyle can be readily received.

Table 2-4 Summary and key findings of review articles assessing nutrition or weight focused interventions in church settings

Author, year	**Review aim and methods**	**Number of papers reviewed**	**Geographical coverage**	**Key findings** – Church setting
Perez et al, 2013 American Journal of Preventive Medicine	Systematic review of obesity related treatment interventions in Latino adults. Reviewed literature from 1990 to 2010. 2 independent reviewers screened and evaluated identified studies.	22 studies identified. 3 interventions in churches.	US	Evidence of negative, small and medium positive effects of interventions in churches on weight loss.
Osei-Assibey and Boachie, 2012 Public Health Nutrition	Review the effect of diet interventions longer than 3 months in blacks (African ancestry) on weight/BMI. Reviewed literature between 1990 and 2009. 1 reviewer screened search results, a second assessed studies identified.	18 studies identified. 3 interventions in churches.	US	Two thirds of the studies in churches found a positive effect on weight status between intervention and control groups. HDL cholesterol and triglycerides also improved however total cholesterol did not.
DeHaven et al, 2004 American Journal of Public Health	Systematic review of health programs in church settings. Reviewed literature between 1990 and 2000. Identified studies were assessed by 2 reviewers.	20 studies identified. 5 focused on weight/nutrition outcomes.	US	All nutrition/weight related studies reported significant evidence of increased fruit and vegetable consumption or reduced weight status. The effect sizes were not reported.

Author, year	Review aim and methods	Number of papers reviewed	Geographical coverage	Key findings – Church setting
Glanz and Yaroch, 2004 Preventive Medicine	To provide an overview of environmental, policy and pricing strategies for increasing fruit and vegetable intake in community locations.	2 large studies (6 articles) conducted in churches.	US	Both studies included individual and environmental strategies and showed 0.85–1.3 increase in fruit and vegetable serves per day in the intervention groups. Environmental strategies included serving more fruit and vegetables at church functions, taste tests and partnering with local grocers.

2.4.3.3 Early childhood settings

Two published reviews[158 159] of the nutrition environment in early childhood settings were identified. These reviews covered 27 original research papers. Four additional original research articles[160-163] that were not included in these reviews were also identified. These papers covered research from Australia, Israel, UK and US, but the majority of the literature was from the US. Most articles evaluated the nutrition environment of childcare settings and all focused on implications for children's diets. These studies did not measure dietary outcomes in parents or childcare staff, nor evaluated the quality of the nutrition environment in children's development centres (e.g. Sure Start Children's Centres) where parents attend with their children. Socioeconomic area level differences in facilities' nutrition environments were not reported. Most studies evaluated the nutrition environment of childcare centres via observation and/or questionnaires completed with centre staff or management. Table 2-5 presents a summary of the two reviews and four original research papers.

The vast majority of articles reported that providing healthy foods was important to childcare centre staff and management but that improvements could be made to the nutritional quality and variety of foods being provided. In particular, researcher observations revealed that the number of fruit and vegetable servings was inadequate and the availability of sweet and salty snacks remained high.[159 161] Studies assessing parental perceptions of food provision highlighted similar concerns. Parents reported wanting centres to serve more fruit and vegetables, fewer nutrient-poor foods and a greater variety of foods.[159] However, direct observation of parent-provided lunch boxes also showed suboptimal nutrition with only 30% having sufficient servings of fruit and vegetables and almost 50% having more fat than recommended. These findings suggest that both childcare facilities and parents could improve the nutritional quality of foods they provide.

Three studies reviewed the existence and content of policies related to food and beverages.[160-162] Qualitative research in Southampton, UK, identified that only one out of the eight childcare centres interviewed reported having a nutrition policy.[162] In addition, water accessibility was only specified in 15% of 44 centre policies surveyed in Connecticut, US.[160] By contrast, 77% of childcare centres evaluated in North Carolina, US, had a written nutrition policy but only a quarter of these centres specified the nutritional quality of foods sold for fundraising.[161] These findings suggest considerable variation in nutrition policy existence and content across different geographical locations. The review that assessed state regulations related to nutrition provision in childcare in the US found considerable variation among states, but concluded that most states lacked strong regulations related to healthy eating in early childhood settings.[159] Voluntary interventions to influence the nutrition environment in childcare settings have shown positive effects on food provision and policies including increases in healthy menu options and introduction of healthy requirements for foods served during celebrations.[159 163] Studies did not report how changes in policy content were conveyed to parents, but improvements in staff practice were reported in response to management support for healthy eating in childcare centres.

The literature highlighted the pivotal role of early childhood staff to encourage and model healthy eating. Several studies assessed staff practice during meals and snacks.[160-162] Staff were generally reported to sit with children at mealtimes and consume some of the food the facility provided.[159 161 162] A small number of facilities, however, reported discouraging staff from joining the children at the table during mealtime. Observations of water consumption revealed that staff in approximately 50% of childcare centres modelled drinking water, but a much smaller percentage (19%) verbally encouraged children to drink water.[160] Missed opportunities to promote healthy eating and encourage children to try new foods during meals were also noted.[159] One observational study reported that only 52% of staff refrained from eating less healthy food in front of children at childcare centres, indicating that a good proportion of staff still modelled the consumption of less healthy foods.[161]

Poor nutrition knowledge was noted as a potential barrier to staff promoting healthy dietary habits. The number of staff who had attended nutrition training in the past year varied considerably across studies from less than half to more than three-quarters of staff surveyed.[159 161] There was consensus across studies of the need to encourage annual nutrition training of staff working in early childhood settings to improve staff knowledge, mealtime behaviour and confidence in engaging in nutrition related activities with children and parents.

Intervention studies including nutrition activities for children and nutrition information for parents, as well as healthier food provision, have shown positive effects on children's dietary intake.[159] The impact of these interventions on parental dietary intake was not measured. The literature revealed that one quarter to half of childcare centres undertake nutrition education activities with children, such as reading books or playing games with a healthy eating theme.[159 161] Far fewer centres reported sharing nutrition information with parents. The potential benefits of enhancing communication between staff and parents, and parental recognition of the health promotion role of early childhood facilities was highlighted.[159 162] In the UK, there was agreement across childcare centre staff that parental nutrition education is vital. However, staff from publically funded facilities reported being more willing to discuss healthy eating with parents than private childcare providers who feared losing private custom.

This body of literature identified three key factors that are influential in determining the nutrition environment of early childhood facilities: *i)* food provision and policies, *ii)* staff food knowledge and behaviours and *iii)* nutrition education/information. Nutritious food provision and policies, healthy food promotion by staff and engagement of children and parents in nutrition activities have been associated with positive dietary effects in children. However, the body of evidence linking dietary outcomes in adults to nutrition environments in early childhood settings is small. Few studies have assessed the nutrition environment of children's development centres and there is not a study that has associated environmental exposures with dietary outcomes in parents or staff.

Table 2-5 Summary and key findings of articles evaluating the nutrition environment of early childhood centres

Author, year	**Aim and methods**	**Number of papers reviewed**	**Geographical coverage**	**Key findings** – Early childhood centres
Larson et al, 2011 Journal of the American Dietetic Association	Review of the literature on regulations, practices and policies, and interventions promotion healthy eating and physical activity in early childhood settings. Reviewed literature from 2000 to 2010.	26 nutrition related articles identified: 4 regulations 11 environmental 11 interventions	US, Israel, Scotland	Four articles identified that states in the US lack strong regulations related to healthy eating, particularly in family care. Six studies showed healthy eating promotion but identified the need to increase fruit and vegetables and reduce saturated fat and sweet snacks. Parental perceptions about food provision support these concerns however, observation of packed lunches also showed inadequate fruit and vegetable serves. All four interventions which measured child dietary outcomes found positive effects. Successful interventions included healthier food provision and nutrition education targeting children and parents.
Glanz and Yaroch, 2004 Preventive Medicine	To provide an overview of environmental, policy and pricing strategies for increasing fruit and vegetable intake in community locations.	1 article related to childcare centres.	Australia (Western Australia)	The Start Right Eat Right intervention was successful at increasing healthy menu options in participating centres. No data on food intake or foods served was reported.

Author, year	Aim and methods	Number of papers reviewed	Geographical coverage	Key findings – Early childhood centres
Middleton et al, 2013 Journal of Nutrition Education & Behavior	Assessment of policies and practices promoting water consumption in childcare centres. Observation and management interviews in 44 randomly selected childcare centres in Connecticut. All surveyed centres participate in the Child and Adult Care Food Program that supports vulnerable families.	Not applicable	US (Connecticut)	Water was available in most centres, with only 16% having no water available. Verbal promotion of water by staff was low (19%). However, in half of the centres surveyed management reported that all staff model water drinking in front of the children. Centre wellness policies and staff handbooks rarely included clear guidelines on water consumption. Methods used to share information or policies about water consumption with parents were not reported.
Benjamin Neelon et al, 2012 Childhood Obesity	Assessment of nutrition policies, practices and environment in a sample of childcare centres. Observations in 96 childcare centres in 2005 to assess: food availability, nutrition policies and information, and staff food-related practices. Three quarters of participating centres received reimbursement for providing food to low-income children.	Not applicable	US (North Carolina)	The vast majority of childcare centres had written nutrition policies (80%), had a staff member attend nutrition training in the past year (81%) and had no vending machine access for parents/children (82%). Less than half of the centres surveyed provided two or more serves of vegetables or syrup-free fruit and a third provided self-service water. Few centres avoided serving high sugar, salt snacks but most centres avoided serving fried potatoes, fish or meats. Methods used to share nutrition information or policy content with parents was not reported.

Author, year	Aim and methods	Number of papers reviewed	Geographical coverage	Key findings – Early childhood centres
Buttivant and Knai, 2011 Public Health Nutrition	Exploration of nutrition policies and practices in a small sample of early childhood settings. 13 semi-structured interviews were completed across eight early childhood sites (4 nurseries, 2 preschools, 2 child minders) from deprived and affluent areas.	Not applicable	UK (Southampton)	Only one site had a nutrition policy. All settings reported attempting to provide healthy food and the range of food and drink offered was similar. Views on mandatory nutrition guidelines were polarised. At some sites staff always ate the same food as the children but in other sites it was discouraged. All sites agreed that parental education on nutrition was vital. Publically funded settings, however, were more willing to discuss healthy eating with parents than private providers. Access to professional nutrition advice varied across settings. Common information sources included magazines, internet and parents.
Matwiejczyk et al, 2007 Health Promotion Journal of Australia	Assess the outcomes of the 'Start Right Eat Right' intervention on food availability, nutrition practices and policies in 50 childcare centres. Nutritional quality and quantity of foods provided were measured using a menu assessment tool. Qualitative interviews were used to assess nutrition policies in a sample of 10 centres. Centres were located in low-average socioeconomic areas.	Not applicable	Australia (Adelaide)	Most centres (88%) attended the intervention training and 50% achieved the intervention award after 30 months. All centres made changes to menus and food policies, and improvements in staff knowledge and skills in healthy menu development were reported. Barriers to completing the intervention included costs of kitchen upgrade, time and management changes. Strategies to share nutrition information or engage parents were not reported.

2.5 Discussion

This review: *i)* summarised the evidence for neighbourhood disparities in community and consumer nutrition environment from ten previous review articles, *ii)* assessed the evidence for the effect of community and consumer nutrition environments on dietary intake, and *iii)* summarised the evidence from review articles for an association between the nutrition environment of workplaces, churches and early childhood facilities and dietary quality.

There is evidence that disadvantaged neighbourhoods in the US have poorer access to healthy foods than more affluent areas. Across high-income countries, there is also a trend for greater access to less healthy foods in neighbourhoods of higher deprivation. More than a quarter of density investigations and a fifth of proximity investigations provide evidence for an association between increased access to stores selling healthy foods and better dietary outcomes. There is some evidence for neighbourhood disparities in the availability of healthier foods but the evidence on price is less robust. A quarter of the food availability investigations showed that greater availability of healthy foods was related to better dietary outcomes, however half of the price investigations revealed that higher prices for healthy products related to better dietary outcomes. The literature for other consumer nutrition environment factors, such as variety, quality, placement and promotions, is limited.

The literature shows some evidence for healthier nutrition environments in workplaces, churches and early childhood settings having a small positive effect on dietary outcomes. Improvements of up to one additional serving of fruit or vegetable each day have been observed. However, the body of evidence from churches is small and the evidence from early childhood settings does not include adult dietary outcomes.

2.5.1 Community nutrition environment

There is consensus across review articles of evidence in the community nutrition environment literature for area-based inequalities in healthy food access in the US: residents of low-income and ethnic minority neighbourhoods in the US have disproportionately poorer access to healthy food than residents of more affluent neighbourhoods. The evidence for differences in access to healthy food is equivocal for Australia, Canada and the UK. However, there is compelling evidence across high-income countries for inequalities in access to less healthy foods: neighbourhoods with higher levels of deprivation and ethnic populations have greater access to fast food outlets than more affluent, predominantly white neighbourhoods. This evidence confirms that, particularly in the US, there is variation in terms of neighbourhood factors that influence diet and health. The stronger evidence from the US may be in part due to the higher levels of urban residential segregation in the US than in other developed countries. Globally, low-income areas offer low rent, low competition and cheap labour opportunities, however black areas in the US are also stigmatised and seen as undesirable to many retailers including supermarket chains.[164] In these circumstances, policy makers may be reliant on retailers willing to trade in these communities, such as fast food chains, to create jobs and employment opportunities for local residents.

Fraser et al[82] have suggested that the disparities identified above are an illustration of the 'deprivation amplification' effect. Deprivation amplification describes how individual or household deprivation, for example household income or educational attainment, is amplified by area level deprivation and the conditions within deprived neighbourhoods, such as the increased availability of less healthy foods or decreased availability of affordable healthy food.[165] However, as has been suggested in the literature[166] and confirmed by the evidence in the current review, it may not always be true that poorer neighbourhoods provide a less healthful environment for residents. Initiatives such as: *i)* public-private partnerships to introduce supermarkets to underserved areas, *ii)* improved transportation in low-income neighbourhoods, and *iii)* restrictions or incentives for food retailers, such as zoning regulations or tax rebates, have been proposed as strategies to enable a more equitable distribution of food sources.[83]

2.5.2 Consumer nutrition environment

There have been fewer studies of the consumer nutrition environment than the community nutrition environment and the findings of these studies are mixed. There is some evidence in the US for poorer availability of healthy products in low-income and ethnic neighbourhoods than more affluent neighbourhoods. The evidence from other developed countries is weaker and less consistent. The evidence for neighbourhood disparities in price is varied across all countries with findings showing both cheaper and dearer prices in disadvantaged neighbourhoods. While few studies have assessed neighbourhood differences in quality of food, the evidence consistently showed poorer quality produce in more deprived than more affluent neighbourhoods.

Moving to consider how consumer nutrition environment factors relate to diet, the literature shows evidence for associations between price and availability and dietary intake in the US. The literature and evidence from other developed countries is limited and weaker. Changes in the price of less healthy foods, particularly sweet carbonated drinks, have shown that as price increased intake of these foods decreased. This relationship was differentiated by ethnicity and income with the strongest associations observed in black people and low-income earners. Local availability of healthy foods was also shown to relate to poorer dietary patterns but not better dietary patterns. This finding suggests that individuals with poorer diets may be disproportionately affected by their neighbourhood food environment than individuals with better quality diets. This disparity may result from being less likely to have access to a private car to travel to other shopping opportunities or more likely to keep daily activities to a more localised space.[167]

2.5.3 Organisational nutrition environment

Across workplace, church and early childhood settings, healthier nutrition environments were associated with better dietary behaviours. The presence of nutrition policies and provision of healthy foods, support from management and staff for healthy eating, and availability of nutrition education/information were consistently related to healthier organisational nutrition environments. Multi-component interventions, including environmental and educational strategies, had the most positive effects on the diets of employees, congregation members and children. These findings suggest that organisational settings, such as workplaces, churches and early childhood facilities, have significant potential to influence both conscious and unconscious dietary choices[153] and are therefore an important component of the local food environment.

Differences in the organisational nutrition environment of workplaces, churches or early childhood facilities by area or individual level deprivation have not been reported. Interventions with Latino and African American church groups however have shown promising weight loss results.[155 156] Community institutions that are frequently visited by vulnerable groups may therefore provide a comfortable environment for them to be supported in healthy eating.

2.5.4 Limitations of the local food environment literature

Methodological limitations of the community and consumer nutrition food environment literature have been cited in review articles.[47-49 79-82] Heterogeneity in the categorisation of outlets, definition of neighbourhood and measurement of exposure variables, as well as the ecological study design of many studies have been reported as potential contributors to the inconsistent findings observed in review papers. A great assortment of neighbourhood boundaries have been applied including various predefined boundaries from census blocks to county boundaries and wide range of buffer zone radii measured by road network or Euclidean distance. A variety of food outlet categorisation systems have been applied across studies and the majority of studies have focused on one or two outlet types with very few assessing the neighbourhood differences or dietary effects of a full range of food retailers.

Much of the community and consumer nutrition environment research to date is ecological in design, comparing neighbourhood or dietary data from national or cohort surveys with secondary food outlet information, and may not accurately represent true associations. Few studies ground-truthed their food outlet data and may misrepresent food outlet access by including outlets that have ceased to trade and miss those which have recently opened. Field validation studies of secondary data have shown only fair to moderate agreement between observation and existence of food outlets from commercial and government lists or remote sensing technology, such as Google Street View.[168 169] Levels of agreement, however, were poorer when categorisation of outlets was included in the comparison.[170 171] The findings from secondary data may therefore need to be viewed with caution and more longitudinal studies are needed, particularly using individualised data.

Another methodological limitation of the community nutrition environment literature is the premise that people shop and are primarily influenced by food outlets geographically proximate to their homes.[172] The assessment of individualised activity spaces for community nutrition environment research has been piloted in a small number of studies. One study used seven-day global positioning system tracking data to create a total individualised area by buffering all locations visited by 0.5 mile (0.8 km) radius.[172] Another study used one day travel surveys and locations visited as anchor points to calculate an individualised area.[173] Time-geographic accessibility measures may also provide opportunities for more complete and realistic representations of the food environment by considering exposures along routes people regularly travel in conjunction with practical time restrictions on food shopping.[174] Applying these individualised food environment exposure measures to individualised dietary measures will help eliminate the ambiguity found in the current evidence.

There is also a need for consumer nutrition environment studies to link dietary data to the in-store environment of where people shop to overcome previous methodological assumptions.[59] Consumer nutrition environment studies could be further enhanced by the use of reliable tools that assess the range of environmental stimuli consumers face when shopping in addition to product availability and price, including product placement, promotion and labelling.[175]

The tools used to measure the organisational nutrition environment generally relied upon self-reported answers from staff or management, and few applied validated or reliable tools. Observations of the nutrition environment were undertaken in some childcare facilities; however, evaluations were only completed on a single day. The design of studies evaluating changes to the nutrition environment in workplaces, churches and childcare facilities was moderate to weak because only a small number of studies were randomised controlled trials. While the body of literature from workplaces was reasonable, the evidence base of associations between adult dietary intake and nutrition environment in churches and early childhood settings is limited. There is also a need for evidence of differences in organisational nutrition environments between deprived and affluent settings.

2.5.5 Implications for future research

An important strategy for future food environment research is combining multiple environment assessment techniques. An intelligent mix of in-store audit measures and GIS based methods would provide a more accurate characterisation of the local food environment.[176] A good example of such multi-dimensional assessment is work by Hermstad et al[111] which used structural equation modelling to investigate the relative influence of environmental, social and individual level factors on dietary fat intake. The reliable in-store audit tool NEMS-S was used to assess the availability, cost and quality of lower fat items. Scores were summed for all grocery and convenience stores within a five mile (8 km) radius of participants home. Proximity measures of fast food outlets were also calculated. Modelling calculated the combined effect of these exposures plus the home nutrition environment, perceived nutrition environment and psychosocial factors.

Further research applying a multi-dimensional approach to investigating the local food environment and incorporating potential mediating factors, such as transport method and psychosocial factors, is needed. Recent qualitative research has shown that residents of deprived neighbourhoods do not respond in a uniform manner to similar in-store supermarket environments suggesting a mediating role for psychosocial factors.[177] Therefore, socio-ecological conceptual approaches and sophisticated modelling techniques are required to enhance the current state of the evidence and identify the relative influence of multiple dimensions of the local food environment and psychosocial factors on dietary inequalities. Findings of such research are likely to help highlight areas most effective for action and inform the development of complex interventions to improve disparities in dietary intake.

2.6 Conclusion

This chapter identified a conceptual model (Figure 2-2) based on an ecological approach to health that describes policy, environmental, social and psychological determinants of diet. The local food environment was defined as incorporating three environmental components of this model: *community nutrition environment, consumer nutrition environment* and *organisational nutrition environment* (sections 2.2.1 to 2.2.3). The literature assessing these three environments was reviewed. There is evidence for inequalities in food access in the US although trends are less evident in other developed countries. The evidence also shows a trend for greater access and availability, to either healthy or less healthy foods, relating to better and poorer dietary patterns respectively. The evidence for price shows a trend for higher prices of healthy foods being associated with better dietary outcomes. There is also some evidence for healthier nutrition environments in workplaces, churches and early childhood settings having a small positive effect on dietary outcomes. In particular, healthy food provision and policies, socio-cultural support for healthy eating and nutrition education are important factors to support better dietary outcomes.

There are several methodological limitations of the local food environment literature that future research needs to address to enhance the current state of the evidence, particularly in the UK. Current evidence is based on the assumptions that people are primarily influenced by food outlets geographically proximate to their homes and that exposures can be determined by markers, such as density of supermarkets and fast food outlets, or availability and price of healthy foods. There is increasing recognition of the need for studies to increase measurement accuracy by using actual exposures including activity space areas and main food store. Comprehensive measures that provide a summary of each local food environment exposure rather than proxy measures are also required. For example, the full range of retail food outlets within an individual's activity space. Alternatively, measures of the full range of factors that can affect healthy and less healthy food choices within food stores, such as product placement, promotion and quality in addition to availability and price. Furthermore, evidence of the relative effects of the three components of the local food environment on diet, and the potential mediating effects of perception and psychosocial factors, is needed to inform the development of interventions that are most likely to improve dietary quality. Finally, greater understanding of the differing effects of local food environment exposures on the dietary outcomes of individuals with lower and those with higher socioeconomic position is necessary to identify effective actions to reduce dietary inequalities. The study described in this thesis aims to address these limitations of the current literature by using actual environmental exposures, developing novel, comprehensive exposure measures and assessing the relative effects of environmental and psychosocial factors on dietary quality. The next chapter (Chapter 3), specifies the research strategy for this study including the hypotheses, study design and study samples.

Chapter 3 Research strategy

Chapter 1 described the political and social importance of improving the diets of disadvantaged individuals, particularly mothers, in an effort to curb inequalities in health in England. Chapter 2 reviewed the literature on the local food environment, inequalities and diet. The review identified the need for future research to: be guided by conceptual frameworks, measure multiple dimensions of the local food environment and examine how environmental exposures interact with individual factors to effect diet. Also highlighted was the need for further evidence in countries outside the US.

This thesis addresses a gap in the literature by exploring how three individualised environmental exposures (i.e. community, consumer and organisational nutrition environments) are associated with the dietary quality of mothers with young children in Hampshire, UK. This work examines the independent relationship of these three nutrition environments with diet, as well as the mediating role of psychosocial factors.

This chapter (Chapter 3) draws upon the literature reviewed in Chapter 1 and Chapter 2 to outline the research strategy for this study. A conceptual framework postulating how the local food environment is, directly and indirectly, associated with mothers' dietary quality is described. The testable research hypotheses developed from this conceptual framework are then presented. Finally, the study design, study area and three study samples (mothers, food outlets and Sure Start Children's Centres) are detailed. This chapter introduces the data collection methods for the environmental, individual, outcome and socioeconomic variables in the conceptual framework. The methods sections of each data chapter (Chapter 4 to 8) provide detailed descriptions of the data collection and analyses techniques.

3.1 Model: The local food environment and mother's diet

The model of nutrition environments by Glanz et al (described in section 2.2) was used as the basis of the conceptual framework for this study. The Glanz model was adapted to describe how the local food environment relates to mothers' dietary quality. Figure 3-1 presents the adapted framework, which is described below.

Three environmental components, *community, consumer* and *organisational nutrition environments* (described in sections 2.2.1, 2.2.2 and 2.2.3), form the local food environment. The fourth environment, the *information environment* (section 2.2.4), in the Glanz model was beyond the scope of this study. The primary exposures described for the community, consumer and organisational nutrition environments were derived from the Glanz model and the findings of the literature review (section 2.4). The exposures specified for each of the individual variables namely socio-demographic, psychosocial and perceived nutrition environment, were identified from previous food environment research[59] and evidence of the determinants of dietary quality and inequalities among mothers (section 1.3).

The conceptual framework (Figure 3-1) proposes that the three components of the local food environment act directly on maternal dietary behaviour, and can act indirectly through psychosocial factors and perceptions of the local food environment. The model also suggests that neighbourhood and individual socio-demographic factors influence environmental and psychosocial factors, and may alter or moderate the relationships between environmental factors and dietary behaviours. Policies of local health and government bodies and of local food stores are shown to have an influence on the local food environment, however, analysing such policies in detail was beyond the scope of this study. The role of national and local policies is considered in the discussion sections of each chapter.

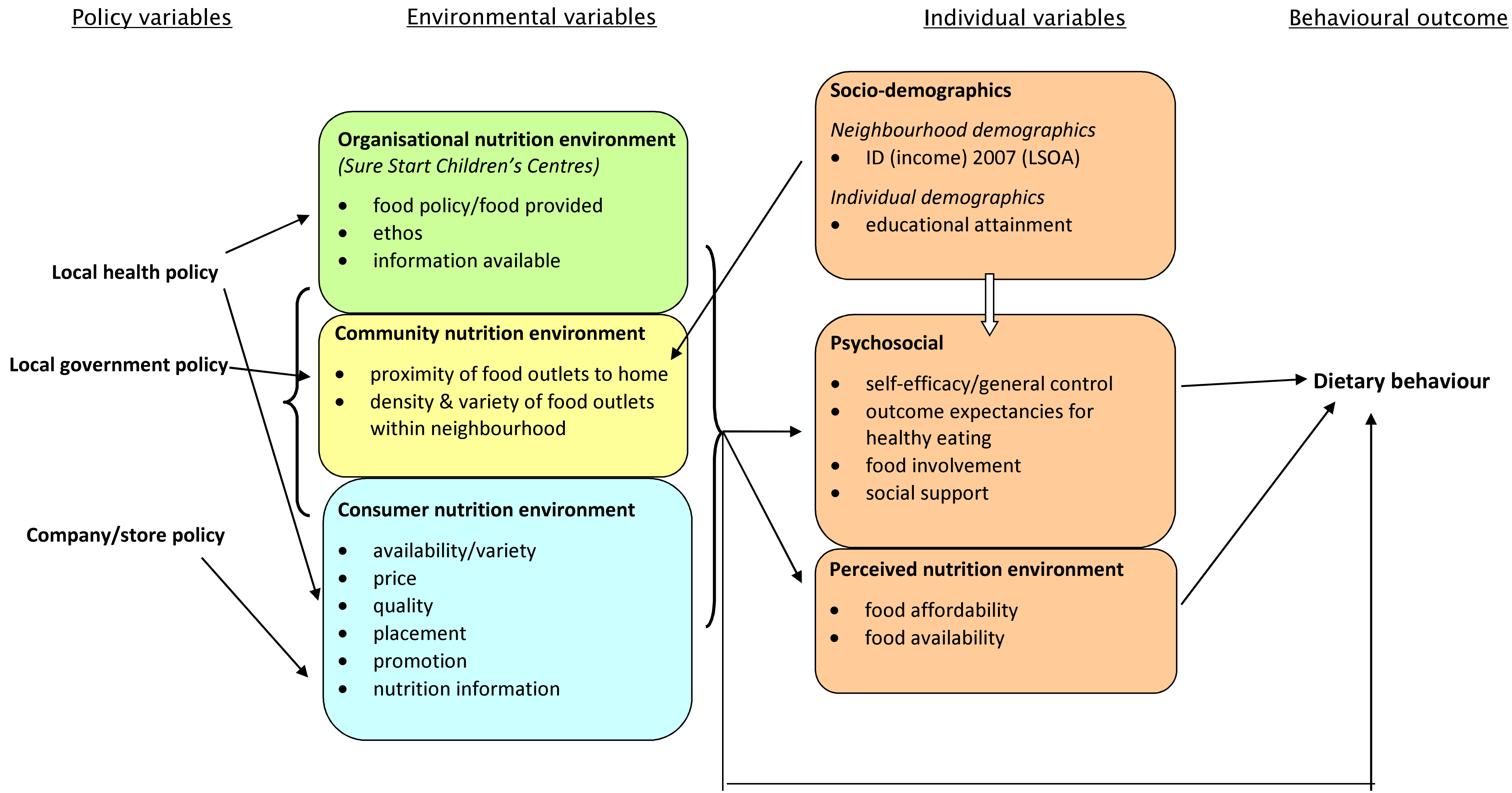


Figure 3-1 Conceptual model of the local food environment and mothers' dietary behaviours[a]

[a] Adapted from Glanz et al 2005

The conceptual framework (Figure 3-1) was used to develop the research hypotheses for this study.

3.2 Hypotheses

There are four research hypotheses this study will assess:

1. **Disadvantaged neighbourhoods have significantly poorer local food environments than more affluent neighbourhoods.**
2. **Local food environment exposures are associated with mothers' dietary behaviours.**
3. **Mothers' levels of education have a moderating effect on associations between local food environment exposures and their dietary behaviours.**
4. **Psychosocial and environmental perception factors mediate associations between local food environment exposures and mothers' dietary behaviours.**

3.3 Study design

This study is observational and cross-sectional in design. Environmental data was collected using cross-sectional surveys that were designed and conducted by the author of this thesis. Maternal individual, dietary quality and psychosocial data were collected as part of a wider project, the Southampton Initiative for Health.

The Southampton Initiative for Health was designed by researchers at the MRC Lifecourse Epidemiology Unit in collaboration with representatives from the Southampton Primary Care Trust. The University of Southampton, Faculty of Medicine ethics committee granted ethical approval for the study.

3.3.1 Southampton Initiative for health

The Southampton Initiative for Health was an intervention study set in Sure Start Children's Centres that aimed to improve the diets and physical activity levels of women with young children. Sure Start Children's Centres offer a range of support services to families, particularly those living in socially deprived communities, to enhance the health and development of children under five years.[178] The Southampton Initiative for Health was designed to improve the perceived self-efficacy (e.g. confidence in choosing healthy foods) and perceived control of mothers from disadvantaged backgrounds as an intermediary step to improving their lifestyle behaviours. A full description of the 'Healthy Conversation Skills' training intervention[179] and evaluation results[180 181] have been published.

The intervention was delivered by the research team to staff working in Sure Start Children's Centres in the Southampton. Sure Start Children's Centres in Gosport and Havant were the control areas. Baseline surveys were conducted with mothers while attending Sure Start Children's Centres from January to March 2009. Follow-up surveys were completed between December 2010 and May 2011.

For this thesis, data from the Southampton Initiative for Health follow-up survey was used as the cross-sectional dataset of mothers. The primary focus for these data was to evaluate the intervention described above. The author of this thesis supplemented the second wave of data collection with 11 additional questions designed specifically to address the research questions of this thesis. The additional information included four questions about mothers' main food store, work, physical activity and home locations in order to determine mothers' activity spaces; one question about usual mode of transport to their main food store; four questions about perceived neighbourhood food environment; and two questions about intake of fast food and takeaway foods. The author of this thesis wrote the protocols for these questions and was part of the team of field workers that completed the second wave of data collection. Section 3.3.3.1 details the data collected.

3.3.2 Study area

The geographical area for this study was six council areas in Hampshire, UK: the three areas of the Southampton Initiative for Health namely Southampton, Gosport and Havant, and three neighbouring council areas of Eastleigh, Fareham and Portsmouth. The neighbouring areas were included because data from the Southampton Initiative for Health baseline survey showed that mothers shopped or worked in these areas and therefore have important environmental exposures to capture. The map of Hampshire County (Figure 3-2) shows the six study areas.

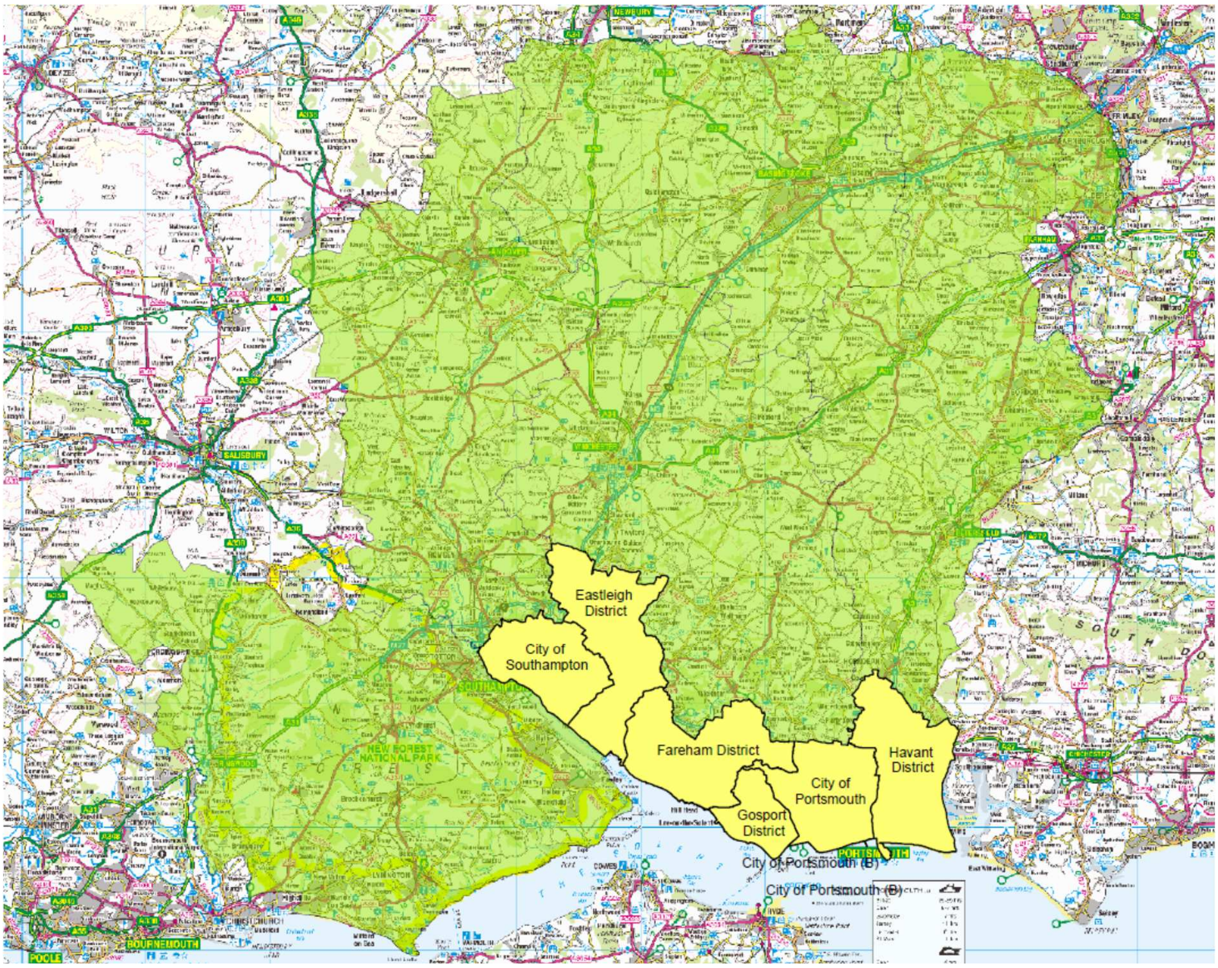


Figure 3-2 Study area: six council areas of Southampton, Eastleigh, Fareham, Gosport, Havant and Portsmouth within Hampshire, UK

3.3.3 Study samples

This study included three key samples. Mothers who participated in the Southampton Initiative for Health follow-up survey were one sample. The other two samples were food outlets and Sure Start Children's Centres which characterised the environmental exposures.

3.3.3.1 Mothers

The Southampton Initiative for Health follow-up survey (Appendix B) was conducted fieldworkers between December 2010 and May 2011. A cohort of 921 mothers completed the follow-up survey. A questionnaire was administered either by telephone (n=509) or face-to-face (n=412). Face-to-face administration was employed to enhance representation of younger mothers from more disadvantaged backgrounds. All mothers were recruited whist attending Sure Start Children's Centres in Southampton, Gosport or Havant (section 3.3.3.3).

Table 3-1 presents the differences between mothers' characteristics according to the two questionnaire administration methods. Mothers who completed the questionnaire face-to-face were younger in age, more likely to have one child, had lower levels of education and lived in more deprived neighbourhoods than mothers surveyed by telephone. The final sample combined both groups of mothers to enable representation from across the socioeconomic spectrum. Thus, ensuring adequate representation of mothers from varying socioeconomic backgrounds. Chapter 4 provides a full description of the individual, psychosocial and perception characteristics of mothers that participated in this study. The differences in these characteristics according to highest educational attainment are also described.

Table 3-1 Characteristics of the sample of mothers according to the two questionnaire administration methods

Demographic characteristic	Telephone survey (n=509)	Face-to-face survey (n=412)	p-value
Mean age	34	30	<0.001[a]
	%	%	p-value
Number of children			
0	1	1	
1	29	54	
2	50	29	
3	14	12	
4+	6	4	<0.001[b]
Educational attainment[c]			
≤GCSE	32	40	
A-level/HND	38	32	
Degree	30	28	0.03[b]
Neighbourhood deprivation[d]			
Most deprived	17	25	
2	20	22	
3	30	28	
4	16	12	
Least deprived	17	13	0.02[b]

[a] t-test, [b] chi squared test, [c] see section 3.3.5.2, [d] see section 3.3.5.1

3.3.3.2 Food outlets

The sample of food outlets included those where food products made up at least half of all products on sale. Outlets such as pharmacies and off-licenses were excluded. Restaurants that did not offer takeaway options were also excluded because families with young children are more likely to eat takeaway meals than eat in restaurants.[20]

An initial list of all retail and takeaway outlets and their postcodes within the study area was compiled in July and August 2010 using information from each council's Food Safety Register. Information from on-line business directories (Yellow Pages and yell.com) was used to supplement the council lists. Stores were classified into a unique classification system that was based on a combination of the Local Authority Enforcement Monitoring System (LAEMS)[182] and previous UK research.[168] Table 3-2 summarises this categorisation system.

Table 3-2 Food outlet categorisation system

Code	Store type	Description	Examples
Supermarkets and convenience stores			
0	Premium supermarket	5+ manned cash registers Promoted as high quality goods and service	Waitrose, M&S
1	Large supermarket	5+ manned cash registers All foods & many varieties Majority of supermarket share	Tesco, Sainsburys, Asda,
2	Discount supermarket	5+ manned cash registers Heavily promoted as low price	Aldi, Lidl, Iceland, Netto, Kwiksave
3	Small supermarket	1-4 manned cash registers Known brand name	Tesco Express, Co-Op, Sainsburys Local
4	'World' store	1-4 manned cash registers Products for specific ethnicities	Asian supermarkets, Polish supermarkets,
5	Convenience store	1-4 manned cash registers Limited number of products Independents & symbols[a]	Spar, OneStop, MACE, Independent stores
6	Petrol store	Sell petrol/diesel Have foods for sale	Shell Select, Tesco Petrol Station, BP, M&S

Code	Store type	Description	Examples
Specialty stores			
7	Bakers	Bake & sell bread May sell some pastries/cakes	Greggs The Three Cooks
8	Butchers Delicatessen	Sell fresh & cured cuts of meat May sell cheese & other items	Uptons butchers Malinka
9	Confectioners	Sell mostly sweets, cakes etc Includes discount stores (most foods sold were sweets)	Sweet Candy Heaven 99p Stores Julian Graves
10	Farm shops	A shop that sells food stuff directly from the producers	Aldermoor Farm Shop
11	Greengrocer	Sell mainly fruit & vegetables May also sell some other items	Evergreen Carousel Fruit & Veg
12	Health food shops	Specialize in vegetarian and organic produce	Holland and Barrett
13	Newsagents	Sells newspapers, magazines and snacks. No fresh produce sold.	Thompsons newsagents
Fast food and takeaway stores			
14	Fast food outlets	No waiting Large chains	McDonalds, KFC, Burger King
15	Fish & chips	Wait to cook Sell mainly fish & chips	George's fish & chips, Cap'n'Cod
16	Chinese takeaway	Wait to cook East Asian cuisine, noodles	Chinese Thai
17	Indian takeaway	Wait to cook West Asian cuisine, curries etc	Indian Bangladeshian
18	Other takeaway	Wait to cook Sells kebabs, pizzeria, burgers	Best kebab Charcoal Grill
19	Sandwich shop	Wait to prepare Generally open office hours Sells sandwiches, salads etc	Upper Crust Culshaw sandwiches Perfect Spud
Excluded			
	Restaurants/pubs Coffee shops/cafes Wholesalers	Predominantly sit-in Sells mainly coffee/muffins Do not sell directly to public	Prezzos, Weatherspoons Costa, Tesco cafe Hadi cash and carry

[b] 'Symbol' convenience stores are affiliated with a symbol group brand e.g. OneStop and Spar

All store categories were included in the community nutrition environment analyses. Only the six supermarket and convenience store categories were included in consumer nutrition environment analyses because these stores make up the grocery market share in the UK.[183]

The author of this thesis coordinated the 'ground-truthing' of the study area to confirm the existence and classification of stores between July 2010 and June 2011. The author completed the majority of the ground-truthing, but was assisted by four field workers who were trained by the author in the data collection and store categorisation procedures. The locations of food outlets were identified using postcodes. During the ground-truthing process, field workers also completed in-store surveys in supermarkets and convenience stores according to the protocol developed by the author (Appendix F). Not all streets within the study areas were checked for food outlets. It is therefore possible that some food outlets were missed by the field workers. Figure 3-3 shows the food outlet sample identification process.

A total of 1793 food outlets were identified, including 606 grocery stores, 576 takeaway outlets and 80 fast food chains.

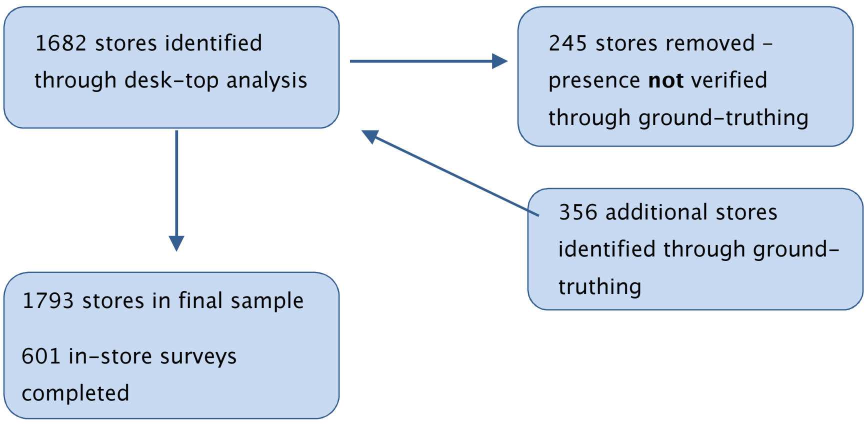


Figure 3-3 Food outlet sample identification and verification process

3.3.3.3 Sure Start Children's Centres

The organisational nutrition environment describes institutional settings where defined groups of people consume food or can learn about healthy eating, such as workplaces, churches and early childhood facilities.[1] Sure Start Children's Centres were selected as the target organisation in this study because mothers with children under the age of five years frequently visit these centres.[178 179] In addition, assessing differences in the nutrition environment of Sure Start Children's Centres by area deprivation and associations between this environment and mothers' dietary quality will also address current gaps in the literature (section 2.4.3.3).

Sure Start Children's Centres are a UK government initiative to provide health, education and support services for young children and their parents.[184] These centres emphasise supporting vulnerable families and are often located in deprived neighbourhoods. Healthy eating is a target issue for Sure Start Children's Centres and they can provide an environment that encourages healthy dietary behaviours.[185]

The author of this thesis developed an audit tool to survey the environment of Sure Start Children's Centres within the study area (Appendix I). The author and one field worker, who was trained by the author in the survey protocol (Appendix J), completed cross-sectional telephone surveys with centre staff. All Sure Start Children's Centres in Southampton (n=14), Gosport (n=8) and Havant (n=6) were surveyed from August to October 2011. Centres in Eastleigh, Fareham and Portsmouth were not included because they were not included in the Southampton Initiative for Health.

3.3.4 Data collection

Figure 3-4 presents a summary of the environmental exposure, individual and dietary outcome variables collected in this study. The methods section of each data chapter (Chapter 4 to 8) provide detailed descriptions of the methodological techniques used to collect and analyse data for each variable. Novel techniques were used to collect and analyse data on each of the environmental variables in order to address methodological limitations in the food environment literature. Data about mothers' individual, dietary outcome and socio-demographic characteristics were collected using published scales. The following sub-sections briefly describe of each of the environmental, individual, outcome and socio-demographic variables.

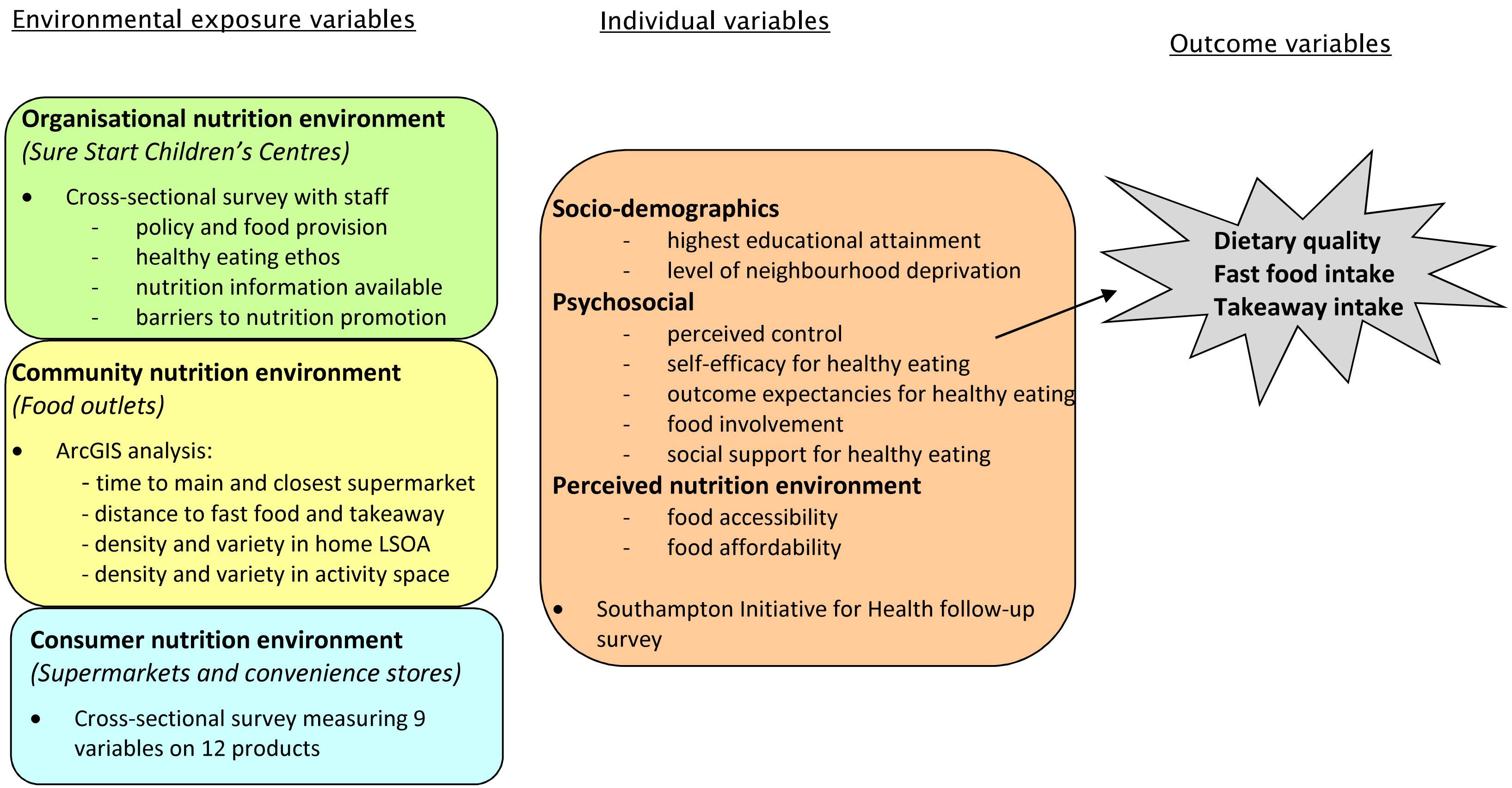


Figure 3-4 Summary of environmental exposure, individual and outcome variables[a]

[a] Chapters 4 to 8 provide detailed descriptions of the methodological techniques for these variables

3.3.4.1 Environmental exposures

The novel component of this study is the concurrent examination of three nutrition environment exposures and assessment of their relationship with dietary quality. The methods used to characterise each of these environments contribute innovative approaches to the research methodology in this field.

Geographic measures were used to characterise the *community nutrition environment* including the density and variety of different types of food outlets within predefined neighbourhood boundaries ((Lower Super Output Areas (LSOAs)) and individualised boundaries. Individualised proximity measures of time and distance to supermarkets and takeaway outlets were calculated. Density and variety measures were compared across neighbourhood deprivation quintiles. The relationships between individualised density, variety and proximity measures and quality of diet were examined. Chapter 5 provides the methodological details.

The *consumer nutrition environment* was characterised using an in-store cross-sectional survey. Data on the number of varieties, price, quality, promotion, shelf placement, store placement, nutrition information, healthier alternatives for less healthy foods and ability to buy fruit singularly were collected on a 12 food products (seven healthy and five less healthy). A composite score of healthfulness was calculated for each store surveyed. Scores were compared across neighbourhood deprivation quintiles. The scores from mothers' main food stores were matched to their dietary quality and this relationship was assessed. Chapter 6 provides the methodological details.

Staff from the 28 Sure Start Children's Centres completed a cross-sectional survey to provide information about the *organisational nutrition environment* of their centre. Data were collected on three key areas identified as important in the literature. Questions were also asked about perceived barriers to promoting healthy eating. Scores were created to represent each of these areas and a composite score was derived to characterise the overall nutrition environment. Scores were compared across neighbourhood deprivation quintiles, and then the relationship between the score of mothers' Sure Start Children's Centres and their dietary quality were examined. Chapter 7 provides the methodological details.

3.3.4.2 Individual variables

Individual level data were collected from mothers from December 2010 to May 2011. This time period overlaps with the in-store data collection and 'ground-truthing'. The questionnaire administered to mothers (Appendix B) included a validated questions informed by the literature. Data were collected about mothers' demographic characteristics, psychosocial factors and perceptions of their neighbourhood food environment. Chapter 4 presents details of the instruments used to measure these variables and a description of this sample of mothers.

3.3.4.3 Outcome variables

The mothers' questionnaires also included items to assess the outcome variables: dietary quality, fast food intake and takeaway intake. A validated 20-item food frequency questionnaire that contains items that discriminated between diets of better and poorer quality was used to create a quality of diet score for each mother. Chapter 4 provides a detailed description of the dietary quality score development, questions used to assess fast food and takeaway intake, and the dietary patterns of the participating mothers.

3.3.5 Socio-demographic variables

Examining socioeconomic inequalities is a fundamental theme in this thesis. The socio-demographic variables of highest educational attainment and level of neighbourhood deprivation were used to detect inequalities. Previously, environmental exposures have been examined using level of neighbourhood deprivation to identify area-based differences in food outlet accessibility or healthy food availability and cost.[49 60] In this study, neighbourhood deprivation was assessed as a predictor of characteristics of the community, consumer and organisational nutrition environments. Highest educational attainment was used as the individual level socio-demographic marker to detect inequalities in dietary behaviours among the sample of mothers, and to identify educational differences in the relationships between environmental exposures and dietary outcomes. The following sub-sections provide further details about these socio-demographic measures.

3.3.5.1 Neighbourhood deprivation

Neighbourhood deprivation was measured using the 2007 English Index of Deprivation (ID) income domain. The Index of Multiple Deprivation (IMD) was not applied because of circularity with the access to services domain that includes access to grocery stores. These deprivation indices cover Lower Super Output Areas (LSOAs), which are small areas constructed from the 2001 English census that are socially homogeneous and have a population size between 1000-1500 residents.[186] There is a total of 32,482 LSOAs across England. LSOAs provide an important tool for identifying the most disadvantaged areas in England and provide the best quality data for comparison across levels of deprivation.[186]

Each LSOA in the study area (n=550) was assigned to a quintile of deprivation using the national ranks of 2007 ID income (1=most deprived and 5=least deprived). Postcode information was used to allocate each of the three study samples (mothers, food outlets and Sure Start Children's Centres) to a LSOA quintile. Figure 3-5 illustrates the LSOA boundaries within the study area.

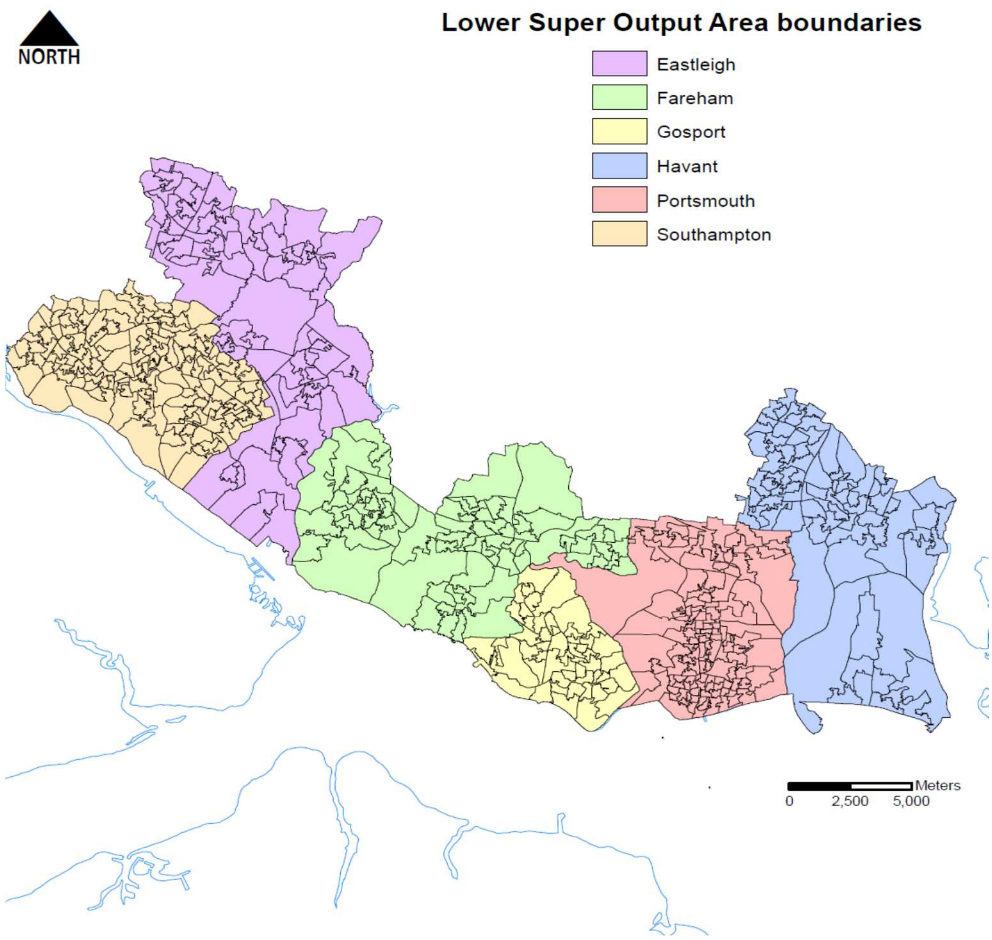


Figure 3-5 Lower Super Output Area boundaries in the study area

Differences by LSOA rural and urban classification were not assessed because more than 98% of the study area was classified as urban[187] leaving inadequate variability.

3.3.5.2 Educational attainment

Education was the chosen marker of socioeconomic position in this study because education shapes other socio-demographic markers, including an individual's employment status, their job and their income.[188] Previous research has shown that educational attainment is the strongest predictor of dietary quality among women of childbearing age after considering a range of individual, lifestyle and socio-demographic characteristics including social class, neighbourhood deprivation and receipt of benefits.[26] Mothers were asked to report their highest educational qualification attained against seven categories ranging from none (zero) to higher degree (six). These seven categories were used as the continuous educational attainment covariate in all adjusted regression analyses to test for trend.

Effect modification of level of educational attainment was tested to assess differences in environmental exposure and dietary outcome associations. An interaction term for three levels of educational attainment (Table 3-3) was added to regression models. These educational groupings were applied because they have been used in previous research assessing dietary inequalities.[54 189] Regression models were also stratified by level of educational attainment to describe any differences in associations between environmental exposures and dietary outcomes.

Table 3-3 Levels of educational attainment – indicator for dietary inequalities

Three levels of educational attainment	
Low	General Certificate of Secondary Education (GCSE) or below
Mid	Advance Level (A-level)/Higher National Diploma (HND)
High	Degree

3.4 Conclusion

This chapter described the conceptual framework guiding this study, the hypotheses to be tested and the study design. The conceptual framework was based on the Glanz model, which is widely cited in the food environment literature, and evidence of the determinants of dietary quality and inequalities, particularly among mothers. The conceptual framework led to the hypotheses that:

1. Disadvantaged neighbourhoods have significantly poorer local food environments than more affluent neighbourhoods.
2. Local food environment exposures are associated with mothers' dietary behaviours.
3. Mothers' levels of education have a moderating effect on associations between local food environment exposures and their dietary behaviours.
4. Psychosocial and environmental perception factors mediate associations between local food environment exposures and mothers' dietary behaviours.

The study area covers six neighbouring local council boundaries within the Hampshire county. The hypotheses were tested using three key samples: mothers with young children, food outlets and Sure Start Children's Centres. The study sample of mothers was those who participated in the Southampton Initiative for Health follow-up survey. The Southampton Initiative for Health was an intervention study set in Sure Start Children's Centres which aimed to improve the diets and physical activity levels of women with young children. Data pertaining to mothers' dietary quality, individual and psychosocial characteristics were primarily collected to evaluate the intervention but were also used in the study described in this thesis. In addition, specific questions designed specifically for this thesis were included at the authors' request, such as mothers' main food stores and environmental perceptions. The food outlet sample included data pertaining to all retail food and takeaway outlets in the study area that were identified through 'ground-truthing'. This sample included data from an in-store cross-sectional survey completed in supermarkets and convenience stores across the study area. The Sure Start Children's Centre sample included data from a cross-sectional survey of the nutrition environment of all centres in three council boundaries within the study area. These food outlet and Sure Start Children's Centre samples characterised the three environmental exposures of this study: *community*, *consumer* and *organisational nutrition environments*.

Data collection for each of the three samples was temporally connected to provide greater accuracy of relationships between environmental exposures and dietary outcomes. Novel techniques were used to collect and analyse data on each of the environmental variables in order to address methodological limitations in the food environment literature. Data about mothers' individual characteristics and dietary behaviours were collected using published scales. The method section of each of the data chapters that follow (Chapter 4 to 8) provide detailed descriptions of the methodological techniques used to collect and analyse data for each variable.

Chapter 4 Mothers' characteristics

As highlighted in Chapter 1 improving the dietary choices of mothers could have widespread benefits and help to reduce dietary and health disparities in future generations. The dietary behaviours of young mothers affect the health of their children and partner, and their own health. Supporting young women, particularly those from disadvantaged backgrounds, to make healthier dietary choices for themselves and their families is a current political priority. Psychological and perceived environmental factors have been identified as determinants of maternal dietary quality but quantitative evidence about local food environment determinants, and interactions between environmental and psychosocial and perception factors, is limited.

As described in Chapter 3 a population sample of mothers with young children is a focal point of this study. This chapter sets the scene for this thesis by describing the dietary behaviours and the demographic, psychosocial, perceived environmental characteristics of this sample of mothers. The chapter also examines whether mothers' dietary behaviours are associated with her demographic, psychosocial, perceived environmental characteristics, and investigates whether these relationships differ according to level of educational attainment.

The chapter begins by highlighting the social gradient in dietary behaviours of mothers, then briefly examines methods to assess dietary quality, and concisely reviews the evidence for psychosocial and perceived environmental determinants of maternal dietary behaviours. The published measures used in this study to assess mothers' dietary behaviours, individual, psychosocial and perceived environmental characteristics are described and results are presented. In the discussion section, the findings are summarised and compared with previous research, and the policy and research implications of these findings are highlighted.

4.1 Background

As established in section 1.2.1 the dietary quality of mothers is important, not only for their own health,[3 9] but for the short and long term health of their children.[18 23 24] As shown in section 1.2.2, women and mothers also remain primarily responsible for tasks, such as shopping, food selection and food preparation.[20 31] As a result, mothers have considerable authority over food-related decisions in families and can influence their partners and children's diets positively or negatively depending on their own dietary patterns.[27 190 191]

Women from more affluent backgrounds have better quality diets and lower rates of chronic illness than those from disadvantaged backgrounds.[4 7 26 32 34 35] This difference illustrates the social gradient in health where the greatest disease burden falls upon those most disadvantaged.[4 192] As reported in section 1.1.1 addressing these health and dietary inequalities is an important political priority nationally and internationally, particularly among women of childbearing age.[17 57] Understanding the determinants of dietary quality, particularly differences between mothers from poorer and more affluent backgrounds, is essential to identify avenues for future intervention to address these health disparities.

Dietary pattern assessment has been an important tool for understanding the role of dietary quality in the aetiology of disease and identifying the determinants of dietary quality.[193-195] Dietary pattern indices summarise multiple dietary components into a single exposure. Such indices are typically determined using one of two methods: *i)* assessment of compliance with prevailing dietary guidelines or *ii)* use of data-driven methods, such as factor analysis to derive dietary patterns.[193] Indexes of overall dietary quality, from either of these methods, have been shown to relate more strongly to the risk of disease and determinants of health, and are more preferable, than tools measuring individual nutrients or foods.[195 196] However, brief dietary assessment instruments, such as 'screeners' or one- to two-item tools, are appropriate for investigations of the determinants of a specific type of food. For example, one question pertaining to the frequency of fast food consumption may be appropriate for studies focused on access to fast food outlets.[196] Similarly, a dietary components measure for fruit and vegetable intake is likely to be suitable in studies investigating perceived health outcomes of eating fruit and vegetables.[38] In this study, overall dietary quality was the primary outcome measure to capture mothers' patterns of dietary intake.

A number of psychosocial factors have been identified as determinants of healthy dietary behaviours, specifically perceived control and self-efficacy, social support and knowledge and beliefs about diet-disease relationships.[38 197]

Differences in several psychosocial variables have also been described as contributors to the disparities in dietary quality between women from more affluent and those from disadvantaged backgrounds. Quantitative and qualitative work has shown that women with lower educational attainment receive less social support for healthy eating from family members and feel less control over family food choices than more affluent women.[39 41 114] Additional factors associated with poorer dietary behaviours among women and mothers include feeling less positive about their ability to eat healthily, having little belief in the health benefits of eating nutritiously, poorer nutrition knowledge and less interest in food shopping, preparation and consumption.[42 198 199]

Self-efficacy describes an individual's belief in their capability to carry out a specific behaviour (i.e. eating healthily), including having the knowledge and skills to overcome any difficulties in performing the behaviour.[200] Self-efficacy and perceived control exhibit some overlap.[38] High self-efficacy is considered a prerequisite to an individual feeling in control and in turn, exercising that control supports greater self-efficacy.[179 201] Simultaneous measurement of self-efficacy and control has been recommended in research to enable assessment of these measures relative influence on dietary behaviours.[202] Generally, psychosocial constructs are measured with either single or multiple-item scales, where a range of tools are available for each construct.[38] Using tools with good to excellent reliability and validity is important because tools with weak psychometric properties can lead to biases in measurement and subsequent under or over estimation in the psychosocial factor's relationship with diet.[203] In this study, published scales with good reliability and validity were used to measure mothers' psychosocial factors.

Another predictor of dietary behaviour, particularly fruit and vegetable consumption, is an individual's perception of their neighbourhood food environment. A systematic review by Caspi et al[59] showed that positive perceptions of healthy food availability have been consistently related to better dietary behaviours. However, the evidence for an association between perceived accessibility and affordability of healthy foods and dietary behaviours is equivocal.

A number of recent studies in the US have focused on the relationship between environmental perceptions and fruit and vegetable consumption among disadvantaged populations. The results were mixed. Two studies showed no relationship between perceived grocery store access or fresh produce availability and fruit and vegetable intake.[138 204] However, another study showed that high overall satisfaction with the accessibility, quality and variety of healthy food locally more than doubled the likelihood of consuming three or more serves of fruit and vegetables a day.[205] Research outside the US has investigated the mediation effects of perceived environmental factors on the relationship between socioeconomic position and diet. In Australia, research with women found that the perceived quality and affordability of fresh produce, and perceived accessibility of healthy options to eat out locally mediated the relationship between educational attainment and fruit and vegetable intake.[54] However in the Netherlands, perceived availability and affordability of fruit or vegetables was not shown to contribute to the relationship between educational attainment and fruit or vegetable intake.[206] Exploring the mediation effects of environmental perceptions is important to help ascertain whether interventions to improve dietary choices, particularly among disadvantaged groups, should include strategies to improve awareness of where nutritious and affordable foods can be purchased locally.[207]

Measures used to assess perceptions of the local food environment have included single question items to examine various aspects of perceived accessibility, availability and affordability and multiple-item scales combined into a single score.[59] Some scales have been psychometrically evaluated and shown high test-retest reliability and construct validity.[205 208 209] Most studies have measured fruit and vegetable consumption as the outcome variable.[59] Fewer studies have assessed the predictive or mediatory role of environmental perceptions on quality of diet. A recent review of the food environment literature showed that studies that use dietary quality outcomes were less error-prone and more consistently predicted by perceived and objective environmental exposures than brief or component dietary measures.[196] This makes an advancement on previous food environment research by using a standardised score to represent mothers' dietary quality that remains robust in statistical analyses.

As described above, a number of psychosocial and perceived environmental factors have been associated with dietary quality, and dietary inequalities. The conceptual framework guiding this study (Figure 3-1) proposes that the relationship between the local food environment and dietary behaviour can be mediated by these psychosocial and perceived environmental factors.[1] Few studies have examined the mediatory role of these groups of individual factors on the relationship between objective environmental measures and dietary quality in adults.[56 111 114] This study addresses the need for further research to understand how these factors interact in determining dietary quality and how such interactions may differ across socioeconomic groups to identify the most effective points for intervention.[78 210]

This chapter:

i) Describes the demographic, psychosocial and perceived environment characteristics of the mothers in this study

ii) Assesses associations between demographic, psychosocial and perceived environmental factors and mothers' dietary quality

iii) Examines the modification effect of maternal education on identified relationships

4.2 Methods

4.2.1 Mothers

Participants were mothers who took part in the Southampton Initiative for Health follow-up survey conducted between December 2010 and May 2011. The survey included questions about individual characteristics and items about dietary behaviours, psychosocial factors and perceptions of the local food environment.

4.2.2 Dietary outcomes

Mothers' dietary outcomes included dietary quality, fast food intake and takeaway intake.

4.2.2.1 Dietary quality

Dietary quality was the primary outcome variable for this study and was assessed using a validated 20-item food frequency questionnaire (FFQ).[211] The 20-item FFQ was statistically derived from a 100-item FFQ using principal components analysis.[26] The 20-item FFQ contained foods consistent with dietary recommendations of the UK Department of Health and was used to characterise quality of diet. Mothers were asked to indicate how often in the previous month they consumed each of the 20 foods (six point scale from never (zero) to once a day or more (five)). A quality of diet score was calculated for each mother using the prudent diet pattern method.[211] Calculation of the score involved multiplying frequency of consumption of each item by its principal components analysis coefficient. Table 4-1 lists these 20-items and corresponding coefficients. The dietary quality scores were standardised across the sample to have a mean of zero and standard deviation of one. Better quality diets described higher intakes of vegetables, vegetarian products and wholegrain bread, and poorer quality diets described higher intakes of processed meats, crisps and sugar.

Table 4-1 Items and corresponding coefficients from the 20-item food frequency questionnaire and used to calculate mother's dietary quality scores

Better dietary pattern		**Poorer dietary pattern**	
Items	co-efficient	**Items**	co-efficient
Peppers and watercress	0.20	Roast potatoes and chips	-0.21
Tomatoes	0.19	Meat pies	-0.19
Vegetable dishes	0.19	Sausages or sausage rolls	-0.19
Courgettes, marrow, leeks	0.19	Gravy	-0.18
Green salad	0.17	Added sugar	-0.17
Wholemeal bread	0.16	White bread	-0.16
Onion	0.16	Yorkshire pudding	-0.15
Vegetarian products	0.15	Crisps	-0.15
Pasta	0.15	Beef	-0.14
Spinach	0.14	Full fat milk	-0.14

4.2.2.2 Fast food and takeaway intake

Mothers provided information about their fast food and takeaway intake by reporting how often over the past month they consumed foods from *i)* fast food outlets and *ii)* takeaway shops.[73 212] Examples of stores were provided for appropriate response allocation and a six-point response scale was used from never to once a day or more. Similar to previous food environment research,[213 214] responses were dichotomised. The binary measures included never consumed or consumed fast food in the past month, and never consumed or consumed takeaway in the past month.

4.2.3 Individual characteristics

Mothers answered questions about their individual characteristics including age, number of children, highest educational qualification attained (section 3.3.5.2), clothing size and home postcode. Clothing size was dichotomised into categories that discriminate between increased and decreased odds of chronic health conditions, such as hypertension and diabetes mellitus (≤size 16, >size 16).[215] Home postcode was used to determine level of neighbourhood deprivation according to English LSOA deprivation quintiles (section 3.3.5.1).

4.2.4 Psychosocial factors

Published scales were used in the follow-up survey to measure each of the psychosocial factors.

Mothers' perceptions of control were derived from a nine-item scale about **perceived control** over life.[216] Responses to the nine-items were scored from strongly disagree (one) to strongly agree (four). Scores were summed to create a score for perceived control for each mother where higher scores indicated greater sense of control. The Cronbach's alpha statistic of 0.61 indicated the scale was internally consistent.

Self-efficacy for healthy eating was assessed using a five-item scale that measured mothers' perceptions of personal competence in anticipating difficulties and overcoming setbacks to healthy eating.[217 218] Responses were made on a four-point scale from strongly disagree (one) to strongly agree (four). Scores were summed to provide a single continuous variable for each mother. Higher scores characterised greater sense of personal competence to overcome barriers to healthy eating. The internal consistency for this scale was excellent (Cronbach's $\alpha=0.88$).

A six-item **healthy eating outcomes expectancies** scale was used to assess mothers' beliefs about the health benefits of eating healthy foods (Cronbach's $\alpha=0.82$).[217 219] A four-point scale from strongly disagree (one) to strongly agree (four) was reported on all six-items. Responses were summed to create an overall score for each mother. Higher scores represented attitudes that are positive toward good health outcomes from healthy eating.

A 12-item **food involvement scale** was used to measure the priority given to food-related activities, such as the acquisition, preparation, cooking, eating and disposal of food.[42 220] Mothers indicated how strongly they agreed or disagreed with each statement on a five-point scale. Half of the items were worded negatively thus, these responses were reversed prior to scores being summed to create a composite score. Higher values characterised mothers who valued and prioritised food-related activities in daily living. This scale has shown to have high test-retest reliability with a Cronbach's alpha of 0.67.[220]

Social support for buying fruit and vegetables from family members was assessed using a five-item scale (Cronbach's α=0.79).[114] Responses were categorised on a five-point scale from never (one) to very often (five). A composite measure of social support was calculated for each mother by summing her responses. Higher scores indicated better social support for purchasing fruit and vegetables.

4.2.5 Perceived nutrition environment

Mothers answered six questions about their perceptions of the food environment in their local neighbourhood while completing the Southampton Initiative for Health follow-up questionnaire. Local neighbourhood was defined as a ten to 15 minute walk, or five minute drive from home. Four questions asked about the accessibility to food stores, variety and quality of fresh produce and availability of healthy takeaway options within their local neighbourhood. Responses were scored from strongly disagree (zero) to strongly agree (three). Two affordability questions asked whether mothers had been unable to afford to buy food or balanced meals in the past year. Possible responses included never (zero), sometimes (one) or often (two). These questions were adapted from previous research in Australia[54 56] though are akin to work in other high-income countries.[134 138 208]

4.2.1 Statistical analyses

Descriptive statistics were used to summarise the individual characteristics, dietary outcomes, psychosocial and perceptions of the neighbourhood food environment of the full sample of mothers. Relationships between dietary quality and fast food and takeaway intake with each of these variables were explored using linear and logistic regression respectively. To test for differences in individual, psychosocial and perceived food environment variables by three levels of education Pearson correlation was used for the normally distributed continuous variables. Spearman correlation was used for the non-parametric variables. Chi squared or Fisher's exact tests were used for categorical variables depending on the cell count. To examine effect modification by education, an interaction term for educational attainment and each exposure variable was added to regression models. Step-wise backward elimination regression models were used to adjust for covariates that may confound relationships examined in this chapter including age, number of children, seven levels of educational attainment and five levels of neighbourhood deprivation.

4.3 Results: mothers' characteristics

4.3.1 Dietary outcomes

The mean dietary quality score for the sample of mothers was 0 (SD: 1), and the scores ranged from -2.8 to 2.9. One standard deviation improvement in dietary score equates to mothers eating salad vegetables up to six times more per week and crisps up to six times less per week.

Most mothers (61%) reported consuming fast food in the past month and more than three quarters of mothers (80%) had consumed takeaway foods in the past month.

4.3.2 Individual characteristics

A total of 921 mothers participated in the Southampton Initiative for Health follow-up survey and their mean age was 32 years (SD: 6). Demographic characteristics of mothers are presented in Table 4-2. The vast majority of mothers had one or two children (81%) and a clothing size less than 16 (85%). Approximately a third of mothers (36%) had not attained an educational qualification higher than GCSE (16 years of age) and nearly a quarter of mothers (21%) lived in neighbourhoods that fall in the most deprived quintile in England.

Table 4-2 Demographic characteristics of mothers (n=921)

Demographic characteristic	n (%)
Number of children	
0	5 (1%)
1	371 (40%)
2	372 (40%)
3	124 (14%)
4+	48 (5%)
Clothing size	
≤ 16	783 (85%)
≥ 16	138 (15%)
Educational attainment[a]	
≤GCSE	327 (36%)
>GSCE – HND	321 (35%)
Degree	260 (29%)
Neighbourhood deprivation[b]	
Most deprived	178 (21%)
2	180 (21%)
3	248 (29%)
4	118 (14%)
Least deprived	126 (15%)

[a] see section 3.3.5.2, [b] see section 3.3.5.1

Better dietary quality was associated with older age (β=0.04; 95% CI 0.03, 0.05), fewer children (β=–0.13; 95% CI -0.21, -0.06), higher educational attainment (β=0.5; 95% CI 0.4, 0.6) and neighbourhood affluence (β=0.19; 95% CI 0.14, 0.24). Dietary quality was not associated with mothers' clothing sizes (p>0.1).

The odds of consuming fast food were greater for mothers who were older (OR=0.94; 95% CI 0.92, 0.96), had more children (OR=0.15; 95% CI -0.01, 0.30), had a larger clothing size (OR=0.34; 95% CI -0.04, 0.73), had lower educational attainment (OR=–0.63; 95% CI -0.81, -0.46) and lived in more deprived neighbourhoods (OR=–0.26; 95% CI -0.37, -0.37). Only increasing age was associated with increased odds of eating takeaway foods (OR=0.97; 95% CI 0.94, 0.99; other variables p>0.1).

4.3.3 Psychosocial characteristics

For all psychosocial scales, higher scores indicated the psychosocial factor was more likely to be associated with healthier dietary patterns. Each of the composite psychosocial variables followed a normal distribution. Table 4-3 shows the descriptive findings for each of the psychosocial variables. The average for all psychosocial variables was towards the upper limit of the scales. These findings show that mothers generally perceived some level of control over their lives, had reasonable levels of confidence to overcome barriers to healthy eating, and had a relatively positive attitude towards better health outcomes resulting from healthy eating. The mothers in this study also indicated that they were involved in food-related activities, such as the acquisition, preparation and cooking, and received moderate support from their family to make healthier food choices. It is important to note that some mothers scored poorly on three scales, which indicates that some mothers: *i)* had very low levels of confidence to overcome barriers to eating healthily, *ii)* had little belief that healthy eating relates to health outcomes, and *iii)* received little support for buying fruit and vegetables from their family.

Table 4-3 Descriptive findings for the mothers' psychosocial variables

Psychosocial variable	**mean (SD)**	**range**	min	max
Perceived control	26 (2)	16 to 36	9	36
Self-efficacy for healthy eating	14 (2)	6 to 20	5	20
Outcome expectancies for healthy eating	18 (6)	6 to 24	6	24
Food involvement	44 (5)	29 to 59	12	60
Social support for buying fruit & vegetables	16 (5)	5 to 25	5	25

Univariate regression analyses revealed that, as expected, dietary quality was positively associated with each of the five psychosocial variables. These relationships remained statistically significant after adjustment for individual covariates though the relationships weakened (Table 4-4). Section 4.3.5 presents differences in these psychosocial variables across the three levels of mothers' educational attainment.

Table 4-4 Multivariate regression analyses of dietary quality with each of the five psychosocial variables

Psychosocial variable	**Quality of diet score β (95% CI)**	p-value
Perceived control	0.06 (0.03, 0.09)	<0.001
Self-efficacy for healthy eating	0.07 (0.05, 0.10)	<0.001
Outcome expectancies for healthy eating	0.07 (0.04, 0.09)	<0.001
Food involvement	0.02 (0.01, 0.03)	<0.001
Social support for buying fruit & vegetables	0.01 (0.01, 0.03)	0.02

4.3.4 Perception of the local food environment

Tables 4-5 and 4-6 present the results of mothers' perceptions of their local food environment. The majority of mothers agreed that they could do most of their food shopping within their local neighbourhood (74%) and that the fresh produce on sale locally is of a high quality (79%). Two thirds of mothers (67%) disagreed that the variety of fruit and vegetables available locally is limited. Most mothers (82%) did not feel that healthy takeaway options were available in their local neighbourhood. Not having enough money to buy food or buy balanced meals was never a problem for most mothers (84% and 87% respectively).

Table 4-5 Mothers' perceptions of food access, variety and quality in their local neighbourhood

Perceived food accessibility variable	**Strongly disagree**	**Disagree**	**Agree**	**Strongly agree**
In my local neighbourhood…	n (%)			
I can do most of my food shopping	43 (5)	193 (21)	483 (52)	202 (22)
The fruit and vegetables variety is limited	129 (14)	488 (53)	270 (29)	33 (4)
The fresh produce is usually high quality	15 (2)	177 (19)	630 (68)	98 (11)
There are healthy takeaway options	154 (17)	600 (65)	158 (17)	8 (1)

Table 4-6 Mothers' perceptions of food affordability in their local neighbourhood

Perceived food affordability variable	**Never**	**Sometimes**	**Often**
In the past 12 months	n (%)		
Ran out of money to buy food	771 (84)	117 (13)	32 (3)
Can't afford to eat balanced meals	801 (87)	89 (10)	30 (3)

None of the perceived food accessibility or availability variables were associated with dietary quality (all $p>0.1$). Perceptions about the availability of healthy fast food or takeaway locally were not related to fast food or takeaway intake (both $p>0.1$). Mothers who had concerns about the affordability of buying food or buying balanced meals had poorer dietary quality ($\beta=-0.42$; 95% CI −0.55, −0.28; $\beta=-0.39$; 95% CI −0.53, −0.24 respectively). These relationships weakened slightly but remained statistically significant after adjustment for covariates ($\beta=-0.18$; 95% CI −0.31, −0.05; $\beta=-0.18$; 95% CI −0.31, −0.04 respectively). Section 4.3.5 presents differences in these environmental perceptions across the three levels of mothers' educational attainment.

4.3.5 Differences in mothers' characteristics by level of educational attainment

Table 4-7 presents mothers' individual characteristics according to their level of educational attainment. Mothers with the lowest educational attainment were younger, more likely to have a greater number of children, and larger clothing size, and live in more deprived neighbourhoods than other mothers. Strong evidence of an interaction was identified between educational attainment and mothers' age ($p=0.002$) and neighbourhood deprivation ($p<0.001$). Stratified analyses, adjusted for covariates, revealed that increasing age was associated with better dietary quality among mothers with low and mid educational attainment ($\beta=0.04$; 95% CI 0.02, 0.05; $\beta=0.02$; 95% CI 0.01, 0.04 respectively), but not among mothers with degrees ($p>0.1$). Similar results were revealed for neighbourhood deprivation: better dietary quality was associated with higher neighbourhood affluence among mothers with a low educational attainment ($\beta=0.18$; 95% CI 0.10, 0.27) but not among mothers with mid or high levels of education.

Table 4-7 Mothers' demographic characteristics by level of educational attainment

	Educational attainment			
Demographic characteristic	**Low** (≤GCSE)	**Mid** (A-level/HND)	**High** (Degree)	p-value
Mean (SD) **age** in years[d]	31 (0.3)	33 (0.3)	34 (0.3)	<0.001[a]
	n (%)			
Number of children				<0.001[b]
1	115 (35)	123 (39)	127 (49)	
2	123 (38)	139 (44)	105 (41)	
3	58 (18)	43 (13)	22 (8)	
4+	30 (9)	12 (4)	5 (2)	
Clothing size				0.001[c]
≤size 16	264 (81)	268 (83)	239 (92)	
>size 16	63 (19)	53 (17)	21 (8)	
Neighbourhood deprivation				<0.001[b]
Most deprived	94 (30)	68 (23)	14 (6)	
2	85 (27)	59 (20)	35 (15)	
3	77 (25)	89 (30)	78 (34)	
4	28 (9)	41 (14)	48 (21)	
Least Deprived	28 (9)	40 (13)	55 (24)	

[a] Test for trend, [b] Spearman test for trend, [c] Chi squared test, [d] low=327; mid=321; high=260

Table 4-8 shows differences in mothers' psychosocial variables across the three levels of educational attainment. There was a trend across psychosocial variables for mothers with lower education having lower scores than mothers with mid or high educational attainment. Mothers with low educational attainment perceived less control over their lives, had poorer attitudes towards dietary effects on health and prioritised food-related activities less. Mothers with low educational attainment also received less support from their family for buying fruit and vegetables. Self-efficacy for healthy eating was the sole psychological variable that did not differ by level of educational attainment, indicating mothers reported similar levels of confidence to overcome barriers to eating healthily.

Table 4-8 Mothers' psychosocial variables by level of educational attainment

	Educational attainment			
Psychosocial variable	**Low** (≤GCSE) n=326	**Mid** (A-level/HND) n=321	**High** (Degree) n=260	p-value[a]
	mean (SD)			
Perceived control	25 (0.1)	26 (0.1)	27 (0.1)	<0.001
Self-efficacy for healthy eating	15 (0.1)	14 (0.1)	15 (0.1)	0.3
Outcome expectancies for healthy eating	17 (0.1)	18 (0.1)	18 (0.1)	<0.001
Food involvement	43 (0.3)	44 (0.3)	45 (0.3)	<0.001
Social support for buying fruit & vegetables	15 (0.3)	15 (0.3)	17 (0.3)	0.01

[a] Test for trend

Strong evidence of an interaction was only identified between level of educational attainment and outcome expectancies for healthy eating (p=0.01). Stratified analyses, adjusted for covariates, revealed that belief in the health benefits of healthy eating was associated with better dietary quality among mothers with low and mid educational attainment (β=0.10; 95% CI 0.06, 0.14; β=0.07; 95% CI 0.03, 0.11 respectively), but not among mothers with degrees (p>0.1) (Figure 4-1).

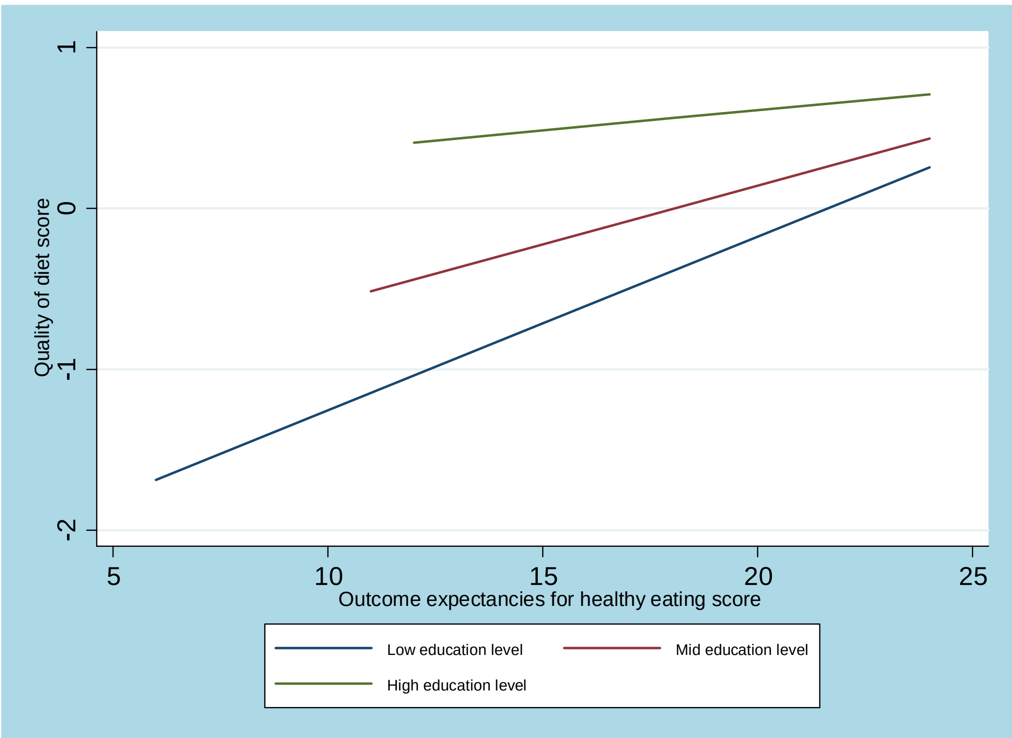


Figure 4-1 Mothers' quality of diet scores by outcome expectancies for healthy eating score according to level of educational attainment

There were no differences in mothers' perceptions of local food access, or local fruit produce variety or quality across the three levels of educational attainment (Table 4-9). Most mothers felt their local neighbourhood had stores for their food shopping, and that those stores had a good variety and high quality fresh produce. Few mothers believed their local neighbourhood offered healthy takeaway options. Perceived concerns about the affordability of buying food or buying balanced meals were greater among mothers with lower educational attainment (Table 4-10).

Table 4-9 Mothers' perceptions of neighbourhood food environment exposures across three levels of educational attainment

	Educational attainment			
Perceived food accessibility variable	**Low** (≤GCSE)	**Mid** (A-level/HND)	**High** (Degree)	p-value
In my local neighbourhood…	n (%)			
I can do most of my food shopping				0.3[a]
Strongly disagree	16 (5)	14 (4)	13 (5)	
Disagree	79 (24)	58 (18)	53 (20)	
Agree	174 (53)	177 (55)	129 (50)	
Strongly agree	58 (18)	72 (23)	65 (25)	
Fruit & vegetables variety is limited				0.2[a]
Strongly disagree	36 (11)	49 (15)	40 (15)	
Disagree	164 (50)	173 (54)	144 (56)	
Agree	114 (35)	88 (27)	66 (25)	
Strongly agree	12 (4)	11 (4)	10 (4)	
Fresh produce is high quality				0.9[b]
Strongly disagree	7 (2)	4 (1)	4 (2)	
Disagree	68 (21)	62 (20)	45 (17)	
Agree	220 (67)	219 (68)	183 (70)	
Strongly agree	31 (10)	36 (11)	28 (11)	
Healthy takeaway options available				0.4[b]
Strongly disagree	42 (13)	58 (18)	51 (20)	
Disagree	223 (68)	207 (64)	160 (61)	
Agree	58 (18)	53 (17)	47 (18)	
Strongly agree	3 (1)	3 (1)	2 (1)	

[a] Chi squared test, [b] Fisher's exact test

Table 4-10 Mothers' perceptions of food affordability in her local neighbourhood across three levels of educational attainment

	Educational attainment			
Perceived food affordability variable	**Low** (≤GCSE)	**Mid** (A-level/HND)	**High** (Degree)	p-value
In the past 12 months	n (%)			
No money for more food				<0.001[a]
Never	250 (76)	267 (83)	243 (94)	
Sometimes	60 (18)	41 (13)	89 (6)	
Often	17 (5)	13 (4)	1 (0)	
Can't afford to eat balanced meals				0.001[a]
Never	270 (83)	276 (86)	244 (94)	
Sometimes	42 (13)	35 (11)	11 (4)	
Often	15 (5)	10 (3)	4 (2)	

[a] Fisher's exact test

Strong evidence of an interaction was observed between mothers' levels of education and their perception of local food access (p=0.03) and perception of fresh produce quality locally (p=0.02). For both these variables, the relationship with dietary quality differed in direction between mothers with low and those with higher educational attainment (Figure 4-2 and Figure 4-3). Perceptions that were positive corresponded with better quality diet among mothers with higher educational attainment, but among mothers with low educational attainment positive perceptions related to poorer dietary quality. However, only the association between dietary quality and perceived fruit and vegetable quality among mothers with the low education was statistically significant after adjustment for covariates (β=-0.21; 95% CI -0.38, -0.05).

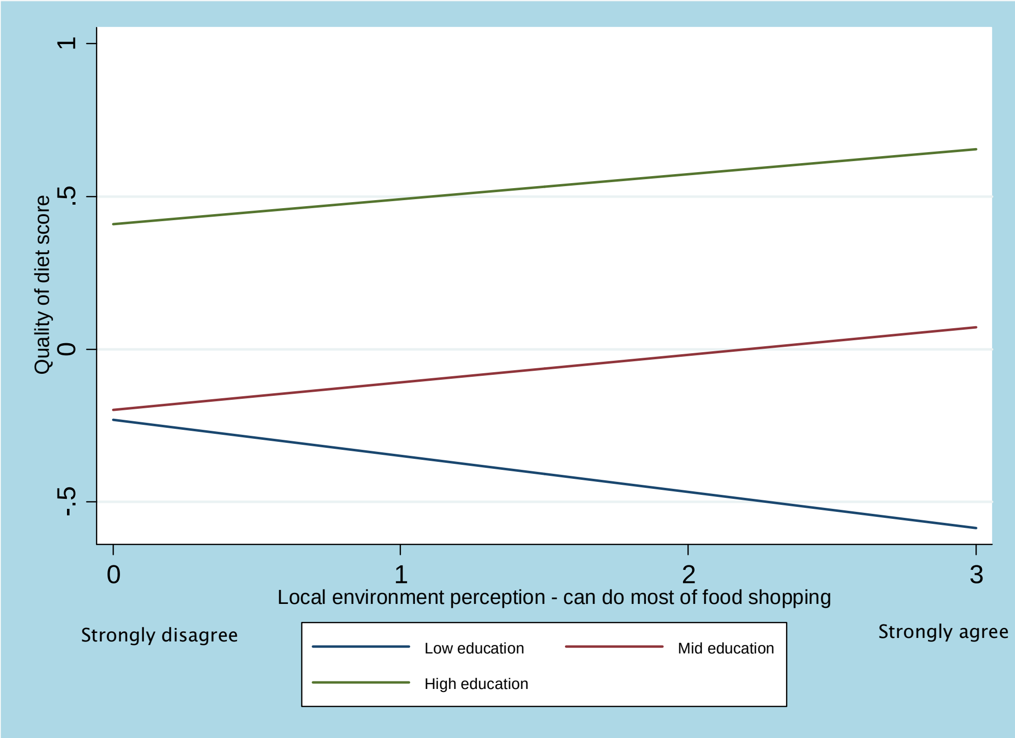


Figure 4-2 Mothers' quality of diet scores by perception that most food shopping can be done locally according to level of educational attainment

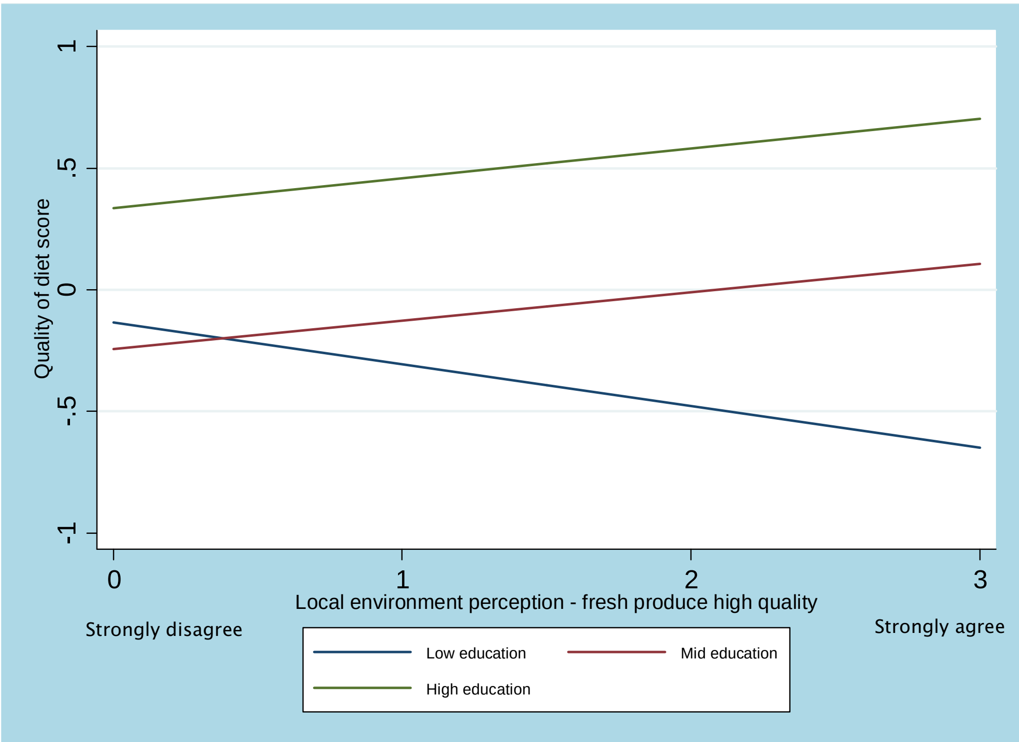


Figure 4-3 Mothers' quality of diet scores by perception that fresh produce is high quality locally according to level of educational attainment

An interaction was not observed between mother's education and either of the perceived affordability variables (both $p>0.1$). Stratified analyses, after adjustment for covariates, showed that affordability concerns about buying food were negatively associated with dietary quality among mothers with mid educational attainment ($\beta=-0.23$; 95% CI -0.43, -0.03). Affordability concerns about buying balanced meals were also negatively associated with dietary quality but only among mothers with mid educational attainment ($\beta=-0.35$; 95% CI -0.56, -0.13) but this relationship attenuated after adjustment for covariates ($p>0.1$).

4.4 Discussion

4.4.1 Summary of findings

There was a clear socioeconomic gradient in dietary quality among mothers in this study. Those with low educational attainment, who lived in more deprived neighbourhoods and had greater numbers of children had the poorest quality diets, and were more likely to consume fast food. Increasing maternal age was associated with better dietary quality among mothers with low and mid educational attainment. Only among mothers with low educational attainment was living in a more affluent neighbourhood associated with better dietary quality.

A number of psychosocial and environmental perception characteristics of mothers in this study were associated with dietary behaviours. Mothers had better quality diets if they had a higher sense of control over their lives, confidence in their ability to eat a healthy diet and belief in diet-disease relationships. Greater interest in planning, preparing and consuming food, and receiving support for healthy eating from family members were also associated with healthier dietary patterns. Mothers' who experienced affordability concerns about buying food or balanced meals had poorer dietary quality. Mothers' perceptions of food accessibility, variety or quality were not associated with their dietary behaviours. Most mothers perceived that their local neighbourhood offered them access to food stores that sold good quality, and a variety of, fresh produce. Few mothers felt they had healthy takeaway options close to home.

Some psychosocial and environmental perception characteristics differed by mothers' levels of education. Mothers with a low educational attainment showed the lowest scores for almost all of the psychosocial variables. However, educational attainment was only shown to moderate the relationship between dietary quality and beliefs in the benefits of healthy eating. Significant associations between belief that eating healthily can promote one's health and better dietary quality were identified among mothers with low and mid educational attainment but not among mothers with degrees.

Level of educational attainment was also shown to moderate several relationships between dietary quality and environmental perceptions. Among mothers with the lowest educational attainment, positive perceptions of food accessibility and quality in their local neighbourhood and negative perceptions about food affordability linked to poorer dietary quality.

Combined, the findings of this chapter suggest that younger age, living in a more deprived neighbourhood and having a poorer understanding of diet-disease relationships, and perhaps the local food environment, could be contributing to the poorer dietary quality of mothers with low educational attainment.

4.4.2 Comparison with previous research

The socioeconomic gradient in dietary quality and fast food intake observed in this study is consistent with previous research across high-income countries.[26 33-35 221] The difference in dietary patterns between mothers with low and those with high educational attainment was just over one standard deviation in dietary quality score. This disparity equates to mothers with degrees consuming crisps up to six times less and salad vegetables up to six times more per week than mothers with low educational attainment. Other research has identified similar differences in dietary patterns according to household income. The national report on household food purchases in 2012, and the low-income national diet survey in 2005, both showed that individuals living in low-income households consume approximately one portion of fruit and vegetables a day fewer than the general population.[12 222] In addition, low-income households purchase more food and drinks high in fat and/or sugar, and consume more total energy than the general population.

The findings that poorer quality diets were associated with lower levels of perceived control and self-efficacy in healthy eating are consistent with the literature.[38 41 223] The inverse relationship observed between perceived control and level of educational attainment is also consistent with previous work.[41 216 224] But unlike prior research,[41] educational attainment did not moderate the relationship between perceived control and dietary quality. Educational differences in perceived control have been observed in qualitative research. In focus groups, mothers with low educational attainment spoke of feeling less in control of food choices and regularly conceding to the preferences of their partner and children. In contrast, mothers with higher educational attainment reported standing firm on their food decisions for their family.[39] Experiencing multiple hardships and feeling little confidence in being able to combat familial body shape or food cravings have also been raised in qualitative studies as barriers to healthy eating among low-income mothers.[199 225]

Consistent with previous research, mothers' beliefs about the health benefits of eating nutritious foods were positively associated with dietary behaviours.[38] The more ambiguous attitudes of mothers with low educational attainment about the benefits of healthy eating were also similar to research from the US. Awareness of nutrition-related health risks was significantly lower among individuals with less than high school qualifications and African American or Hispanic backgrounds than those with higher educational attainment and white ethnicity.[226] Level of educational attainment was found to moderate the relationship between outcome expectancies for healthy eating and dietary quality. Belief in the health benefits of eating a nutritious diet was a greater predictor of better dietary quality among mothers of low and mid educational attainment than among mothers with degrees. Qualitative and quantitative research has shown that health and weight considerations are more important influences on food choices among women of higher socioeconomic position than those of lower socioeconomic position.[114 198] Nutrition knowledge and interest in food preparation and cooking have also been shown to be greater among those with higher educational attainment. The results of this study similarly showed that mothers with lower educational attainment had less interest in food-related activities than other mothers. However, educational attainment did not moderate the association between food involvement and dietary quality indicating that the relationship was consistent across educational attainment levels. This finding is consistent with previous work which did not identify an interaction between educational attainment and food involvement.[42]

There is strong evidence in the literature that higher levels of social support improve the adoption and maintenance of healthier dietary behaviours.[38 227] This study also showed that greater support from family for purchasing fruit and vegetables was associated with improved dietary quality. Levels of social support also varied by educational attainment: mothers with degrees received significantly more social support from their family than mothers with lower educational attainment. Research from Australia revealed that social support from family attenuated associations between education and intake of fruit and vegetables.[114] The effect of social support on dietary quality was consistent across education groups among the mothers in the current study. The lack of modification effect by education observed in this study is similar to research in the US, which found no association between social support and dietary quality in low-income mothers one year postpartum.[228] The use of different outcome measures may partly explain the differences in study findings across countries. Fruit and vegetable intake was the outcome in the Australian study, while dietary quality scores were the outcome in the other studies.

The finding that mothers who were concerned about food affordability had poorer quality diet is similar to qualitative and quantitative research among women in Australia.[54 198] The lack of association between mothers' perceptions of food accessibility, variety and quality in their local neighbourhood and dietary outcomes observed in this study largely contrasts previous research.[59] However, recent work from the US has shown evidence that is more equivocal for an effect of environmental perceptions on diet, with null findings identified among women[134] and low-income groups.[138 204]

Results of this study showed that positive perceptions of the neighbourhood food environment relate to poorer quality diet among mothers with low educational attainment. This finding is inconsistent with, and the opposite direction to, associations observed in previous studies.[53 205] Research with housing estate residents showed that a positive perception of supermarket accessibility was a greater predictor of higher fruit and vegetable consumption than objective access.[53] Qualitative work has shown that difficulty accessing healthy food is an issue for some disadvantaged groups,[225 229] but not all.[39 198] Young mothers from poorer backgrounds have reported being reliant on their family to provide food,[199] and having more difficulties food shopping (i.e. with small children or carrying heavy food) than more affluent mothers.[39]

Food affordability was a more important predictor of dietary quality in mothers with lower educational attainment than among those with degrees. This finding reflects national food purchasing statistics from 2012 which showed that low-income households spend substantially more of their budget on food than the average household in the UK (16.6% versus 11.6%).[222] Food cost has also been consistently cited as a strong influence over food choices among more disadvantaged groups.[39 198 225 229] Interestingly, the findings of this study showed that greater concerns about the affordability of food strongly predicted poorer dietary quality among mothers with mid educational attainment after adjustment for covariates, but this relationship attenuated among mothers who left school at 16 years of age. Research among women with low educational attainment in Australia showed that lower perceived cost of fruit was associated with higher fruit intake but perceived cost of vegetables did not predict vegetable intake.[56]

The unexpected relationships, observed in this study, between environmental perceptions and dietary quality among mothers with lower educational attainment may have occurred because factors, such as the weight or cost of fruit and vegetables, taste preferences or family circumstances may lead them to buy little fresh produce. Therefore, they reported overly positive perceptions because they did not really know.[59] The findings may have also resulted from high optimistic bias, a belief that current dietary behaviours are positive when compared with the diets of others.[225] Low-income families have comparatively limited social networks and therefore fewer opportunities for exposure to a variety of foods or cooking methods.

Another reported barrier to healthy eating among disadvantaged groups is the vast number of takeaway and fast food outlets available locally.[198 225] Unlike research in Australia,[54] perceived access to healthy takeaway foods locally was not related to fast food intake, takeaway intake or dietary quality in this study. The lack of association may be caused by the overwhelming agreement among mothers that healthy takeaway options were not available. Objective measures of food outlet access, such as fast food, takeaway and other food outlets within the community, have been shown to predict dietary behaviours. A thorough exploration of the objective community nutrition environment and mothers' dietary quality, and inequalities, is described in Chapter 5.

4.4.3 Strengths and limitations

A key strength of this study is the use of a validated, statistically derived composite measure of dietary quality that considers both healthy and less healthy dietary habits.[211 230] The foods included in the FFQ account for most of the variance in better and poorer dietary patterns in young women. Many of the same foods included in this FFQ determine disparities in dietary quality among young children and older adults.[27 231] The standardised dietary quality score provides a robust outcome measure to conduct and interpret analyses and makes an advance on brief dietary measures that have been frequently used in food environment research.[196] However, measuring dietary quality accurately is challenging. Response bias is possible, although interviewer-administered questionnaires have generally shown greater accuracy than self-administered questionnaires.[232] Biomarker validation of the tool used in this study only covered a few dietary components which makes the true intake of other components unknown,[233] and validation was not repeated in the sample of mothers in this study.[232] Dietary data collected using 24-hour recall instruments have been less affected by systematic error than food frequency questionnaire data. In addition, researchers can examine many aspects of dietary intake and the data may be more useful for comparative studies. However, 24-hour recalls and food diaries are more affected by random error than food frequency questionnaires due to day-to-day variation in intake and have greater burden on participants if repeat measures are taken (as recommended). There is also greater burden on researchers due to the extensive time associated with coding food record data.[196] The dietary results of this study were also consistent with high quality, nationally representative, dietary data that used the optimal assessment measures of weighed food diaries and biomarkers.[234]

This study has a number of limitations including the use of a convenience sample and the cross-sectional nature of the study. All mothers attending Sure Start Children's Centres in Southampton, Gosport and Havant were eligible to take part in the Southampton Initiative for Health. However, as the selection was not random, the mothers who took part may differ from mothers who declined to participate and the final sample is unlikely to represent the broader population of women of childbearing age in the UK. Only cross-sectional survey data were used in this study to enable temporal connection to environmental data collection. However, conclusions about causal direction between exposure and outcome variables cannot be made. There are also inherent limitations to the use of self-report psychosocial, perceived environmental exposure and dietary outcome measures. Measurement error may underestimate or overestimate associations by a common bias. For example, the use of self-reported clothing size rather than anthropometric measures may have underestimated a true association with dietary outcomes even though clothing size has been associated with markers of chronic disease in previous work.[215] Although the difference in findings may relate to the normalisation of being overweight and the size inflation of clothes with the same size becoming progressively larger in recent decades.[235] Finally, the dichotomisation of takeaway and fast food intake may have contributed to the lack of associations for these measures. It may have been more appropriate to group intake into three categories or provide additional response options to obtain a distribution closer to the normal curve; others have used both these methods.[189 221]

4.4.4 Policy and research implications

Despite government campaigns, such as *Change4Life,* the educational inequalities observed in this study and data from across England show that inequalities in diet remain or have worsened.[16] The results of this study showed that dietary health beliefs were a greater predictor of dietary quality among mothers with low educational attainment than among those with higher educational attainment. This finding suggests a need for nutrition campaigns and interventions that are suitable for and specifically target people with low educational attainment.[236]

Similarly, the positive associations between the five psychosocial variables and dietary quality observed in this study provide evidence for the widespread notion that supporting individuals to feel that they have more control over their lives is fundamental to improving health behaviours and addressing health inequalities.[4 237] Assisting the development of social networks and groups that offer support and opportunities to experience new foods and cooking techniques can be effective, particularly among mothers with young children.[238 239] Sure Start Children’s Centres provide a good environment for such activities. Many vulnerable families use these centres because they offer safe environments and can support mothers to make healthier food choices for themselves and their families.[179]

Furthermore, the UK Chief Medical Officer recently highlighted links between fast food outlets, poorer neighbourhoods and obesity but noted the need for further research.[235] The findings from this chapter did not show a relationship between perceived access to healthy takeaway food and dietary outcomes but did find that mothers overwhelmingly agreed that there were few healthy takeaway options in their residential neighbourhood. In addition to assessing the role of the objective food environment on diet (Chapter 5), further research is needed to understand the mediating role of psychosocial and perceived environmental factors in the relationship between the food environment and dietary quality. Such evidence could help to identify points of intervention that are most likely to be effective at supporting healthier food choices, particularly among the most disadvantaged. This thesis contributes to this need for further research (Chapter 8).

4.5 Conclusion

This chapter described the individual characteristics and dietary behaviours of a sample of 921 mothers with young children. Dietary disparities were apparent. Compared to mothers with degrees, mothers who left school at 16 years of age ate salad vegetables up to six times less each week and crisps up to six times more each week, and were more likely to eat fast food. Mothers who were younger and lived in more disadvantaged neighbourhoods were also more likely to have poorer dietary habits. Consistent with previous literature, five psychosocial variables were positively associated with dietary quality. Mothers with a greater sense of control, confidence in their ability to eat healthily, belief that diet affects health, an interest in food-related activities and social support had better dietary quality. Perceived affordability of food was related to dietary quality, with mothers who experienced times of not being able to afford food or balanced meals having poorer quality diets. Perceptions of food accessibility, variety and quality were not associated with dietary quality in the full sample of mothers.

There was evidence that psychosocial and perceived affordability factors were generally poorer among mothers with lower educational attainment. In particular, believing in the benefits of healthy eating was a more important predictor of dietary quality among mothers with lower educational attainment than among mothers with high educational attainment. Mothers with the lowest educational attainment also showed high optimistic bias in their perceptions of accessibility, quality and affordability of healthy foods locally whereby positive perceptions were associated with poorer dietary quality. It is possible that these mothers buy little fresh produce and therefore reported positively biased perceptions because they were not familiar with the actual environment, or because poorer dietary patterns and being overweight have become normalised in their social circles. These findings highlight the need for nutrition campaigns and interventions that specifically target people with low educational attainment. Finally, mothers overwhelmingly perceived that there were few healthy takeaway options in their residential neighbourhood. In Chapter 5, objective measures of food access are assessed and the relationship with mothers' dietary quality is explored.

Chapter 5 Community nutrition environment

The community nutrition environment denotes the geographical accessibility of food outlets and posits that greater access to different types of food outlets can affect dietary quality. As highlighted in Chapter 2, investigations of the community nutrition environment have applied three metrics of accessibility: *density*, *proximity* and, to a lesser extent, *variety*. Previous research has focused on food outlet accessibility within the residential neighbourhood and overlooked food outlets individuals are exposed to while going about their daily activities (i.e. work or childcare). This chapter assesses how density, proximity and variety measures within residential areas, as well as activity spaces, relate to the dietary quality of mothers described in Chapter 4. The introduction briefly recaps the evidence for the effect of the community nutrition environment on diet, and justifies the need for more nuanced exposure measures. In an attempt to better represent true exposure measures, this study used novel measures of density and proximity, which are described in the methods. Results are presented against the first three hypotheses of this study that are expressed in terms of the community nutrition environment.

1. **Disadvantaged neighbourhoods have significantly poorer community nutrition environments than more affluent neighbourhoods.**

2. **Community nutrition environment exposures are associated with mothers' dietary behaviours.**

3. **Mothers' levels of education have a moderating effect on associations between community nutrition environment exposures and their dietary behaviours.**

In the discussion, the findings are summarised and compared with previous research, and the policy and research implications are addressed.

5.1 Background

The community nutrition environment has been conceptualised as the physical accessibility of food outlets,[1] where proximate access to outlets selling a range of healthy foods or those selling predominantly less healthy foods can improve or worsen dietary behaviours respectively.[240] This concept is founded on the idea that place shapes individual health.[241] Contextual explanations for a place-health relationship posit that the spatial orientation and accessibility of physical resources can help or hinder an individual's health independent of their individual risk factors, or may even exacerbate individual circumstances.[165] In the case of place effects on diet, if access to healthy foods is limited then more time and/or money are required to eat nutritiously; disadvantaged families, in particular, those with resource constraints, may subsequently consume fewer healthy foods.[240]

As seen in the literature review for this thesis (section 2.5.1), there is some evidence for area-based inequalities in healthy food access in the US but disparities in other high-income countries are less evident and less researched. Internationally, there is a trend for greater access to fast food outlets in areas of higher deprivation. However, there is weak empirical evidence for a relationship between increased access to healthier food outlets and better dietary patterns or between greater access to less healthy food outlets and poorer dietary patterns. Approximately three quarters of studies have shown no association. Similar trends were observed in the small number of studies that analysed relationships between food outlet access and diet among disadvantaged populations. Methodological limitations restrict the ability to make clear conclusions about this literature.[59 78 80] Particular methodological flaws include the ecological design of a large proportion of studies, the use of administrative and generalised place boundaries, the focus on residential neighbourhoods and the use of a limited range of food outlets as exposures.

Advancements in the conceptualisation of environmental health research address several previous assumptions about the way individuals interact with the built environment that forms part of their daily activities.[241-243] A current limitation of epidemiological research on health and place is the dominant use of administrative units, such as census tracts. Administrative units can provide information about socially homogenous populations and have been considered useful for area based comparisons of environmental features (such as distribution of food outlets) and for multilevel analyses.[186 242] However, administrative unit analyses are limited because they assume residents use and perceive their neighbourhood in similar ways. While administrative units can provide useful contextual information, more sophisticated measures are recommended to understand relationships between the built environment and dietary behaviours.

Intertwined with the use of administrative units is the focus on residential neighbourhoods in the majority of environmental health research.[243] In the community nutrition environment literature most investigations have been based on the premise that people shop and are primarily influenced by food outlets geographically proximate to their homes.[172] However, previous work has shown that mothers in urban areas with low-incomes generally shop for food outside their residential neighbourhood.[244] In addition, many environmental resources required for family life, such as medical services and childcare facilities, have been shown to be external to the residential neighbourhood.[241] Measuring environmental exposures solely around an individuals' home ignores the exposures at other frequently visited locations, such as workplace or childcare, and may therefore misrepresent their true exposure to health promoting, or health damaging, environments.[172 241 242]

An alternative method to using residential neighbourhood is to draw boundaries around a number of individualised points to create activity spaces.[173 243] Activity spaces represent locations frequently visited by an individual within their daily activities or other specified time period.[70 242] Activity spaces are likely to provide more precise reflections of environmental exposures than purely residential measures and may improve the specificity between exposure and health behaviour or health outcome. Locations can be identified through surveys or by using Global Positioning Systems (GPS).[70] A buffer around identified locations, as well as travel routes taken, can be created with Geographic Information Systems (GIS) using a specified distance. A limited number of studies have examined food outlet access within activity spaces. The need for such research is becoming widespread.[245]

The use of GIS in environmental health research has also enabled sophisticated measures of accessibility to be calculated. Accessibility is defined as the ease of access to a particular environmental facility, where destinations that are more accessible destinations incur lower travel costs in terms of distance, time and financial resources.[70] Accessibility metrics for measuring the community nutrition environment include: *i) density* of food outlets within administrative units, residential buffer or activity spaces, *ii) proximity* (distance or time) from home or work to closest food outlet,[71] and *iii) variety*, the number of different food outlets within an outlet category, such as different types of fast food outlets.[72 73]

Density has most commonly been measured as the count of food outlets within an administrative unit or buffer around centroids, home or activity space points. Studies using administrative units in the US have typically applied census tracts,[48] while in the UK, administrative units have included census wards[98] and LSOAs (see 3.3.5.1).[99] Both Euclidean (straight line) and network buffers have been used around centroids, home or activity space points, covering distances between 110 yards (100m) to 1.5 miles (2.5 km).[71] The types of food outlets included in density assessments have largely been limited to counts of supermarkets and fruit and vegetable stores as proxies of healthy food access and/or fast food outlets and convenience stores as proxies of less healthy food outlets.[246 247] Such a dichotomy may be providing incomplete information about the community nutrition environment and may partly explain the weak evidence for an association between density and diet observed in the literature. Insignificant associations between outlet density and diet have also been observed in studies using the ratio of fast food outlets and convenience stores to supermarkets and grocery stores (Retail Food Environment Index).[134 137] Environmental assessments that are more comprehensive have shown promising associations with body mass index (BMI) and fast food purchasing. In the US, Rundle et al[248] classified 14 outlets into three groups, BMI healthy (3 types), BMI unhealthy (7 types) and BMI intermediate (4 types). In Australia, Thornton and Kavanagh[246] classified 18 different types of food outlets according to the mean weightings of eight academic researchers on a scale from +10 (outlet encourages healthy eating) to −10 (outlet encourages unhealthy eating). Healthy and less healthy 'food environment scores' were then calculated by multiplying the count of each outlet type by its mean weighting and summing the positive values and the negative values. Applying food environment scores to individualised activity spaces, such as in this study, may provide more nuanced assessments of associations between food outlet density and diet than proxy food outlet measures.

Of the GIS proximity calculations, distance by road network has been the most frequently reported measure in the food environment literature.[71] Road network distance can provide a more accurate assessment of proximity than Euclidean distance because network characteristics, such as cul-de-sacs and natural barriers, are considered.[70] Travel time can be calculated according to mode of transport and the characteristics of the network. Travel time may provide even more realistic measures of proximity than network distances when speed limit, topography and network complexity are considered.[141 249] Few studies have examined the relationship between dietary quality and time of travel to closest or frequently used food outlets.[59] This study assessed the relationship between dietary quality and time of travel to main food store and closest supermarket.

Variety of specific food outlets may provide additional information about the community nutrition environment that is not captured by density and proximity measures. Greater variety of fast food outlets, measured as the number of different fast food chains, has been related to increase purchasing of fast food.[73] For example, different types of takeaway or fast food outlets provide a greater choice of food products than two or three of the same type which increases the likelihood that taste preferences can be matched and these foods consumed.[73] This study addresses the need for additional research to further understand the relationship between food outlet variety and diet.

The aims of this chapter were to:

i) Examine differences in the density (using two different measures) and the variety of supermarkets and takeaway outlets across English quintiles of LSOA deprivation (hypothesis one)
ii) Determine the relationship between density, variety and proximity exposures in mothers' residential neighbourhoods and individualised activity spaces and their dietary quality, fast food and takeaway intake (hypothesis two)
iii) Test the moderation effects of level of educational attainment on community nutrition environment exposure and dietary behaviour associations (hypothesis three)

5.2 Community nutrition environment methods

5.2.1 Mothers

Participants were mothers who took part in the Southampton Initiative for Health follow-up survey whose home residence was located within the study area. Mothers were asked to provide their home postcode and details about frequently visited locations including Sure Start Children's Centre, general practitioner, main supermarket, work and physical activity site. Mothers were also asked questions about their usual mode of transport to their main food store, age, number of children and level of educational attainment. Home postcode was used to determine each mother's residential LSOA and corresponding quintile of deprivation.

5.2.2 Dietary outcomes

Three dietary outcomes were related to community nutrition environment exposures: dietary quality score, fast food intake and takeaway intake. Questions about dietary intake were included in the Southampton Initiative for Health follow-up survey. The creation of the dietary quality score is described in detail in section 4.2.2.1. Positive dietary quality scores described higher intakes of vegetables and wholemeal bread, and negative dietary quality scores described higher intakes of processed meats, crisps and sugar. Fast food and takeaway intake measures characterised mothers as those who never consume or those who consumed these foods in the past month. Sections 4.2.2.1 and 4.2.2.2 describe the derivations of these three dietary scores.

5.2.3 Food outlets

Food outlets within the study area were 'ground-truthed' over a similar time period as the surveying of the mothers. Using postcode information, all food outlets that fitted the study classification system for 20 types of food outlets (Table 3-2) were geocoded using ArcGIS 10.1[250] and allocated to a LSOA.

5.2.4 Measures of area

The measures of area used in this study included LSOAs and activity spaces.

5.2.4.1 LSOAs

LSOAs are small administrative units representing socially homogeneous populations sized between 1000-1500 residents.[186] There are 32,482 LSOAs across England and 550 in the study area. English LSOA deprivation quintiles (section 3.3.5.1) were allocated to each LSOA in the study area to assess area level differences in food outlet density and variety. Figure 5-1 illustrates food outlets within LSOAs according to national deprivation quintiles for a section of the study area. LSOAs were used to assess associations between food outlet density and variety in mothers' residential neighbourhoods and their dietary quality.

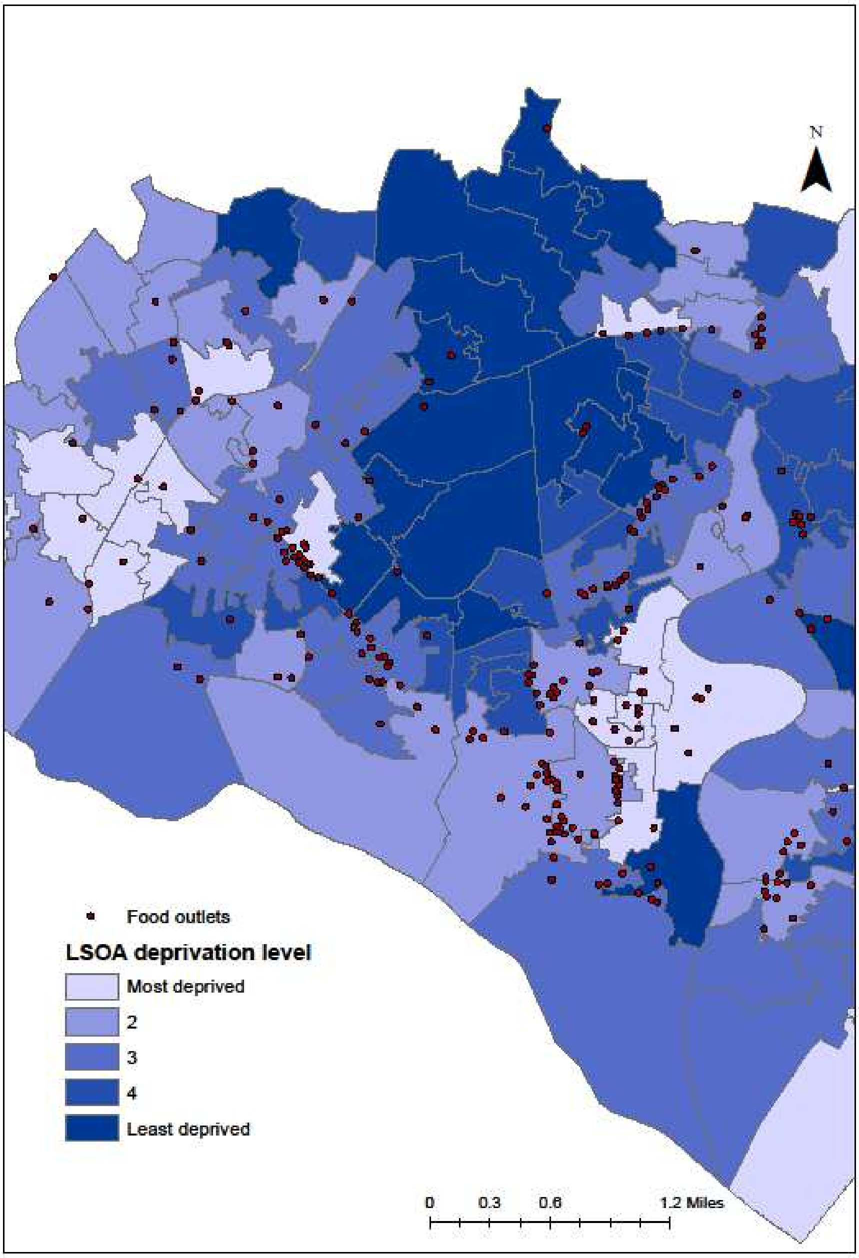


Figure 5-1 Illustration of food outlets within LSOA boundaries by English Deprivation Index income domain quintiles for a section of the study area

5.2.4.2 Activity spaces

Activity spaces were developed for mothers who provided information on at least two frequently visited locations within the study area. Locations were geocoded and individualised activity spaces calculated by buffering all points at 1000 meters and dissolving overlapping boundaries. This buffer distance was selected because it corresponds to an average walking trip to access facilities (10-15 minutes).[95 251] In addition, 1000 meters (0.6 miles) is the midpoint of the range of buffers applied in previous studies measuring activity spaces.[172 214 252] Euclidean distance (straight line) was used instead of road network distance because there is little difference between these two measures at distances of 1000 meters.[253] Food outlets were overlaid onto each mothers' activity spaces to enable density and variety measures to be calculated. The geographical area (km^2) of each activity space was also calculated for consideration as a potential confounder.

Researchers with GIS expertise at the London School of Hygiene and Tropical Medicine wrote the Python syntax that created the activity points, activity spaces, and calculated the food outlets and geographical area (km^2).

Figure 5-2 and Figure 5-3 provide visual representation of an example of food outlets within one mother's home LSOA and activity space respectively.

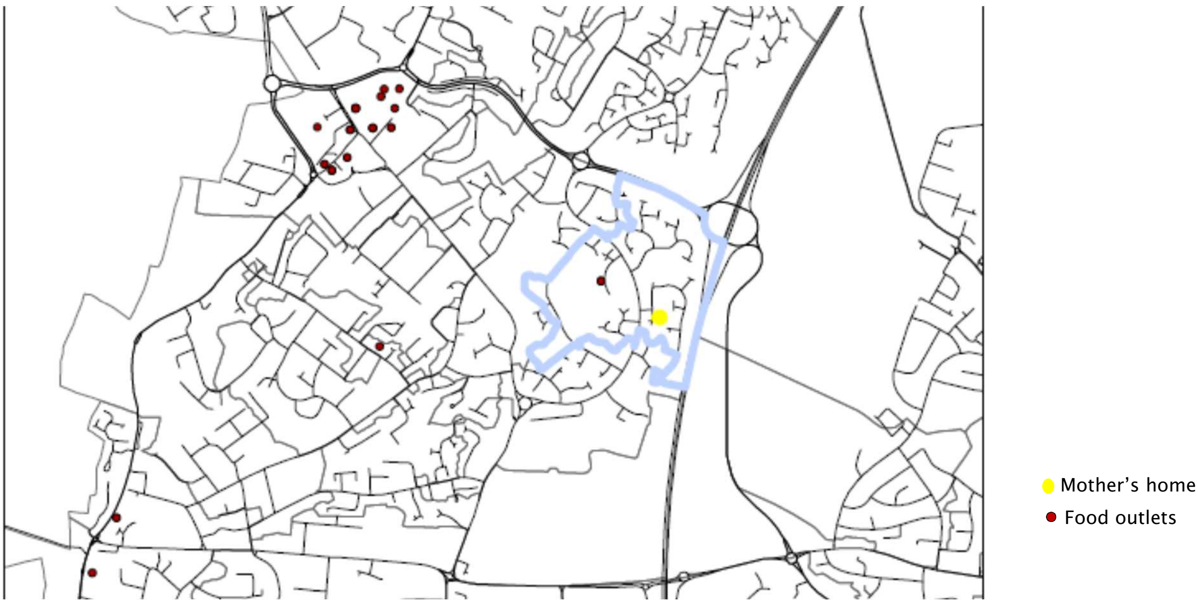


Figure 5-2 An example of a mother's home LSOA with food outlets

Figure 5-3 An example of the same mother's activity space (as Figure 5-2) with food outlets

5.2.5 Accessibility exposures

As discussed in 5.1, accessibility of food outlets were characterised using density, variety and proximity variables.

5.2.5.1 Density

Density was measured using two methods: *i)* count of food outlets and *ii)* food environment scores. The count density and food environment scores were calculated for the two different areas: LSOA and activity space.

A **count** measure of healthier food outlets and less healthy outlets was used based on the classification of previous work by Thornton and Kavanagh[246] which involved a two round Delphi survey with key academic researchers in the food environment field. Eight international researchers were asked to rate food outlets from +10 (outlet encourages healthy eating) to -10 (outlet encourages unhealthy eating) and the mean calculated for each outlet type. The intention of positive and negative numbers was to provide differentiation between healthier and less healthy food outlets.

Table 5-1 shows the healthier and less healthy food outlets from the Delphi study and the corresponding outlet categories in the current study. Five count measures were calculated: *i)* total count of healthier food outlets, *ii)* total count of less healthy food outlets, *iii)* overall count of outlets where the less healthy total count was subtracted from the healthy total count (H-U), *iv)* total count of fast food outlets and *v)* total count of takeaway outlets. Areas without any food outlets were included in all analyses in an attempt to accurately represent exposure.

The **food environment score** (FES) represents a novel measure of density that use the mean weightings for food outlets as determined in the Delphi survey study described above.[246] A weighting for each outlet type was calculated as the mean of the ratings from the eight researchers after the two survey rounds (Table 5-1). Food environment scores were calculated for healthy outlets and less healthy outlets. Following the methods of Thornton and Kavanagh, the negative weightings were transformed to positive values for the calculation of less healthy food environment scores. Scores were created by *i)* multiplying the count of each food outlet type by its corresponding weighting, *ii)* adding the multiplied values for each of the ten healthy food outlets (FES H), and *iii)* adding the multiplied values for each of the five less healthy food outlets (FES U). In this study, an overall food environment score was also calculated (FES H-U) to provide a single summary measure.

Table 5-1 Healthy and less healthy food outlet types and mean ratings according to previous work[246] and corresponding categorisation for the current study

Mean rating score (SD)	Delphi study outlet type	Current study outlet category
Healthy food outlets		
8.8 (2.1)	Fruit and vegetable market	Farm shop
8.8 (2.1)	Fruit and vegetable store	Greengrocer
6.3 (2.9)	Supermarket – large chain	Premium/large supermarkets
5.4 (3.2)	Butcher	Butcher
5.3 (2.5)	Ethnic	'World' stores
5.0 (2.5)	Bakery – bread only	N/A
4.9 (2.7)	Supermarket – mid	Small supermarkets
4.4 (2.4)	Deli	Sandwich shops
4.3 (3.3)	Health	Health food stores
4.3 (2.9)	Convenience – fresh	N/A
3.3 (3.5)	Supermarket – discount	Discount supermarkets
0.8 (1.9)	Bakery – mixed	Bakery
Less healthy food outlets		
-1.1 (4.1)	Convenience – non fresh	Convenience/petrol stores
-1.1 (2.3)	Takeaway – food court	N/A
-1.6 (2.4)	Takeaway – (Asian/Indian)	Chinese/Indian takeaways
-5.0 (0.9)	Takeaway – independent	Fish & chips/Other takeaways
-5.0 (3.6)	Other – miscellaneous	Newsagents/confectioners
-8.3 (1.6)	Takeaway – major chain	Fast food outlets

5.2.5.2 Variety

Consistent with prior research, variety was examined as a measure of variation within food outlet categories. Previously, variety of fast food outlets was measured as the number of different fast food chains.[73] In this study, the variety across the supermarket and takeaway categories were assessed for both LSOAs and activity spaces. The variety values ranged from zero to four in accordance with the sub-categorisation of supermarkets (premium, large, discount, small) and takeaways (Chinese, Indian, fish & chips, other) used in this study.

5.2.5.3 Proximity

Proximity was captured via two measures: travel time (minutes) and travel distance (metres). Ordnance Survey – OS MasterMap® Integrated Transport Network (OS ITN) and Path Network were built in ArcMap 10.1 and the network functionality of ArcMap was used to calculate all proximity measures. Times from home to main supermarket and to closest supermarket were calculated in accordance with the mode of transport mothers' reported using to access their main food stores. For mothers who drove, time calculations were based on the fastest route according to road network, road hierarchy, road restrictions and speed limits. Walking time was calculated as the fastest route of the road-path network, using road hierarchy and a speed of five kilometres per hour (three miles per hour). This speed is consistent with findings of the average walking speed of women in early pregnancy.[254] The use of road-path network for walkers was advantageous because sensitivity analyses showed that road network distance differed from road-path network distance in most cases (86%). The time for mothers using public transport or cycling was calculated as the mean of walking and driving time. Figure 5-4 presents the road network route from a mother's home to her closest supermarket.

Proximity to closest fast food outlet and closest takeaway outlet from mothers' home residences were measured as the road network distance because the mode of transport mothers used to access these outlets were not known thus travel time could not be accurately calculated.

Figure 5-4 An example of the road network route from a mother's home to her closest supermarket

5.2.6 Statistical analyses

The distribution of food outlets and all accessibility exposure variables were described and presented in tables or histograms. Differences between the demographic characteristics of mothers who used their closest supermarket as their main supermarket and those who did not were assessed using: two tailed t-test for age and dietary quality; rank sum test for number of children, level of educational attainment and neighbourhood deprivation; and fishers exact to test for differences in mode of transport.

To detect differences in density and variety across LSOA deprivation quintiles Spearman test for trend was applied. Relationships between mothers' dietary outcomes and density, variety and proximity exposures were examined using regression analyses. Linear regression was used for the continuous, normally distributed dietary quality variable and logistic regression for the binary measures of fast food and takeaway intake. Similar to previous work,[120] proximity variables were log transformed for regression analyses due to their positively skewed distributions. Step-wise backward elimination regression models were used to adjust for the covariates age, number of children, seven levels of educational attainment and five levels of neighbourhood deprivation. Clothing size was not included because it was not related to dietary quality in the sample of mothers in this study. Geographical area of activity space was included as a covariate in activity space analyses. All covariates were treated as continuous variables to test for trend.

Differences in all exposure variables were examined across three levels of education using Spearman correlations to test for trend. Chi squared test was used to examine differences in mode of transport due to the categorical nature of this variable. An interaction term for three levels of educational attainment and each exposure variable were added to all regression models to assess whether educational attainment moderated the relationship between dietary outcomes and food outlet accessibility exposures. Models were then stratified to identify the separate effects across low, mid and high levels of educational attainment.

All statistical analyses were completed using Stata statistical software package version 13.0.[255]

5.3 Community nutrition environment results

Approximately one quarter of LSOAs (26%) in the study area were classified as the least deprived neighbourhoods in England and another quarter (26%) classified as middle level (3rd quintile) deprivation (Table 5-2). LSOAs classified as the most deprived neighbourhoods in England made up 13% of the study area.

A total of 1787 food outlets were identified within the study area: 30% were healthier food outlets and 70% were less healthy food outlets. Convenience stores (15%, n=272) made up the greatest proportion of outlets followed by Chinese takeaways (12%, n=223). Large (n=32) and premium supermarkets (n=10) made up less than 3 percent of all outlets, as did greengrocers (n=41) and farm shops (n=7). Fast food chains (n=92) represented five percent of all food outlets. Most food outlets were located in the second most deprived and middle deprivation neighbourhoods (27%, n=482 and 31%, n=550 respectively). This trend is mirrored across the 20 types of food outlets (Table 5-2).

Table 5-2 Distribution of LSOA and 20 food outlet types across LSOA deprivation quintiles

	LSOA deprivation quintiles					
	Most deprived	**2**	**3**	**4**	**Least deprived**	**Total n (%)**
LSOA n (%)	71 (13)	93 (17)	146 (26)	98 (18)	142 (26)	550 (100)
Outlet type						
Premium supermarket	1	5	2	2	0	10 (0.5)
Large supermarket	7	9	8	4	4	32 (2)
Discount supermarket	8	7	12	3	5	35 (2)
Small supermarket	13	31	34	24	25	127 (7)
'World' store	17	21	17	6	2	63 (4)
Greengrocer	5	8	16	7	5	41 (2)
Farm shop	0	1	3	0	3	7 (0.5)
Health food store	3	7	5	1	3	19 (1)
Butcher	6	7	15	13	15	56 (3)
Baker	10	16	15	12	15	68 (4)
Sandwich shop	6	22	19	12	7	66 (4)
Convenience store	44	75	77	40	36	272 (15)
Petrol store	10	10	22	8	18	68 (4)
Newsagent	7	24	15	9	10	65 (4)
Confectioner	8	26	25	6	11	76 (4)
Fast food outlet	12	40	22	10	8	92 (5)
Chinese takeaway	28	44	76	44	31	223 (12)
Indian takeaway	19	32	56	26	18	151 (8)
Fish & chips	13	43	53	20	14	143 (8)
Other takeaway	17	54	58	26	18	173 (10)
Total n (%)	234 (13)	482 (27)	550 (31)	273 (15)	248 (14)	1787 (100)

5.3.1 AIM 1: Does food outlet density and variety differ by LSOA deprivation quintiles?

In this section, hypothesis one is assessed. Differences in the density (using two different measures: count density and food environment scores) and the variety of supermarkets and takeaway outlets across English quintiles of LSOA deprivation are examined.

5.3.1.1 LSOA deprivation – count density of food outlets

Approximately one third of LSOAs in the study area contained no food outlets (31%, n=172). LSOAs with food outlets contained no more than one premium supermarket, large supermarket or farm shop, and no more than two greengrocers or health food shops. The greatest numbers of a single type of food outlet within a LSOA included fast food outlets, confectioners and other takeaways (n=9, n=10 and n=11 respectively).

The median count density of healthier food outlets across the 550 LSOAs was zero, with a range from zero to 13 (IQR: 0, 1). The median count density of less healthy outlets was one, with a range from zero to 37 (IQR: 0, 3). Figure 5-5 displays the greater frequency of less healthy food outlets than healthier food outlets. This difference is also presented in the overall count density (H-U), where less healthy count density was subtracted from healthy count density. Only 10% of LSOAs (n=56) had a positive overall count density which indicated greater provision of healthier food outlets than less healthy outlets. The median for overall count density was minus one, with a range from -25 to 5 (IQR: -2, 0).

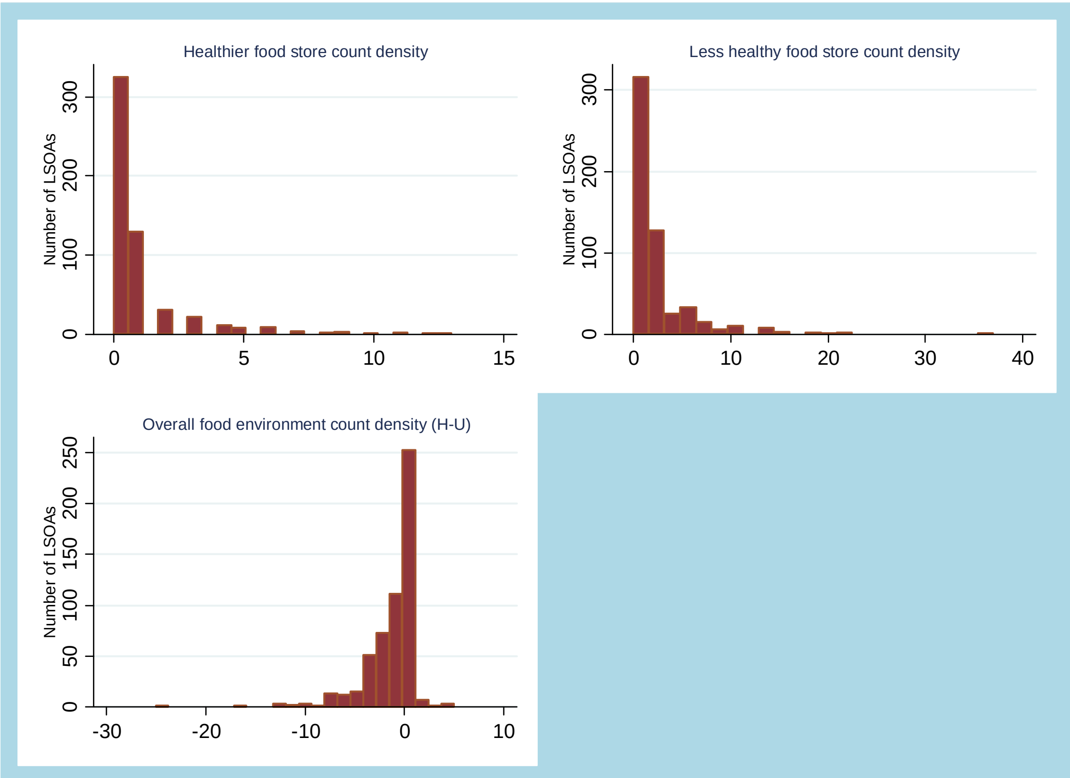


Figure 5-5 Distribution of healthier, less healthy and overall count density (H-U) of food outlets across all LSOAs in the study area

Test for trend analyses revealed greater provision of both healthier and less healthy outlet types in more disadvantaged LSOAs however, the association was stronger for less healthy outlets (Table 5-3). The overall count density showed that more affluent neighbourhoods were more likely to have no food outlets or fewer less healthy and greater numbers of healthier food outlets than more deprived neighbourhoods (Table 5-3 and Figure 5-6).

Table 5-3 Median, interquartile range and correlation of summary count density across LSOA deprivation quintiles

	LSOA deprivation quintiles						
	Most deprived	**2**	**3**	**4**	**Least deprived**		
Count of food outlets	Median (IQR)					r	p-value[a]
Healthier food outlets	0 (0, 1)	0 (0, 1)	0 (0, 1)	0 (0, 1)	0 (0, 1)	-0.10	0.02
Less healthy food outlets	2 (0,3)	1 (0,3)	2 (0,4)	1 (0, 2)	0 (0,2)	-0.20	<0.001
Overall count density (H-U)	-1 (-2, 0)	-1 (-3, 0)	-1 (-3, 0)	0 (-1, 0)	0 (-1,0)	0.19	0.001

[a]Spearman test for trend across

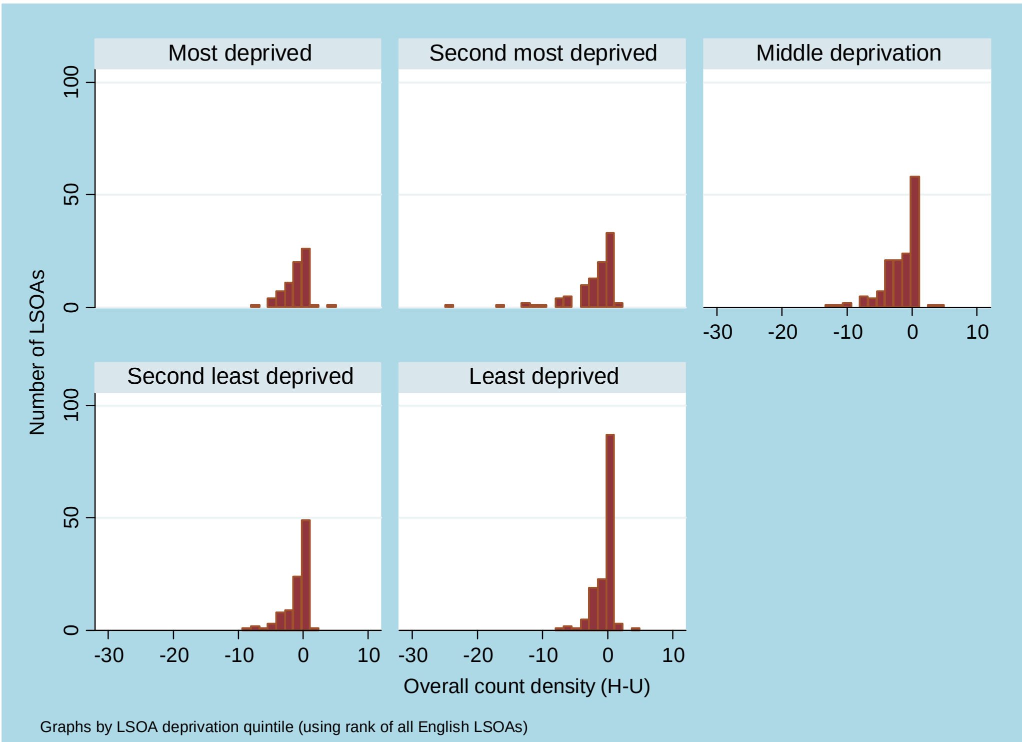


Figure 5-6 Overall count density (H-U) of food outlets by LSOA deprivation quintiles

5.3.1.2 LSOA deprivation – food environment scores

The median food environment score for healthier outlets across the 550 LSOAs was zero, with scores ranging from zero to 64 (IQR: 0, 5.3). The median food environment score for less healthy outlets was 1.1, with a range from zero to 192 (IQR: 0, 8.2). Figure 5-7 presents the distribution of food environment scores for healthier and less healthy food outlets and shows larger scores for less healthy than for healthier food outlets. The overall food environment score had a median of zero and ranged from -138 to 30 (IQR: 3.9, 0). Almost half of the LSOAs in the study area had negative food environment scores (48%, n=265), 31% had neutral scores (n=172) and 21% had positive healthier food environment scores (n=113).

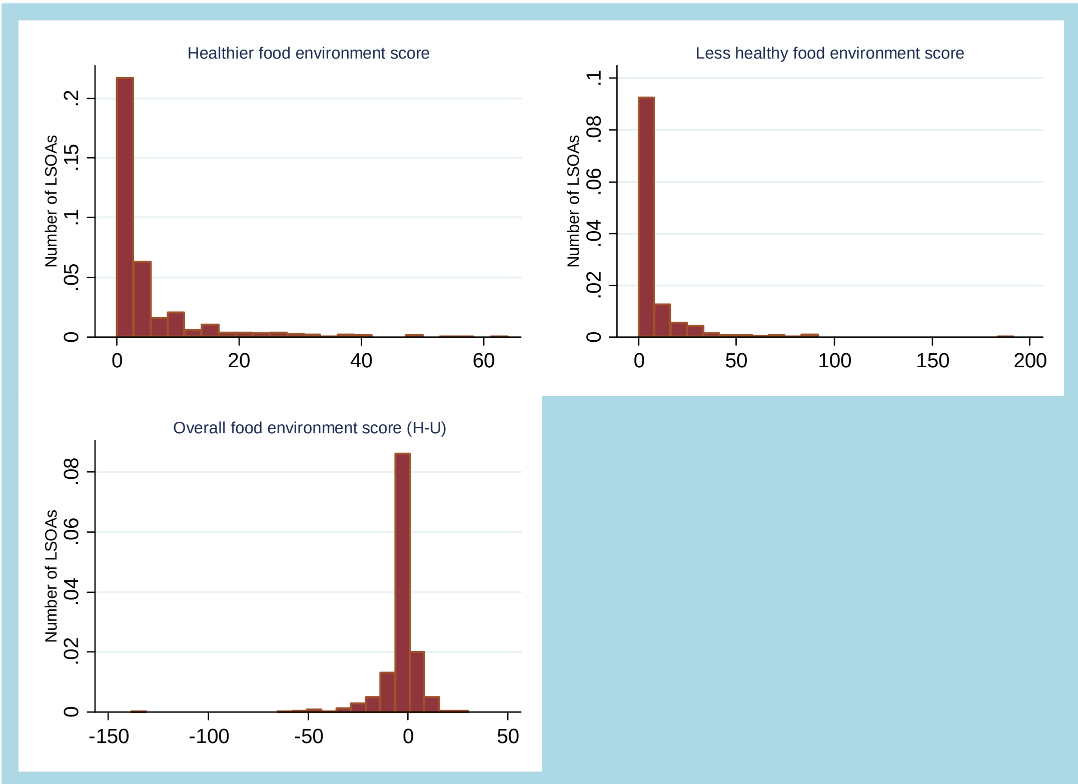


Figure 5-7 Distribution of healthier, less healthy and overall food environment scores in the 550 LSOAs in the study area

Test for trend results revealed that healthier food environment scores favoured more deprived neighbourhoods where the most affluent neighbourhoods had the lowest scores (Table 5-4). Food environment scores for less healthy outlets showed a trend towards poorer food environments in more deprived neighbourhoods. This trend remained unchanged after removal of the outlier. The second most deprived and middle deprivation neighbourhoods showed the highest scores for less healthy outlets while the most affluent neighbourhoods had the lowest scores. A positive relationship was found between overall food environment score and neighbourhood deprivation indicating that the most affluent neighbourhoods were more likely to have neutral or better food environments compared to more deprived neighbourhoods (Figure 5-8).

Table 5-4 Median, interquartile range and correlation for food environment scores by LSOA deprivation quintiles

	LSOA deprivation quintiles						
	Most deprived	**2**	**3**	**4**	**Least deprived**		
Food environment score (FES)	Median (IQR)					r	p-value[a]
FES H	0 (0, 5.3)	0 (0, 5.7)	0 (0, 5.3)	0 (0, 5.4)	0 (0, 4.9)	-0.1	0.01
FES U	2.2 (0, 8)	3.2 (0, 10)	3.0 (0, 13)	1.1 (0, 8)	0 (0, 4)	-0.2	<0.001
FES H-U	0 (-3, 0.4)	-1.1 (-6, 0)	-1.1 (-6, 0)	0 (-3, 0)	0 (-1, 0)	0.13	0.002

[a]Spearman test for trend across

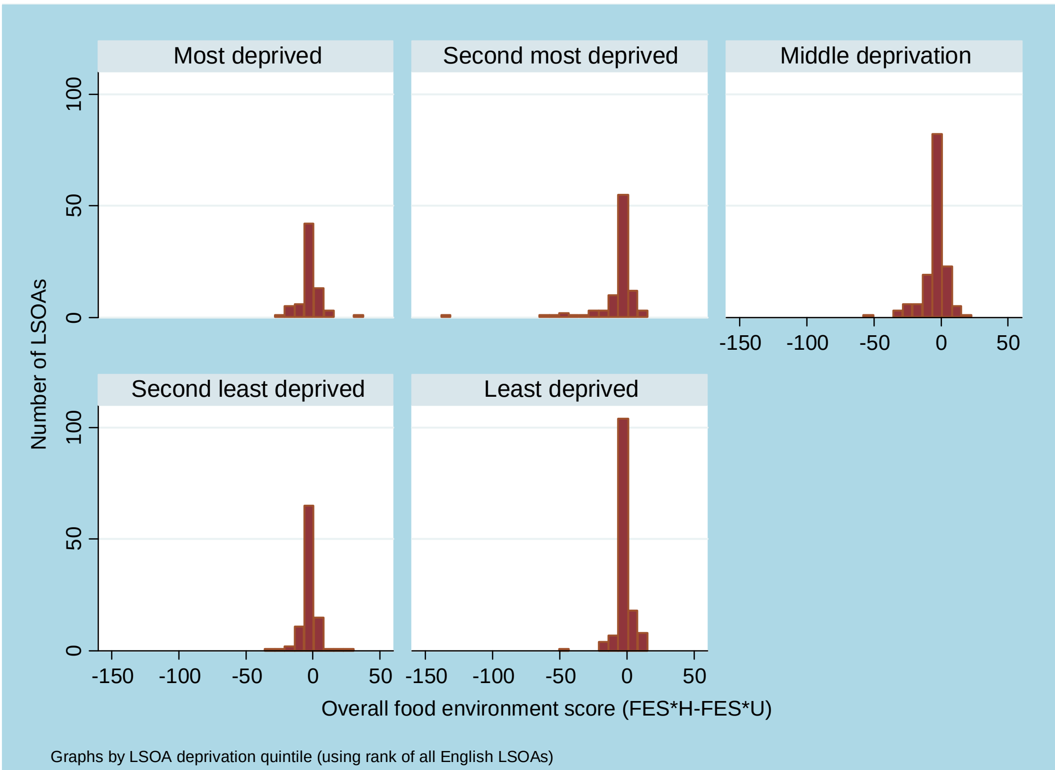


Figure 5-8 Overall food environment scores by LSOA deprivation quintiles

5.3.1.3 LSOA deprivation – variety of food outlets

Figure 5-9 shows the variety of supermarkets and variety of takeaway outlets over the 550 LSOA in the study area. A total of 394 LSOAs (72%) did not contain supermarkets and 304 LSOAs (55%) did not contain takeaways. The median variety across all LSOAs for both supermarkets and takeaway outlets was zero (IQR: 0, 1).

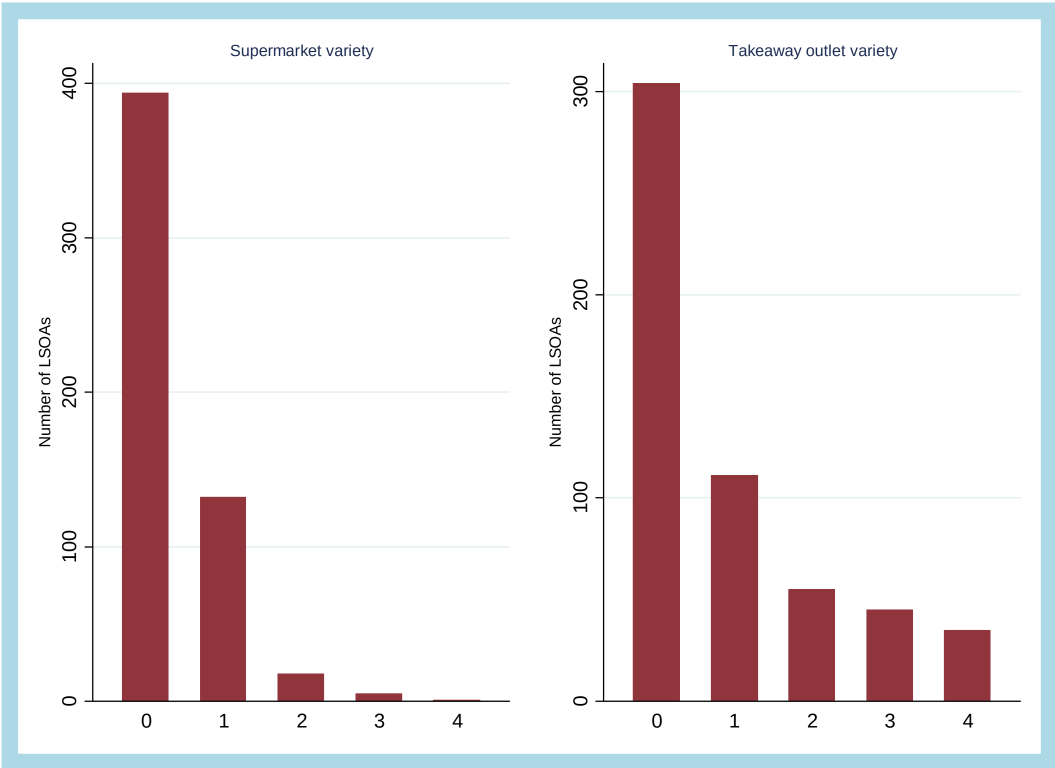


Figure 5-9 Variety of supermarkets and takeaway outlets across 550 LSOAs

Test for trend showed a weak negative relationship between variety of supermarkets (r=-0.1, p=0.01) and variety of takeaway outlets (r=-0.17, p<0.001) by level of LSOA deprivation. These results suggest that variety of both supermarkets and takeaway outlets was greater in more deprived LSOAs.

5.3.2 AIM 2: Are food outlet density, variety and proximity associated with dietary quality?

In this section, hypothesis two is assessed. The relationships between density, variety and proximity exposures in mothers' residential LSOAs and activity spaces, and mothers' dietary quality, fast food and takeaway intake are examined.

5.3.2.1 Residential LSOA - count density of food outlets and diet

Home neighbourhood food outlet count density data from 279 LSOAs in the study area were matched with information from 877 mothers. Mean dietary quality score for this sample of mothers was -0.01 (SD: 1), mean age was 32 years and most mothers (80%) had one or two children. One fifth of mothers (20%) reported never eating takeaway and 38% reported never eating fast food.

The distribution of healthier, less healthy and overall count density (H-U) of food outlets across mothers' home neighbourhoods mirrored the distribution across all LSOAs in the study area (Figure 5-5). More than one quarter of mothers (28%, n=243) did not have food outlets in their home neighbourhood. The median count density of healthier food outlets was zero, with a range from zero to 13 (IQR: 0, 1). The median count density of less healthy food outlets was one, with a range from zero to 22 (IQR: 0, 3). The overall count density (H-U) median was minus one with a range from -13 to three (IQR: -2, 0).

Figure 5-10 shows the relationship between mothers' dietary quality and count densities for healthy, less healthy and overall food outlets in their home LSOAs. Univariate analyses showed a positive relationship between healthier and less healthy outlet count density and dietary quality. Mothers' quality of diet scores increased by 0.06 for each additional healthier food outlet in her home neighbourhood (95% CI: 0.03, 0.1). However, mothers' quality of diet scores also increased, though by a smaller amount (β=0.03; 95% CI 0.01, 0.05), for each additional less healthy food outlet in her home neighbourhood. These associations remained significant after adjustment for potentially confounding factors including mothers' age, number of children, educational attainment and home neighbourhood deprivation (Table 5-5). While only one percent of the variance was explained in the univariate models, 21 percent of the variance was explained in the mulitvariate models. An association was not identified between overall count density of food outlets in mother's home neighbourhood and her quality of diet ($p>0.1$).

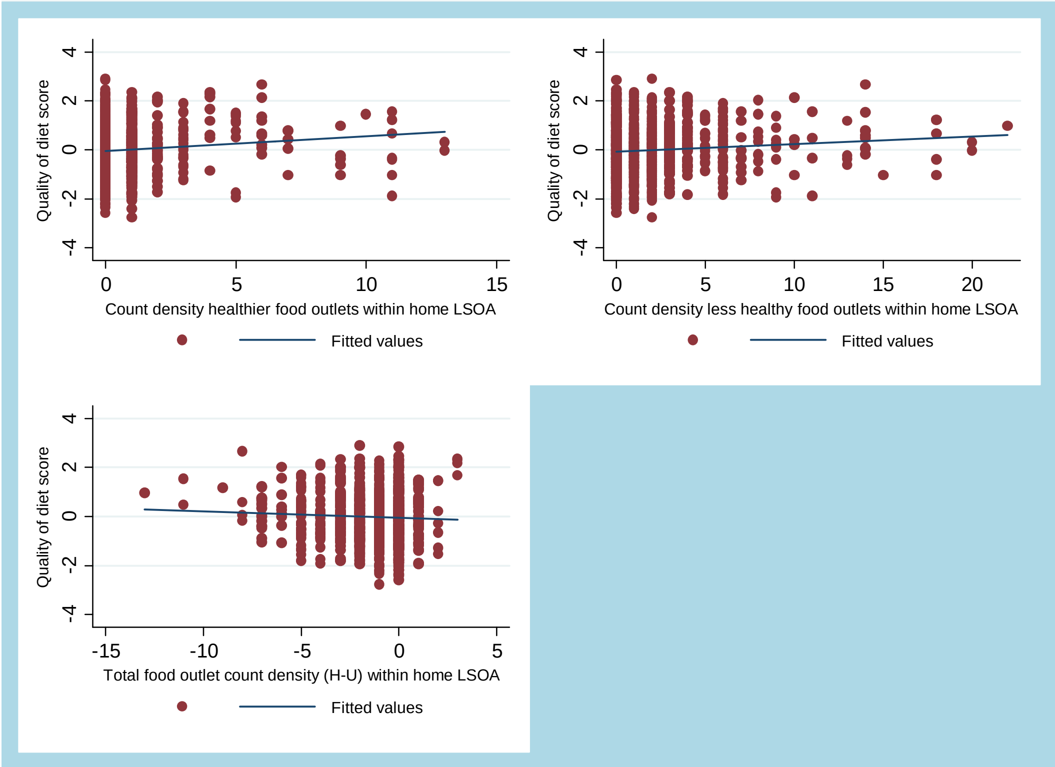


Figure 5-10 Scatter plots of mothers' quality of diet scores by healthier, less healthy and overall food outlet count densities (H-U) within home LSOAs

Associations were not observed between count density of fast food or takeaway outlets in mothers' home neighbourhoods and whether or not they consumed fast food or takeaway foods (both p>0.1).

Table 5-5 Adjusted regression model of the association between mothers' dietary quality scores and count density of healthy and less healthy food outlets in their home LSOAs

	Dietary quality (SD) β (95% CI)	p-value
Healthier food outlet count density	0.05 (0.02, 0.09)	0.002
Education (7 levels)	0.22 (0.17, 0.26)	<0.001
Number of children	-0.08 (-0.15, -0.02)	0.01
Age (years)	0.03 (0.02, 0.04)	<0.001
Neighbourhood deprivation (quintiles)	0.08 (0.03, 0.13)	0.001
Less healthy food outlet count density	0.03 (0.01, 0.04)	0.004
Education (7 levels)	0.22 (0.17, 0.26)	<0.001
Number of children	-0.09 (-0.15, -0.02)	0.009
Age (years)	0.03 (0.02, 0.04)	<0.001
Neighbourhood deprivation (quintiles)	0.08 (0.03, 0.13)	0.001

5.3.2.2 Residential LSOA – food environment scores and diet

The distribution of healthier, less healthy and overall food environment scores in mothers' home neighbourhoods was very similar to that of the 550 LSOAs in the study sample (Figure 5-7). The median healthier food environment score was zero and ranged from zero to 64 (IQR: 0, 5). The median less healthy food environment score was two, with values ranging from zero to 90 (IQR: 0, 8). The overall food environment score (FES H-U) had a median score of minus one and ranged from -50 to 27 (IQR: -6, 0).

Figure 5-11 shows the relationships between mothers' quality of diet and healthier, less healthy and overall food environment scores in their home neighbourhoods. Results of adjusted regression analyses revealed that mothers' quality of diet scores increased by 0.1 for each additional 10 points improvement in healthier food environment score in their home neighbourhoods (95% CI: 0.04, 0.2) (Table 5-6). Surprisingly, mothers' quality of diet scores increased by 0.07 (95% CI: 0.02, 0.1) for each additional 10 points increase in less healthy food environment score. Both of these multivariate models explained 21 percent of the variance in dietary quality. A relationship between overall food environment score (FES H-U) and dietary quality was not observed ($p>0.1$).

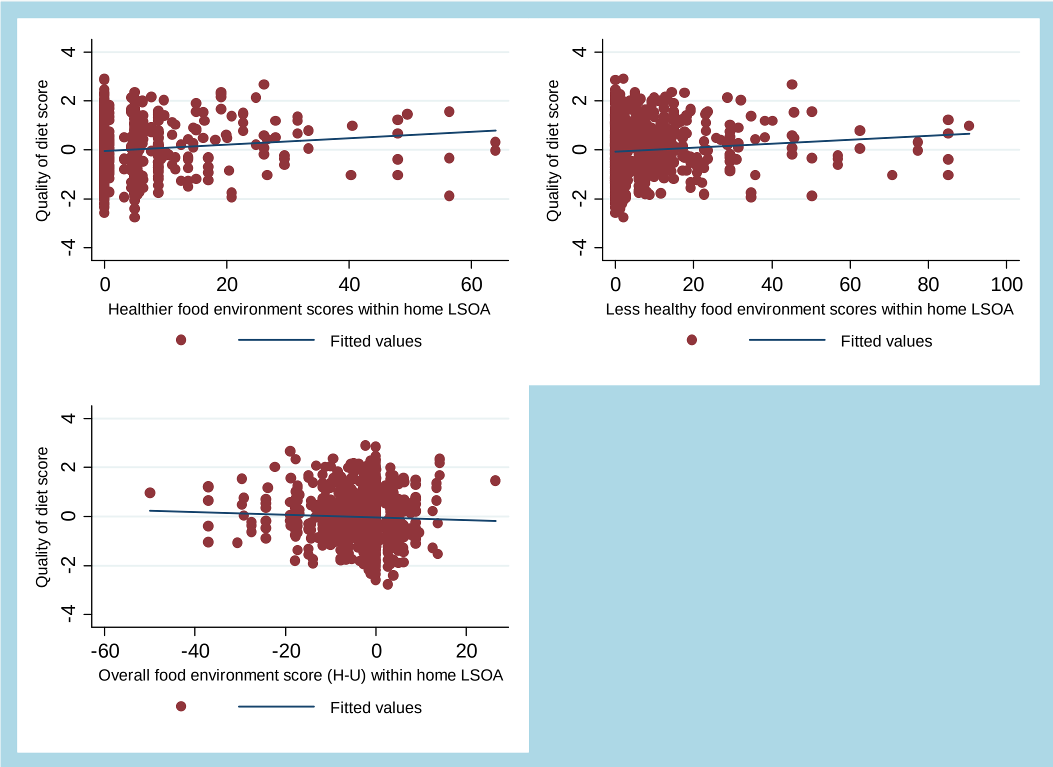


Figure 5-11 Scatter plots of mothers' quality of diet scores by healthier, less healthy and overall food environment scores within home LSOAs

Table 5-6 Adjusted regression models of the relationship between mothers' dietary quality scores and healthier and less healthy food environment scores in their home LSOAs

	Dietary quality (SD) β (95% CI)	p-value
Healthier food environment score (FES H)	0.1 (0.03, 0.18)	0.003
Education (7 levels)	0.22 (0.17, 0.26)	<0.001
Number of children	-0.08 (-0.15, -0.02)	0.01
Age (years)	0.03 (0.02, 0.04)	<0.001
Neighbourhood deprivation (quintiles)	0.08 (0.03, 0.13)	0.001
Less healthy food environment score (FES U)	0.07 (0.02, 0.1)	0.008
Education (7 levels)	0.22 (0.17, 0.26)	<0.001
Number of children	-0.09 (-0.15, -0.02)	0.009
Age (years)	0.03 (0.02, 0.04)	<0.001
Neighbourhood deprivation (quintiles)	0.08 (0.04, 0.13)	0.001

5.3.2.3 Residential LSOA – variety of food outlets and diet

Variety is a measure of the variation across two broad food outlet categories: supermarkets and takeaway outlets. The variety of supermarkets and takeaway outlets in 877 mothers' home neighbourhoods were distributed in a similar pattern to that of the 550 LSOAs in the study area (Figure 5-9). The median variety for supermarkets was zero (IQR: 0, 1) and the median variety for takeaway outlets was zero (IQR: 0, 2).

Univariate regression analysis of mothers' dietary quality and the variety of supermarkets in their home neighbourhoods showed no evidence of an association ($p>0.1$). After controlling for covariates, a positive relationship was identified for takeaway outlet variety where mothers' dietary quality increased by 0.06 for each additional type of takeaway outlet within their home neighbourhoods (95% CI: 0.01, 0.11) (Table 5-7). This multivariate model explained 21% of the variance in mothers' dietary quality. No association between variety of takeaway outlet and consuming takeaway food or not was observed ($p>0.1$).

Table 5-7 Adjusted regression model of the association between mothers' dietary quality scores and variety of takeaways in their home LSOAs

	Dietary quality (SD) β (95% CI)	p-value
Takeaway outlet variety	0.06 (0.01, 0.11)	0.015
Education (7 levels)	0.22 (0.18, 0.27)	<0.001
Number of children	-0.09 (-0.15, -0.02)	0.008
Age (years)	0.03 (0.02, 0.04)	<0.001
Neighbourhood deprivation (quintiles)	0.08 (0.03, 0.13)	0.002

5.3.2.4 Residential proximity of food outlets and diet

This section presents residential proximity analyses. Residential proximity can lie within or outside mothers' residential LSOA boundaries, but represent closest proximity of food outlets to their homes.

Proximity data was obtained for 875 mothers. Mean dietary quality score for this sample of mothers was zero (SD: 1), mean age was 32 years and most mothers (81%) had one or two children. One fifth of mothers (21%) reported never eating takeaway and 39% reported never eating fast food.

The median time to closest supermarket using reported mode of transport to main supermarket was one minute, with time ranging from under one minute to 25 minutes (IQR: 1, 2). Time to closest supermarket was weakly related to mothers' home neighbourhood deprivation (r=-0.07, p=0.048), with longer travel times calculated for mothers' living in more deprived neighbourhoods.

As information about travel mode used to access fast food and takeaway outlets was not known road network distance rather than time formed the proximity measure for these outlets. The median road network distance to closest fast food outlet and takeaway outlet was 1628 meters (IQR: 1045, 2624) and 547 meters (IQR: 330, 838) meters respectively. Distance to closest fast food or takeaway outlet did not differ according to mothers' home neighbourhood deprivation (both p>0.1). Figure 5-12 shows the distributions of time to closest supermarket, and distance to closest fast food and takeaway outlet.

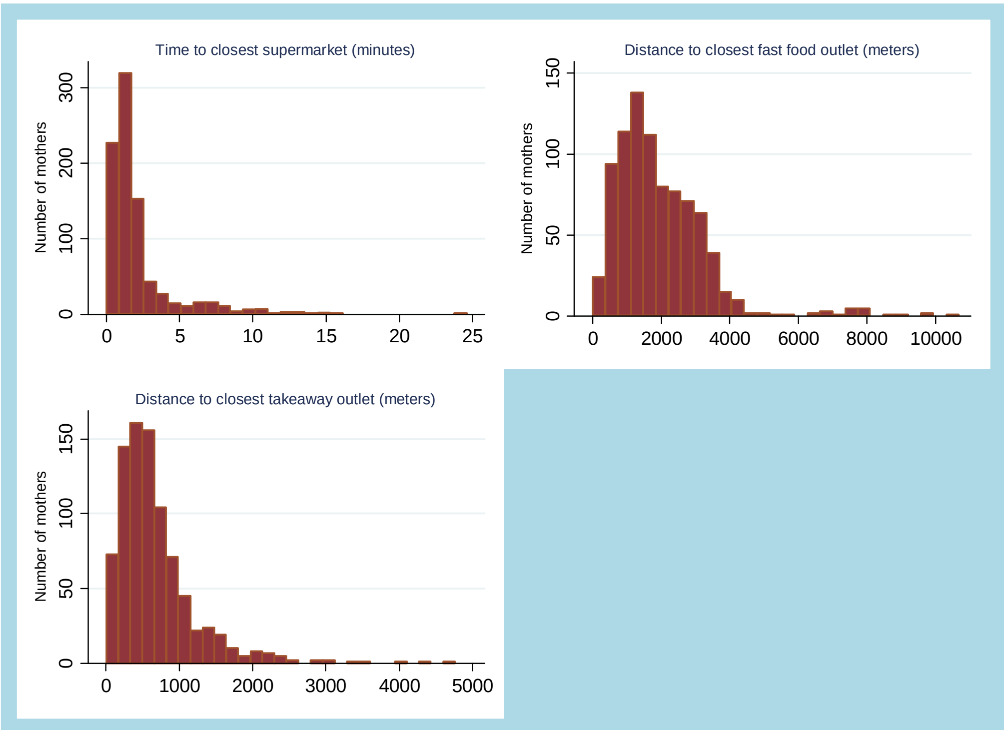


Figure 5-12 Distribution of time to closest supermarket and distance to closest fast food or takeaway outlets from mothers' homes

No significant relationships between logged time and distance proximity measures and quality of diet were observed, nor was distance to closest takeaway outlet associated with takeaway intake (p>0.1). Distance to closest fast food outlet was weakly associated with fast food intake (OR=1.2; 95% CI: 1.00, 1.47) however the relationship attenuated after adjustment for covariates (OR=1.2; 95% CI: 0.98, 1.47) (Table 5-8).

Table 5-8 Multivariable regression analyses of distance to closest fast food outlet from mothers' homes and their fast food intake

	Fast food intake[a] **OR (95% CI)**	p-value
Logged distance to closest fast food outlet	1.20 (0.98, 1.47)	0.08
Exams (7 groups)	0.75 (0.67, 0.84)	<0.001
Age (years)	0.96 (0.93, 0.98)	0.002
Neighbourhood deprivation (quintiles)	0.87 (0.78, 0.98)	0.03

[a] Fast food intake categorised as never/≥1 a month

5.3.2.5 Activity space – proximity to mothers' main food stores

The majority of mothers (59%) drove themselves to their main food stores and a smaller numbers of mothers reported obtaining a lift from someone else or walking (14% and 12% respectively). The median time to main food store according to mothers' reported modes of transport was five minutes (IQR: 4, 9). Under one minute was the quickest trip and the longest time was 66 minutes (Figure 5-13).

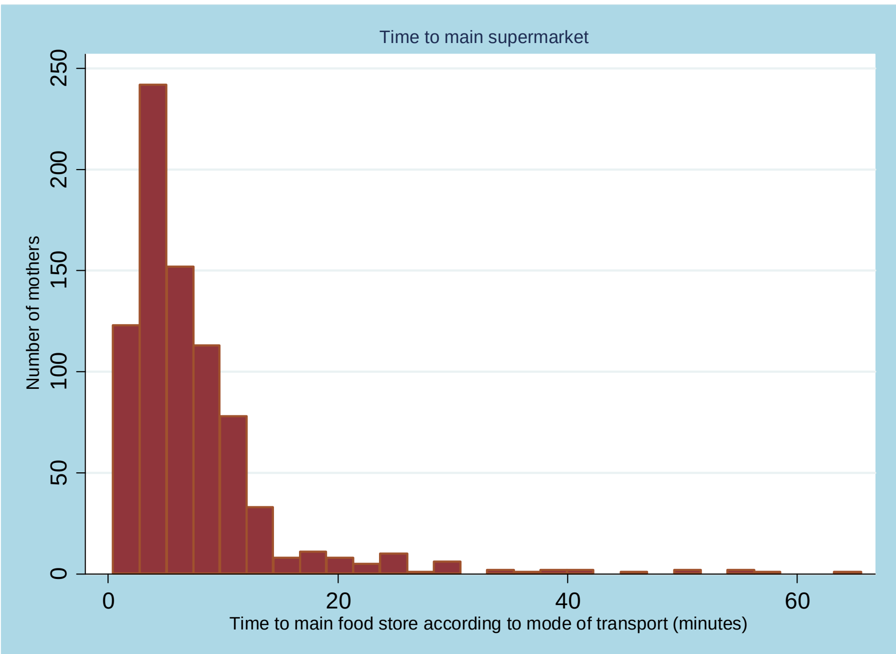


Figure 5-13 Distribution of time to main food store from mothers' homes

Mothers who relied on public transport or cycled to their main supermarket took the longest amount of time, followed by mothers who walked (Table 5-9). Mothers who had car transport had a considerably quicker trip to their main supermarket. Time to main supermarket was quicker for mothers living in more affluent neighbourhoods (r=-0.1, p=0.02).

Table 5-9 Median time (minutes) to main supermarket by mode of transport

Mode of transport to main store	Median	(IQR)
Walk	13	(8, 23)
Public transport/cycle	18	(13, 25)
Car- lift	5	(4, 8)
Car – drive self	5	(3, 7)
Other	5	(4, 8)

Only 44 mothers (6%) named their closest supermarket as their main supermarket. Mothers who shopped mainly at their closest supermarket had fewer children than mothers who did not (p=0.03) and a greater proportion walked (p<0.001). Differences between dietary quality, age, education or neighbourhood deprivation were not observed (all p>0.1).

Mothers' dietary quality was not associated with logged time to their main food stores (-0.05; 95% CI: -0.14, 0.04).

5.3.2.6 Activity space – environment scores and diet

Individualised activity spaces were created for 852 mothers. Mean dietary quality score for this sample of mothers was 0 (SD: 1), mean age was 32 years (SD: 6) and most mothers (80%) had one or two children. One fifth of mothers (20%) reported never eating takeaway and 38% reported never eating fast food.

Mothers' individualised activity spaces included a one kilometre (0.6 mile) radial buffer around locations they visited frequently. Most mothers (86%) reported four or five locations, the smallest number of locations provided was two (0.2%) and the greatest was six (9%). All mothers provided information about the location of their home and Sure Start Children's Centre. Most mothers (94%) reported the location of their main food shop and general practitioner. Approximately one third of mothers (30%) reported a physical activity location other than their home and 33% of mothers reported a work location (41% of the total sample reported working). Test for trend showed that the number of locations provided did not differ by mothers' educational attainment or neighbourhood deprivation ($r=0.02$, $p=0.5$ and $r=0.05$, $p=0.2$ respectively).

The mean geographical area of mothers' activity spaces was ten square kilometres (SD: 2.6). The smallest area covered was four square kilometres and the largest area was 18 square kilometres. Test for trend showed that the geographical area of mothers' activity spaces was larger for those with higher educational attainment and neighbourhood affluence ($r=0.1$, $p=0.003$; $r=0.2$, $p<0.001$ respectively).

The median healthier food environment score across mothers' activity spaces was 99, with scores ranging from 12 to 445 (IQR: 69, 140). The median less healthy food environment score was 176, with a range from 9 to 810 (IQR: 121, 252). Figure 5-14 presents the distributions of healthier, less healthy and overall food environment scores. The overall food environment scores for mothers' activity spaces had a median of -78, and ranged from -387 to 31 (IQR: -118, -45). Almost all mothers (99%, n=842) had negative food environment scores indicating that the vast majority of mothers had greater exposure to less healthy food outlets than healthier food outlets in their activity spaces.

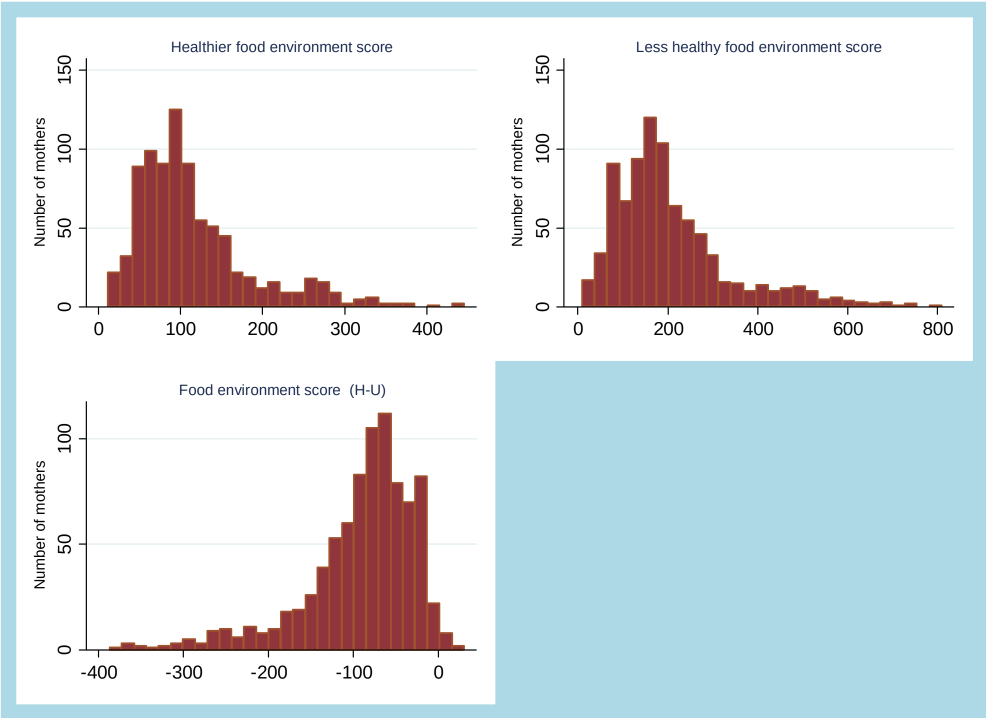


Figure 5-14 Distribution of healthier, less healthy and overall food environment scores in mothers' activity spaces

The median number of fast food outlets in mothers' activity space was five, where counts ranged from zero to 26 (IQR: 2, 7). Takeaway outlets were more abundant with a median count of 28 and range of three to 98 (IQR: 20, 43).

Figure 5-15 shows the relationship between mothers' dietary quality and healthier, less healthy and overall food environment scores in their activity spaces. Dietary quality improved as the food environment score for healthy stores increased. Surprisingly, dietary quality also improved as the food environment score for less healthy stores increased (i.e. greater exposure to less healthy stores). In addition, better overall food environment scores corresponded with poorer dietary quality. Univariate regression analyses confirmed these associations (FES H β=0.02; 95% CI: 0.01, 0.03; FES U β=0.01; 95% CI: 0.003, 0.01; FES H-U β=-0.01; 95% CI: -0.02, 0.002). However, these relationships weakened in multivariate models containing age, educational attainment, number of children, neighbourhood deprivation and geographical area of activity space (Table 5-10).

Associations were not found for fast food or takeaway intake and count of fast food or takeaway outlets in mothers' activity spaces respectively (both $p \geq 0.1$).

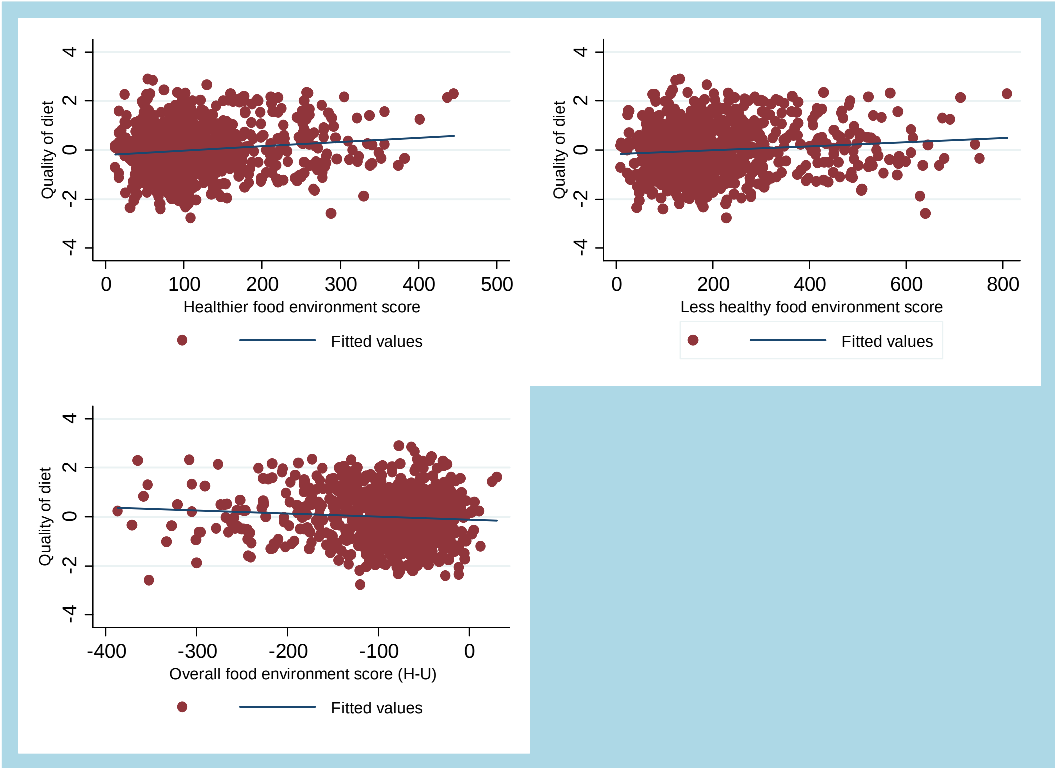


Figure 5-15 Mothers' quality of diet scores according to healthier, less healthy and overall food environment scores in their activity spaces

Table 5-10 Multivariate regression models for the three food environment scores in mothers' activity spaces and dietary quality

	Dietary quality (SD) **β (95% CI)**	p-value
Healthier food environment score (FES H)	0.1 (-0.001, 0.02)	0.08
Education (7 levels)	0.22 (0.17, 0.27)	<0.001
Number of children	-0.09 (-0.16, -0.03)	0.007
Age (years)	0.03 (0.02, 0.04)	<0.001
Neighbourhood deprivation (quintiles)	0.09 (0.04, 0.14)	<0.001
Geographical area of activity space (km^2)	-0.03 (-0.05, -0.002)	0.04
Less healthy food environment score (FES U)	0.005 (-0.00, 0.01)	0.06
Education (7 levels)	0.22 (0.17, 0.27)	<0.001
Number of children	-0.09 (-0.16, -0.03)	0.007
Age (years)	0.03 (0.02, 0.04)	<0.001
Neighbourhood deprivation (quintiles)	0.09 (0.04, 0.15)	<0.001
Geographical area of activity space (km^2)	-0.03 (-0.05, -0.002)	0.04
Overall food environment score (FES H-U)	-0.01 (-0.02, 0.00)	0.07
Education (7 levels)	0.22 (0.17, 0.27)	<0.001
Number of children	-0.09 (-0.16, -0.03)	0.007
Age (years)	0.03 (0.02, 0.04)	<0.001
Neighbourhood deprivation (quintiles)	0.09 (0.04, 0.15)	<0.001
Geographical area of activity space (km^2)	-0.03 (-0.05, -0.002)	0.04

5.3.2.7 Activity space – variety of food outlets and diet

The median variety of supermarkets across 852 mothers' activity spaces was three (IQR: 3, 4). There was little variation in takeaway outlet variety across mothers' activity spaces with 99% of mothers having a choice of four different types of takeaways. Figure 5-16 presents these distributions.

Univariate regression analysis of mothers' dietary quality and supermarket variety in her individualised activity space did not show an association (p>0.1). The relationship between dietary quality or takeaway intake and variety of takeaway outlets was not assessed due to the lack of variability.

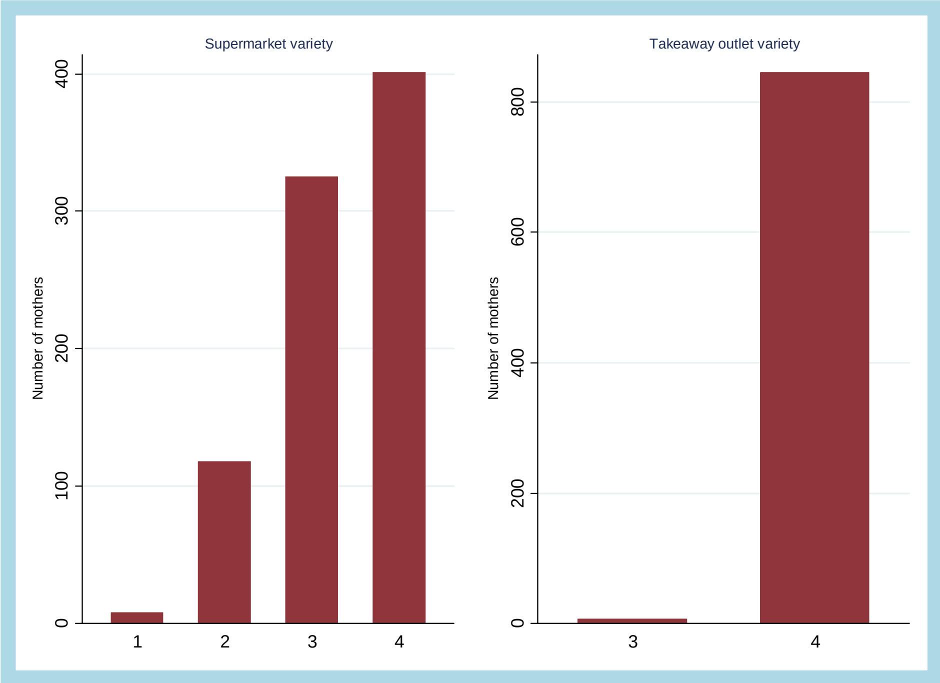


Figure 5-16 Variety of supermarkets and takeaway outlets across mothers' activity spaces

5.3.3 AIM 3: Is there a modification effect of education on community nutrition environment exposure and dietary outcome associations?

In this section, hypothesis three is assessed. The moderation effect of three levels of educational attainment on residential and activity space exposure and dietary behaviour associations are tested. Initially, exposures are described according to mothers' levels of educational attainment.

5.3.3.1 Density, variety and proximity of food outlets in home neighbourhood and dietary inequalities

Mothers with high educational attainment had greater healthier food environment scores for their home LSOA than mothers with mid or low educational attainment (p=0.05); a similar but weaker relationship was observed for count density of healthier food outlets (p=0.07). Other food environment exposures within mothers' home neighbourhoods did not vary significantly by level of educational attainment (Table 5-11).

Effect modification of level educational attainment was tested to assess differences in environmental exposure and dietary outcome associations by a covariate known to be attributed with dietary inequalities. Evidence of an interaction between education and environmental exposure was considered below 10% significance (p<0.1).

Table 5-11 Residential food environment exposures by level of educational attainment

	Educational attainment			
	Low (≤GCSE) n=323	**Mid** (A-level/HND) n=305	**High** (Degree) n=237	
	Median (IQR)			p-value[a]
Residential food environment exposures				
Healthier count density	0 (0, 1)	0 (0, 1)	0 (0, 1)	0.07
Less healthy count density	1 (0,3)	1 (0,3)	1 (0,3)	0.6
Overall count density (H-U)	-1 (-2, 0)	-1 (-2, 0)	-1 (-2, 0)	0.8
FES H - LSOA	0 (0, 4.9)	0 (0, 4.9)	0 (0, 5.3)	0.05
FES U - LSOA	1.6 (0, 9.3)	1.6 (0, 7.7)	2.7 (0, 9.3)	0.4
FES H-U - LSOA	-1.1 (-6.9, 0)	-1.1 (-6, 0)	-1.1 (-5.5, 0)	0.6
Variety of supermarkets	0 (0, 1)	0 (0, 0)	0 (0, 1)	0.5
Variety of takeaway outlets	0 (0, 2)	0 (0, 2)	0 (1, 2)	0.3
Closest supermarket (min)	1 (0.8, 2)	1 (0.8, 2)	1 (0.8, 2)	0.4
Closest fast food outlet (m)	1704 (1122, 2669)	1655 (1097, 2598)	1522 (937, 2575)	0.15
Closest takeaway outlet (m)	546 (315, 779)	546 (336, 841)	547 (356, 886)	0.14

[a]Spearman test for trend across three levels of education

Evidence for effect modification by level of educational attainment was observed for four variables: overall count density and overall food environment scores within residential LSOA (both p=0.07), time to closest supermarket (p=0.07) and distance to closest fast food outlet (p=0.05). For all interactions, differences were identified between low and high levels of educational attainment.

Stratified analyses identified consistent variations in the direction and strength of exposure-outcome associations between mothers with low and high levels of education. Overall count (H-U) and food environment scores (FES H-U) showed that among mothers with degrees, those with healthier neighbourhood environments tended toward better dietary quality (count β=0.01; 95% CI:-0.04, 0.06; FES H-U β=0.03; 95% CI: -0.1, 0.2). However, among mothers with the lowest educational attainment those exposed to healthier neighbourhood environments had poorer dietary quality (count β=-0.06; 95% CI:-0.12, -0.001; FES H-U β=-0.2; 95% CI: -0.3, -0.003). Associations between count density of healthier food outlets and healthier food environment scores were also stronger for mothers with high and mid educational attainment levels than for mothers with low educational attainment (Table 5-12).

Table 5-12 Univariate regression models of healthier count density and healthier food environment scores (FES H) and dietary quality stratified by educational attainment

	Dietary quality (SD) **β (95% CI)**	p-value
Low educational attainment (≤GSCE)		
Healthier count density	0.01 (-0.05, 0.8)	0.65
FES H - LSOA	0.03 (-0.1, 0.2)	0.66
Mid educational attainment (A level/HND)		
Healthier count density	0.05 (-0.003, 0.1)	0.06
FES H - LSOA	0.1 (0.01, 0.2)	0.04
High educational attainment (Degree)		
Healthier count density	0.05 (0.00, 0.1)	0.05
FES H - LSOA	0.1 (-0.01, 0.2)	0.06

Stratified analyses of proximity measures also revealed discrepancies in exposure-diet associations between mothers with low and high educational attainment levels. Living further from a fast food outlet showed a trend toward better dietary quality for mothers with low educational attainment (β=0.05; 95% CI:-0.1, 0.2), but was associated with poorer dietary quality among mothers with high educational attainment (β=-0.16; 95% CI:-0.31, -0.01). Similarly, while increasing time to closest supermarket from home showed a trend toward poorer dietary quality among mothers with a low educational attainment (β=-0.05; 95% CI:-0.16, 0.05), among mothers with high educational attainment dietary quality improved (β=0.1; 95% CI:-0.03, 0.22).

5.3.3.2 Density, variety and proximity of food outlets in mothers' activity spaces and dietary inequalities

The mode of transport mothers used to access their main supermarket differed across the three levels of education ($p<0.001$). Higher numbers of mothers with low educational attainment reported walking, taking public transport or relying on friends or family for a lift to their main supermarket (Table 5-13).

Table 5-13 Mode of transport to main supermarket by level of educational attainment

	Educational attainment			
	Low (≤GCSE)	**Mid** (A-level/HND)	**High** (Degree)	
Mode of transport to main supermarket	n			**Total** n (%)
Walk	43	36	23	102 (12)
Public transport/cycle	23	8	3	34 (4)
Car - lift	68	30	21	119 (14)
Car - drive self	156	204	152	521 (59)
Other	22	30	43	95 (11)
Total n (%)	312 (36)	308 (36)	242 (28)	862 (100)

Table 5-14 presents environmental exposures within individualised activity spaces by mothers' educational attainment. Geographical area (km^2) of activity spaces for mothers with the lowest educational attainment were smaller than for mothers with higher educational attainment. Healthier and less healthy food environment scores were both greater for highly educated mothers than for mothers with mid or low educational attainment. Mothers with high educational attainment had the poorest overall food environment scores and the highest counts of fast food and takeaway outlets within their activity spaces compared to mothers with lower educational attainment. Time to main supermarket, and variety of supermarkets and takeaway outlets did not vary by level of educational attainment.

Table 5-14 Activity space food environment exposures by level of educational attainment

	Educational attainment			
	Low (≤GCSE) n=307	**Mid** (A-level/HND) n=298	**High** (Degree) n=234	
	Median (IQR)			p-value[a]
Individualised activity space environmental exposures				
Main supermarket (min)	6 (4, 10)	6 (4, 9)	5 (4, 9)	0.2
FES H	94 (65, 127)	92 (66, 129)	115 (72, 166)	<0.001
FES U	165 (119, 229)	166 (117, 236)	199 (134, 302)	0.003
FES H-U	-74 (-107, -45)	-77 (-111, -42)	-85 (-134, -49)	0.08
Count of fast food outlets	4 (2, 6)	4 (2, 6)	5 (3, 7)	0.004
Count of takeaway outlets	25 (20, 40)	27 (19, 42)	35 (22, 48)	0.001
Variety of supermarkets	3 (3, 4)	4 (3, 4)	3 (3, 4)	0.4
Variety of takeaway outlets	4 (4, 4)	4 (4, 4)	4 (4, 4)	0.6
Geographical area (km^2)	9.4 (8, 11)	10 (8, 12)	9.9 (8, 12)	0.048

[a]Spearman test for trend across three levels of education

When testing the moderating effects of education on activity space exposures and dietary outcomes, strong evidence of an interaction was identified between educational attainment and overall food environment score of activity space (p=0.04).

Stratification by educational attainment revealed consistent differences in the direction and strength of exposure-diet associations between mothers with low and higher educational attainment. Overall food environment scores showed that poorer environments were associated with better dietary quality among mothers with degrees (β=-0.02; 95% CI:-0.04, -0.004). However, among mothers with the lowest educational attainment this relationship was in the opposite direction, indicating a trend towards better quality diets for mothers exposed to healthier environments (β=0.004; 95% CI:-0.01, 0.02). Similar trends were observed for healthier and less healthy food environment scores. Higher less healthy food environment scores tended toward poorer dietary quality for mothers with low educational attainment (β=-0.0003; 95% CI:-0.01, 0.01) but were associated with better dietary quality among mothers with high educational attainment (β=0.01; 95% CI: 0.001, 0.02). Larger food environment scores for healthier food outlets tended towards better dietary quality among mothers in each of the three levels of educational attainment, though associations were strongest for mothers with the highest educational attainment (β=0.01; 95% CI: 0.00, 0.03). In addition, stratified analyses of time to main supermarket showed a trend for increasing time relating to poorer dietary quality among mothers with low educational attainment, but better dietary quality among mothers with mid and high educational attainment (all $p>0.1$).

5.4 Discussion

5.4.1 Summary of findings

The community nutrition environment across the study area and mothers' activity spaces was characterised by an overwhelming presence of less healthy food outlets. Measures of overall count density (H-U) and food environment scores (FES H-U) showed that no more than one fifth of LSOAs had positive values, which indicates greater access to healthier food outlets. Food environment scores for mothers' activity spaces revealed that only 1% of mothers were exposed to healthy community nutrition environments in their day-to-day activities. These results suggest abundant exposure to less healthy foods in both administrative and individualised areas.

The results presented in this chapter provide some support for hypothesis one: that disadvantaged neighbourhoods have significantly poorer community nutrition environments than more affluent neighbourhoods. Analyses of overall count density and food environment scores showed that more affluent LSOAs were more likely to have neutral or better access to healthier food outlets than more deprived LSOAs. The count density and food environment scores for healthier outlets were higher in more deprived neighbourhoods, but the counts and scores for less healthy outlets were also higher in more deprived neighbourhoods leading to the more favourable results in more affluent areas.

Results for variety measures mirrored this trend and showed a higher choice, of both supermarkets and takeaway outlets, in more deprived neighbourhoods.

There was some support for hypothesis two: that community food environment exposures are associated with mothers' dietary behaviours. A ten point increase in exposure to healthier food outlets (an additional two small supermarkets or one green grocer) in a mother's home neighbourhood and activity space was associated with improved dietary quality equivalent to eating green salad vegetables up to four times more per week. However, some access measures showed associations in unexpected directions. Dietary quality improved with increased exposure to less healthy food outlets, though the effect on diet was weaker than healthy outlets particularly in mothers' activity spaces. Overall food environment scores in mothers' activity spaces showed that increased exposure to healthy food outlets related to poorer dietary quality but the effect size was small. Mothers with a greater choice of takeaway outlets within their home neighbourhood had slightly better dietary patterns than mothers with fewer choices and mothers who lived further from fast food outlets were more likely to consume fast food.

There was some support for hypothesis three: that mothers' levels of educational attainment have a moderating effect on associations between community nutrition environment exposures and their dietary behaviours. Healthier overall food environment scores for mothers' activity spaces were associated with poorer dietary quality among mothers with degrees but related to better quality diet among mothers with low educational attainment. Furthermore, living further from a fast food outlet tended toward better dietary patterns among mothers with a low educational attainment but poorer dietary quality among mothers with degrees. Longer time to closest and main supermarket showed trends toward poorer dietary quality among mothers with a low educational attainment, but better dietary quality among mothers with a high educational attainment. In addition, increased exposure to healthier food environments showed stronger positive associations with dietary quality among mothers of high and mid education than those with low education. While these results need to be viewed with caution, as not all associations were strong, they do provide some indication that the community nutrition environment affects mothers differently according to their level of educational attainment. The smaller geographical area of activity spaces used by mothers with low educational attainment may also suggest that residential exposures are more important to this group than those with higher levels of education.

5.4.2 Comparison with previous research

The dominance of less healthy food stores in the community nutrition environment of this study is similar to previous research. A greater density of unhealthy food outlets than healthy food outlets has been shown within counties[247] and per square kilometre[248] in the US. Few studies have conducted extensive examinations of the community nutrition environment with most using proxy outlets, typically supermarkets or fast food outlets, to represent healthier or less healthy environments respectively.[59 75 78] The major limitation of using proxy measures to link the community nutrition environment to dietary or weight outcomes is the bias that is likely to be introduced as a result of misrepresenting true environmental exposures and the subsequent exacerbation or underestimation of associations.[256]

Consistent with hypothesis one, better community nutrition environments were observed to favour more affluent areas in this study, after considering the proportion of healthy to less healthy food outlets. A recent study in the UK also showed that the prevalence of fast food outlets and other unhealthy food outlets increased with area deprivation but at the Middle Super Output Area (MSOA) level, rather than the LSOA level.[257] In contrast to the findings of this chapter, greater counts of other food outlets (i.e. restaurants, cafes, speciality stores and supermarkets) were identified in more affluent neighbourhoods. The differing results may partly be due to the different area measure. MSOAs are larger than LSOAs, and have a population density of approximately 7500 compared to 1500. The results of this chapter showed that the second most deprived and middle deprivation LSOAs contained the greatest proportion of total food outlets, as well as healthy and less healthy food outlets. This finding is consistent with research from Glasgow which showed greater numbers of total food retailers and food service outlets in middle deprivation and more deprived areas.[99 100 105] The co-location of healthy and less healthy food outlets is consistent with previous research[173 246 248] and highlights the importance of considering both healthy and less healthy outlets in food environment research.

Examination of literature supporting hypothesis two, the community nutrition environment effects dietary behaviour, revealed a number of studies that showed that relationships between density exposures and dietary outcomes weaken or strengthen after adjustment for opposing types of outlets. For example, recent research in the UK found that increased exposure to takeaway and fast food outlets was associated with increased intake of takeaway foods.[252] However, this relationship was dependent on inclusion of supermarket exposure as a covariate. Removal of supermarkets from the analyses resulted in attenuation of the relationship between takeaway exposure and intake. Studies from the US and Canada that measured the proportion of fast food outlets and convenience stores to the proportion of supermarkets and greengrocers (Retail Food Environment Index) within residential buffers[134] or activity spaces[137] did not identify relationships between dietary outcomes and this retail index measure. These findings correspond to the count density results of this chapter that did not identify a link between overall count density (H-U) in mothers' residential LSOAs and their dietary quality. Research from Australia, which created food environment scores for 49 census districts, also found that relationships between healthier or less healthy food environment scores and dietary outcomes weakened or attenuated after addition of the opposite food environment score.[246] Findings in this chapter did not reveal associations between dietary quality and overall food environment scores in mothers' residential LSOAs and a weak association in mothers' activity spaces. The confounding effects of opposing types of food outlets are likely to illustrate patterning in food retailing ecology.

The findings of this chapter provide support for hypothesis two where greater exposure to healthier food outlets related to improvements in mothers' dietary quality. However, this support is tempered by the finding that greater density of less healthy outlets was also associated with better quality of diet, though by a smaller amount. These findings are consistent with previous research where greater density of healthier outlets was associated with better dietary and weight outcomes.[246 248] The unexpected links between less healthy outlets and better diet may be explained by higher commercial investment. Research by Bader and colleagues in the US, showed lower odds of obesity were linked with increased exposure to fast food outlets. In a sensitivity analyses they also found lower odds of obesity with increased exposure to banks. The researchers found that fast food outlets and banks are co-located in areas of high commercial investment. It is likely that the increased commercial investment is positively associated with better behavioural and health outcomes. Commercial investment may improve neighbourhood conditions through mechanisms of increased employment, places for social interaction and concentration of community services and resources.[258] However, in this chapter, associations between improved dietary quality and greater density of healthier food outlets were repeatedly stronger than associations with greater density of less healthy food outlets. These findings may indicate that examining retail investment patterns to identify areas where commercial activity in less healthy food outlets is disproportionately greater than that for healthier food outlets is important, particularly when interested in addressing area-based dietary inequalities. Low-income areas may be seen as undesirable to some retailers due to high crime rates or lack of clientele. Other less healthy retailers, however, may perceive more opportunities because of low rent and cheap labour, and be more willing to trade in these areas.[164]

Providing support for hypothesis three, the results of this study showed that mothers with high educational attainment reside in healthier environments than mothers with low educational attainment. In contrast, activity space exposure to both healthy and less healthy food outlets was greater for more highly educated mothers revealing that their overall exposure was least healthy. This activity space finding is consistent with research from the US[259] and a likely reflection of the larger geographical size of activity spaces for individuals that are more affluent.[172 259] The geographical area of activity spaces was significantly smaller for mothers with low educational attainment in this study. This finding does not reflect differences in the number of activity points, because this number did not vary by level of educational attainment, but rather indicates co-location of points. The environment localised to residential address is therefore likely to be more important to those who are unemployed or are of lower socioeconomic position.[260 261]

Few studies have investigated the moderation effects of education or other markers of dietary inequalities on associations between the community nutrition environment and diet. Healthier food environments had consistently stronger effects on the dietary quality of mothers with higher educational attainment than those with a low educational attainment. In addition, significant interactions between education and overall density, distance to fast food and time to closest supermarket, coupled with the opposing direction of exposure-diet associations provide some indication that mothers with low educational attainment may interact differently with their environment than highly educated mothers. Previous work in Australia showed no association between count of supermarkets or greengrocers within two kilometres of home and fruit and vegetable intake among a sample of women of lower socioeconomic position.[56] However, environmental perceptions may contribute to differences in environmental-diet associations by educational attainment.[53 56 59] The potential mediating role of environmental perceptions is investigated in Chapter 8.

Comparable to the findings in this chapter, other studies have shown that food outlet densities for activity spaces vary considerably from residential densities,[172 173 259] providing further evidence against the sole use of residential measures. Associations between mothers' activity space environment scores and dietary quality weakened after adjustment for individual characteristics but remained below 10% significance. Previous work investigating individualised food outlet density and dietary outcomes have shown a mixture of null and significant associations.[137 172 214 252 259 262] The variation in results across studies may partly relate to the heterogeneous methodologies that have been used. Some studies have included only two locations, typically home and work[214 262] with some including exposures along the travel route between these locations.[263] Other studies have included more data points informed by either travel surveys[173] or three to seven day GPS data.[137 172 259] However, none of these methods provide accurate information about time space mobility (i.e. weighting exposures according to the amount of time spent in each location). Travel surveys or home and work activity space measurements may overestimate exposures in particular locations. GPS data may underestimate or negate regular locations due to the timing of the measurement. New technologies that combine GPS and accelerometer data with travel survey results could provide more nuanced methods of daily mobility patterns and help to eliminate bias in exposure measures.[245 261]

Few studies have investigated how the variety of specific types of food outlets relate to dietary outcomes.[59] This study showed that the variety of supermarkets and takeaway outlets was greater in more deprived neighbourhoods and that better dietary quality was associated with greater variety of takeaways in mothers' home LSOAs but not in their activity spaces. These results provide little additional information to that obtained by the density metrics, and differs to previous research which found the opposite.[73] This difference may be attributed to the limited measure of variety in this study and suggests greater heterogeneity of supermarkets and takeaway outlets than four types. Future research may benefit from further categorisation of 'other takeaways' into, for example, kebab takeaways, pizzerias and chicken takeaways, as has been done in other studies.[246 248]

This study is one of few studies to calculate proximity to supermarket by travel time using reported mode of transport. A high proportion of mothers (73%) reported going to their main supermarket by car, which was a higher percentage than research from Philadelphia (61%).[133] The median travel time to main supermarket of 5 minutes was similar to previous travel time estimates that used population weighted centroids or supermarkets as base locations.[92 141] Mothers who reported their travel mode as walking (12%) took nearly three times longer to travel to their main supermarket than mothers who drove. A greater proportion of mothers with low educational attainment reported walking than other mothers. Time to main supermarket however showed no relationship with dietary quality. Research from the US also found that road network distance to main food store was not associated with fruit and vegetable consumption, nor did mode of transport relate to fruit and vegetable intake.[133]

Median travel time to closest supermarket of one minute was considerably quicker than time to main supermarket and only a very small proportion of mothers reported using their closest supermarket regularly. These findings may be due to the inclusion of small supermarkets in the exposure measure and represent their rapid increase in the UK in recent years.[264 265] This sample of mothers is likely to follow grocery shopping trends in the UK and primarily shop at larger supermarkets.[266 267] Dietary quality was not associated with time to closest supermarket. This finding differs from research in Ireland[120] but is consistent with the majority of proximity investigations.[59 78] The irregularity of proximity metrics being associated with diet questions the extent to which these measures are required in addition to density metrics. Previous authors have concluded that density and proximity measures provide consistent representations of food access.[117 268] The lack of significant findings for a relationship between proximity measures and diet in this study also indicate little need for both measures. The small number of mothers that used their closest supermarket also highlights the error in most proximity measures which assume that food outlets closest to home are used most often. Moreover, community nutrition environment assessments address only a primary level of exposure.[247] Another level of exposure, the consumer nutrition environment, occurs within food outlets and further affects food selection.[175] Investigations of shopping habits in the US have shown that proximity to home or work, as well as in-store characteristics, prompt choice of main food store.[269 270] Individuals are also more likely to shop at supermarkets closest to home if they offer healthier in-store environments.[271] The relationship between consumer nutrition environment of mothers' main food stores and their dietary quality is presented in Chapter 6.

5.4.3 Strengths and limitations

A major strength of this study was the use of food environment scores to weight food outlets according to their potential contribution to healthy or less healthy dietary behaviours. The inclusion of count density and food environment scores for LSOAs provided a comparison of the outcomes of these two measures. The results for the two measures were similar for the LSOA quintile comparison. However, the associations between the two measures and dietary behaviours differed, where the food environment scores showed a stronger relationship with diet. This findings suggests that the food environment scores provided a more nuanced assessment than count measures because it discriminates between different store types. For example, the effect of discount supermarkets on dietary choices was not equal to that of large or premium supermarkets, or butchers equivalent to greengrocers. Including both measures in the LSOA analyses was necessary to ensure confidence in the activity space analyses and so others may feel confident using this metric in the future. Only one previous study has used food environment scores.[246] The current study made advances on this prior work by calculating scores for activity spaces and used a measure of overall dietary quality rather than fast food consumption as the outcome. By capturing a broad range of food sources around both home and non-residential locations including work, children's centres and main supermarket, this study is one of few to provide comprehensive assessment of food retail exposure[272] and its relationship with dietary quality. However, the boundaries of activity spaces used in this study were clear-cut and more accurate assessments of food outlet density may be possible by combining the food environment score weightings with kernel density estimations, which allow for fuzzy outer boundaries.[71 243]

Further strengths of this study include the temporal connection between the surveying of food outlets and mothers, the use of continuous exposure measures and consideration of both residential and activity space exposure measures. Temporal mismatch of food outlet and dietary data is common in food environment research.[71] The overlap in data collection time points in this study provides greater accuracy than previous work. The use of continuous exposure measures is another strength of this study because information about the intensity of exposures was not lost as it can be in categorisation. However, the log transformation that was necessary for the positively skewed proximity measures does make interpretation of these measures more challenging. In addition, the dichotomisation of takeaway and fast food intake may have contributed to the lack of associations for these measures. It may be more appropriate to group intake into three categories.[246] Sensitivity analyses showed that using an alternative binary cut-off point[214] did not alter the results.

Including assessments of community nutrition environment exposures for residential and activity space areas enabled the identification of trends and differences across these geographical metrics. For example, the strength of associations between food environment scores and diet varied across LSOAs and activity spaces and proximity measures indicated little relevance of residential neighbourhood on choice of supermarket. These results provide further evidence that environmental exposures are erroneously missed in residentially focused investigations and support for the use of activity space assessments in future community nutrition environment research.

While the area-level differences observed in this study may point towards the need for improved access to healthier food outlets in more deprived areas, potential residential selection bias and methodological limitations of using LSOA boundaries hinder the interpretability of these results. It is possible that mothers of lower socioeconomic position chose to live in areas with greater numbers of less healthy food outlets. Alternatively, those with higher socioeconomic position moved to more affluent neighbourhoods to reduce their exposure to less healthy outlets, thus confounding the observed associations.[273] In addition, administrative units, such as LSOAs, assume that all residents residing within these boundaries interact with their environment in a similar way. The use and perception of neighbourhood is heterogeneous. Even among individuals residing in the same building, perception of neighbourhood differs and does not often match the predefined administrative boundary.[274] In addition, environmental exposures are measured equally for residents whether they live in the centre or near the unit's boundaries, and barriers, such as railways or rivers, and resources located in adjacent units are not considered.[242 275]

This study had a number of limitations to the activity space calculations used, specifically selective daily mobility bias, space and time assumptions and the size of the buffer applied. Selective daily mobility bias may have been introduced because factors that can influence both a mother's choice of main food store and her dietary behaviours may not have been measured.[245 261] It is likely that mothers select particular stores in particular locations due to taste and other personal preferences which may have resulted in spurious clumping or stratifying of mothers. In addition, only mothers' main food store was measured, which may have overestimated the effect of the area surrounding this store and negated top-up shops, which may be used more regularly. As mentioned previously, this study also assumed mothers' visited each of the reported locations equally and did not include accurate space and time adjustments to provide more realistic exposure measures.[261] For example, mothers may only frequent their local children's centre once a month for a particular activity but go to work several times a week. The buffer distance selected in this study may have been too large. Previous research has applied a 400-500 meter (0.25 to 0.31 mile) buffer around GPS or travel survey locations.[137 172 252] The larger buffer applied in this study may have over exaggerated exposure measures, diluting the strength of associations.

There are a number of additional limitations of this work. The cross-sectional and observational design can suggest associations but cannot determine causality. The collection of longitudinal data to measure changes in dietary patterns and the community nutrition environment could overcome this limitation. The analyses in this chapter did not account for the full range of factors that may be associated with variations in food outlet distribution or dietary quality and may have missed important confounding variables, such as crime rate, traffic safety, taste preferences or cooking skills. Clustering of mothers by LSOA or council area was also not accounted for, and a larger sample size may have provided greater statistical power to show stronger evidence of associations particularly for analyses stratified by level of educational attainment.

5.4.4 Policy and research implications

With the devolution of public health responsibilities to local governments across England there is greater scope for action to improve community nutrition environments and reduce health inequalities. Public Health England, in collaboration with the Local Government Association, have released guidance encouraging local authorities to take action where appropriate to limit the number of takeaways in their areas (especially near schools).[276] Some local authorities have already taken action in this area. For example, Waltham Forest Borough Council have introduced planning laws to ban outlets selling hot takeaway food within 400 meters (0.25 miles) of schools, as well as limit the clustering of takeaways within their borough.[252] The results of this study provide some evidence to encourage local governments within Southampton, Portsmouth and Hampshire to introduce zoning or planning policies, or provide incentives to the proprietors of healthy food outlets to improve the ratio of healthier to less healthy food outlets. Such policies would be particularly beneficial in more deprived areas. Financial constraints on local authorities may prevent the introduction of such policies or laws. Consequently, evidence from natural experiments[272] or intervention research that show financial benefits of making such changes or support in the form of central government grants[277] could provide further impetus for councillors to take action and make healthier food choices easier for their electorate.

In addition to taking opportunities to evaluate natural experiments and conduct intervention studies, future research priorities include: *i)* continuing efforts to accurately measure community nutrition environment exposures using both GPS and travel survey data and metrics to weight food outlet types and locations; *ii)* assessing changes in food outlet exposures and dietary outcomes over time; *iii)* and further exploring the moderating effects of markers of dietary inequalities on environmental exposures and dietary outcomes. A better understanding of the environment within food outlets and how psychosocial factors mediate relationships between environmental exposures and diet is also needed.

5.5 Conclusion

This chapter explored three community nutrition environment exposures (density, proximity and variety) within mothers' residential neighbourhoods and activity spaces. Comprehensive assessment of food outlet density showed an overwhelming dominance of less healthy food outlets across all geographical areas investigated. Prevalence of healthy and less healthy food outlets increased with area deprivation but more affluent areas had healthier food environments overall. There was some evidence that greater access to healthier food outlets was related to better dietary quality. Two additional small supermarkets for example, related to eating green salad vegetables up to four times more per week. However, greater access to less healthy outlets also showed some association with better dietary quality. There was a suggestion from the results that community nutrition environment exposures have differing effects on mothers with a low educational attainment and those with higher educational attainment. Mothers with low educational attainment are also more reliant on outlets in their residential neighbourhood. Local authorities could improve the imbalance in the community nutrition environment through planning restrictions, particularly in more deprived areas.

Measures of accessibility do not necessarily imply food selection or consumption. There is a need to better understand how factors within food outlets affect food selection and how psychological variables interact with the relationship between environmental exposures and diet. Chapter 6 describes the consumer nutrition environment of supermarkets and convenience stores, and presents how the factors within mothers' main food stores relate to their dietary quality.

Chapter 6 Consumer nutrition environment

The consumer nutrition environment has been conceptualised as in-store factors that influence food shopping behaviour, such as the availability, price, promotion, placement, variety and quality of products. As identified in Chapter 2, current empirical characterisations of the consumer nutrition environment are limited mainly to food price and availability. Research measuring the full-range of in-store environmental factors concurrently is limited and few studies have investigated the relationship between the environment of individuals' main food store and their quality of diet. Examining this relationship will provide greater understanding of the environmental determinants of diet and dietary inequalities. This chapter describes the development of a summary score of 'healthfulness', incorporating nine in-store factors that can influence food choices. The results section describes differences between the consumer nutrition environment of seven types of supermarkets and convenience stores in the study area. Results are also presented against the first three hypotheses of this study that are expressed in terms of the consumer nutrition environment:

1. **Disadvantaged neighbourhoods have significantly poorer consumer nutrition environments than more affluent neighbourhoods.**
2. **Consumer nutrition environment exposures are associated with mothers' dietary behaviours.**
3. **Mothers' levels of education have a moderating effect on associations between consumer nutrition environment exposures and their dietary behaviours.**

In the discussion, the findings are summarised and compared with previous research, and the policy and research implications are addressed.

6.1 Background

The consumer nutrition environment has been conceptualised as factors that influence food choice within stores, such as product availability, variety, price, quality, promotions, placement and nutrition information. Assessment of the consumer nutrition environment in retail food stores, such as supermarkets, is important because of the global convergence of shopping habits away from smaller specialty stores towards stores that stock a wider range of products.[265] Consumers' dietary choices are affected by the products sold, prices charged and promotional strategies used in their main food stores.[264] More healthful environments could be defined as those that promote healthful food choices, such as selling good quality healthy foods or placing them in prominent locations to prompt purchasing.

A number of tools to assess the consumer nutrition environment have been developed,[60 278] with the vast majority for use in the US. Few tools have undergone reliability or validity testing, or provide the level of detail required to assess linkages between retail food environments and dietary behaviour.[60 72 279] A great proportion of tools measure two in-store factors: availability and price.[60 278 280] A smaller number of tools have assessed variety and/or quality of fruit and vegetables,[51 91 281] in-store advertising and/or product placement,[74 279 282] or price promotions and nutrition labelling.[283]

Some tools enable the creation of a composite score of the in-store environment including the widely used Nutrition Environment Measures Survey in Stores (NEMS-S)[281] and the *CX³* Food Availability and Marketing Survey;[282] both developed for the US context. The NEMS-S scores and *CX³* store scores incorporate three in-store factors: availability of healthier products, fruit and vegetable quality and price or in-store advertising. The Health Responsibility Index was developed to measure nine supermarkets in the UK.[283] This index measured sodium content, nutrition labelling and information, and price promotions on twelve frequently consumed processed products known to be high in sodium. Composite scores incorporating several consumer nutrition environment factors can provide an overall evaluation of the store environment and have helped communities and policy makers in the US identify priority areas and inform interventions.[282] However, previous scores have not included more than three in-store factors or included standardised measures that can statistically assess relationships between diet and in-store environments or monitor relative change in environment over time.

There is a gap in the literature for a comprehensive tool that concurrently measures multiple in-store factors on healthy and less healthy products, particularly outside the US. Such a tool could provide a thorough evaluation of differences in the consumer nutrition environment by store type and neighbourhood deprivation and may identify target sites for interventions.

The literature portrays supermarkets as offering the healthiest shopping environment for consumers and small convenience stores the poorest.[284 285] These broad categories, however, cover a heterogeneous group of stores.[264 286] In the UK, there are four different types of supermarkets that target different consumer groups[264 265] and are likely to offer different shopping environments. Research that excludes the full range of environmental exposures or measures only healthy or less healthy foods may be misrepresenting the food environment within these stores.

As described in the literature review for this thesis (section 2.5.2), there are area based differences in the consumer nutrition environment in the US, but there is no clear trend in other high-income countries. Evidence for associations between dietary behaviours and food availability and price have also been observed in the US. However, few studies have measured exposures of stores where people shop, and evaluation of the relationship between in-store factors and diet in countries outside the US is limited. In-store assessments based on a limited number of environmental factors and foods may be missing important socioeconomic differences. An observational tool that evaluates several environmental exposures of an individual's main food store, and measures foods commonly used to assess dietary disparities may provide a more complete environmental assessment.

This study addresses a gap in the literature by developing a comprehensive consumer nutrition environment assessment tool to measure the healthfulness of supermarkets and convenience stores in the UK. More specifically this chapter aims to:

i) Examine differences in the overall healthfulness, and nine consumer nutrition environment variables, of supermarkets and convenience stores across English quintiles of LSOA deprivation (hypothesis one)
ii) Determine the relationship between the overall healthfulness, and nine consumer nutrition environment variables, of mothers' main food stores and their dietary behaviours (hypothesis two)

iii) Test the moderation effects of level of educational attainment on consumer nutrition environment exposure and dietary behaviour associations (hypothesis three)

6.2 Consumer nutrition environment methods

6.2.1 Mothers

Participants were mothers who completed the Southampton Initiative for Health follow-up survey whose main food store was located within the study area. Mothers were asked to name the store they used to do their main food shop. Additional questions about age, number of children, highest educational attainment and home postcode were also asked. Home postcode was used to determine residential LSOA deprivation quintile.

6.2.2 Dietary outcome

Quality of diet score, assessed via a validated food frequency questionnaire (FFQ) (section 4.2.2.1), was the primary outcome variable. The FFQ was included in the Southampton Initiative for Health follow-up survey. The creation of the dietary quality score is described in detail in section 4.2.2.1. Positive dietary quality scores indicated better dietary quality and higher intakes of vegetables and wholemeal bread, and negative scores indicated poorer dietary quality and higher intakes of processed meats, crisps and sugar.

6.2.3 Supermarkets and convenience stores

Permission was sought from managers in all supermarkets and convenience stores in the study area (n=606) to complete an audit of the in-store environment. Data were collected from July 2010 to June 2011 to correspond with the timing of the Southampton Initiative for Health follow-up survey. Store categorisation into the seven store types (Table 3-2) was confirmed during data collection. Postcodes were used to identify the LSOA deprivation quintile for each store.

6.2.4 Consumer nutrition environment tool development

A consumer nutrition environment tool was designed to measure nine factors that can affect consumers' food choices. Data on *number of varieties, price, shelf placement, store placement* and *promotion* were collected on seven healthy and five less healthy products. In addition, data on the type of *nutrition information* and availability of a *healthier alternative* were collected for less healthy products. The *quality* of two fruits and four vegetables, and opportunity for *single sale* of the two fruits were also measured. Table 6-1 describes the definitions and measurement scales of the variables included in the tool. Data of fruit and vegetable quality was collected using a published quality indicator.[51] Data on the remaining variables were collected using novel measures.

Table 6-1 Variables measured in the consumer nutrition environment tool

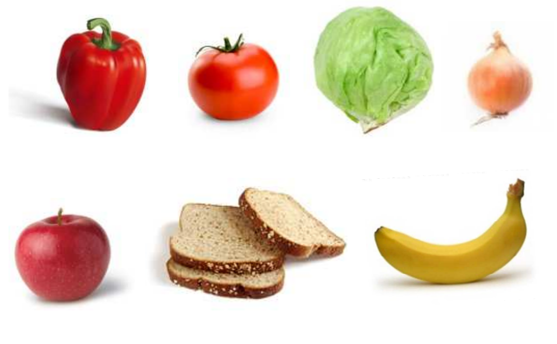
	Variable	**Definition**	**Measurement scale**
I	Variety	The number of different choices within a product range based on: product flavour, product size, fair trade/organic or own-brand/low-cost range	Not available, 1, 2, 3, 4, 5+
II	Price	Price of the cheapest item, £ per portion, for each product	Pound Sterling per portion
III	Promotions	Whether or not the product category was on price promotion	Yes/No
IV	Shelf placement	Where on the shelf the cheapest item for each product was placed	Bottom shelf, other, prominent (eye-level)
V	Store placement	Part of the store where the cheapest item for each product was placed	Inconspicuous, noticeable, prominent
VI	Quality	Level of quality of the two fruit and four vegetables	Poor, medium, good[51]
VII	Healthier alternative	Whether or not a healthier option was available for less healthy products	Yes/No
VIII	Nutrition information	The type of nutrition information available on the cheapest item for each product	None, other[a], back-of-pack, front & back of pack
IX	Single fruit sale	Whether or not single sale of the two fruit measured was possible	Yes/No

[a] For example recipe card

The 12 food products were: peppers, tomatoes, lettuce, onions, apples, bananas, wholemeal bread, white bread, oven chips, sausages, crisps and sugar (Table 6-2). These products were selected because they discriminate between better and poorer dietary patterns,[211] are frequently consumed in

England[287] and could be measured in a large survey. The foods selected represent items from short and long FFQs used to determine differences in dietary quality among a number of populations, including women of childbearing age, young children and older adults.[27 211 230 231] These foods represent the UK Department of Health's dietary recommendations and are foods known to contribute to nutrition-related chronic diseases.[26 211] Further information about the selection of the variables and products, the audit tool and survey protocol can be found in Appendices C to F respectively.

Table 6-2 Food products in the consumer nutrition environment tool

Healthier products	**Less healthy products**
peppers, tomatoes, lettuce, onion, apples, bananas, wholemeal bread	oven chips, crisps, sugar, sausages, white bread
	

6.2.5 Consumer nutrition environment tool pilot

A pilot study of the newly developed tool was conducted in stores in Southampton (195 of a possible 198) from July to September 2010. These pilot data provided preliminary results that suggested the data were useful for investigating the consumer nutrition environment. Details of the pilot study findings have been published in a peer-review journal (Appendix G).

In brief, three of the nine consumer nutrition environment variables (*price*, *variety* and *quality* of fruit and vegetables) and availability (yes/no), were assessed by store type and level of neighbourhood deprivation. Larger stores had greater availability, variety, quality and cheaper prices than smaller stores. Availability and median price of healthy products did not differ according to neighbourhood deprivation. However, stores in more affluent neighbourhoods were 11-34% *less likely* to have *low variety* of healthy products and 69-74%

less likely to have *poor quality* fruit and vegetables when compared with stores in the most deprived neighbourhoods.

6.2.6 Healthfulness score development

A composite score of healthfulness was created for each store surveyed, where each of the nine in-store variables (*variety, price, shelf placement, store placement, promotions, quality, healthier alternative, nutrition information* and *single fruit sale*) were weighted equally. Seven steps were taken to create the healthfulness score (Figure 6-1). Individual scores for each of the nine variables were calculated using steps one to four. All scores were constructed such that higher scores represented environments that are more healthful. Principal component analysis and factor analysis were applied in an attempt to weight the nine variables, but no interpretable patterns were identified.

The process of creating the scores involved: *i)* converting *price* measures to pound per portion (using standard portion sizes[288]) and for each store subtracting the mean price of healthy products from the mean price of less healthy products, *ii)* imputing missing values, due to field work error, using the mean value for the variable of that store type, *iii)* creating summed scores for each store for *quality* of fruit and vegetables, *single fruit sale, nutrition information* on and *healthier alternative* of less healthy products, *iv)* creating a score for *variety, shelf placement, store placement* and *promotions* for each store by calculating the difference between the sum of less healthy scores and the sum of the healthy scores, *v)* standardising all scores, *vi)* creating a composite score for each store by summing the nine standardised scores and dividing by nine, and *vii)* standardising the healthfulness scores to have a sample mean of zero (SD: 1). These methods have been published in a peer-review journal (Appendix H).

For stores that sold no healthy items the rounded 99th centile of healthy items was imputed as the mean healthy price score. This value represented the time, travel or health costs consumers could bear for healthy products not being available. Stores with no less healthy items were given a mean less healthy price of zero. Overall, less than 1% of score components were imputed.

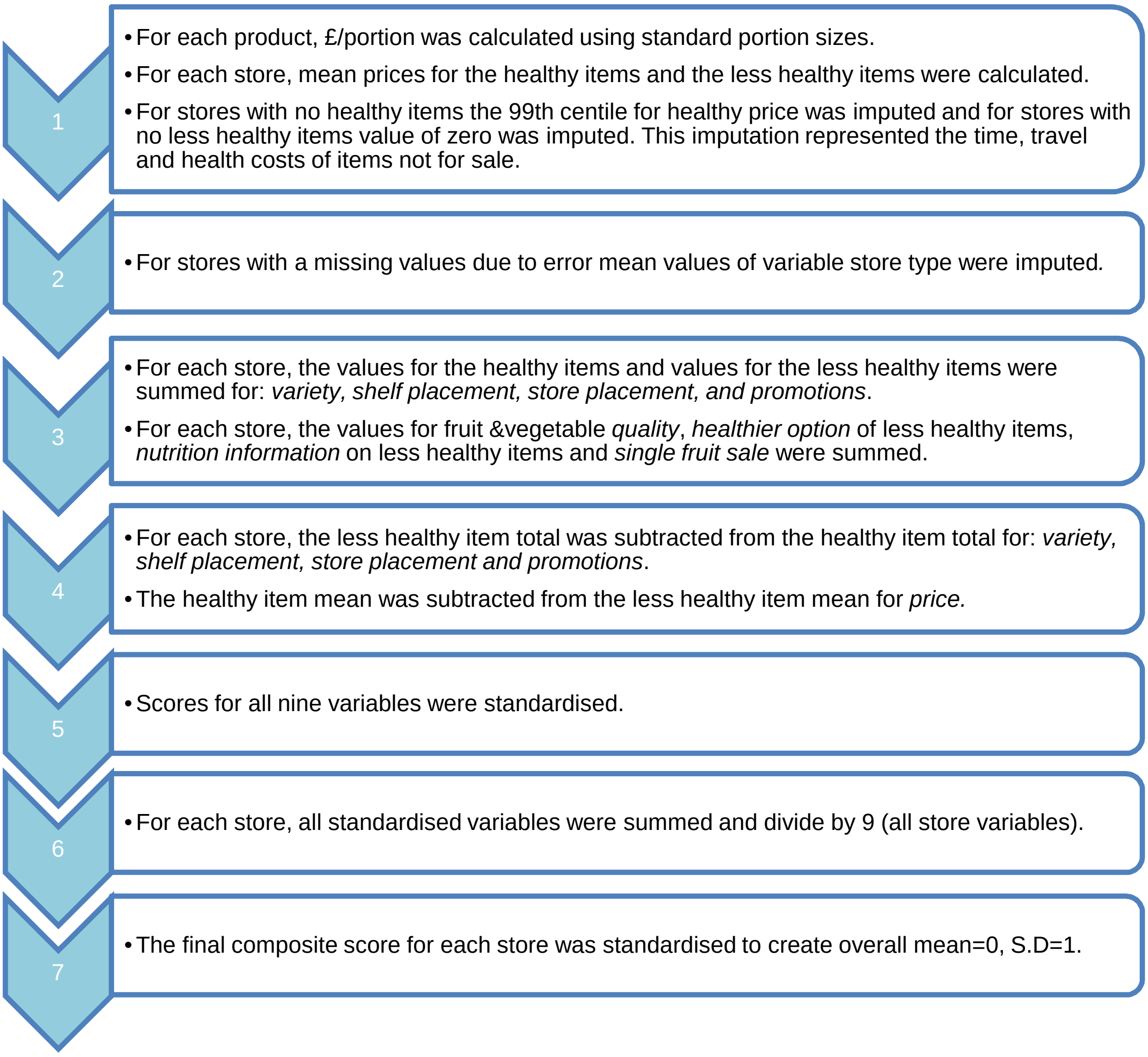


Figure 6-1 Seven step process to create a composite score of healthfulness for supermarkets and convenience stores

6.2.7 Statistical analyses

The distribution of stores, healthfulness scores and in-store variables are presented in tables or box plots. The level of agreement between field workers was assessed by the Kappa statistic on a sample of 14 stores (large supermarket (n=2), discount supermarket (n=1), small supermarket (n=4), 'world' store (n=1), convenience store (n=5), petrol store (n=1)). The relative consistency of *price* responses was assessed using the coefficient of variation: the standard deviation of difference divided by the mean (%). Cronbach's alpha statistic was used to assess the internal consistency of all nine components of the healthfulness score.

To identify differences in healthfulness scores and individual in-store variables by store type and neighbourhood deprivation, analysis of variance was used for normally distributed variables, Kruskal Wallis test for non-parametric variables and Chi squared test for the categorical variable. Spearman test for trend was performed to examine differences in store healthfulness and eight of the individual in-store variables by neighbourhood deprivation. Chi squared test was used to test differences across deprivation quintiles for the categorical variable.

Linear regression was used to examine the relationship between mothers' dietary quality scores and healthfulness of their main food stores. Associations between dietary quality and each of the nine consumer nutrition environment variables were analysed separately using linear regression. A multivariable linear regression model, containing variables univariately associated with dietary quality at the level of $p<0.1$, was then used to explore the relative relationship between each of these variables and dietary quality. Covariates were included in the final model. All covariates were treated as continuous variables to test for trend.

Differences in store type, store healthfulness and each of nine in-store variables across three levels of educational attainment were assessed using Spearman correlation to test for trend for continuous variables. An interaction term for three levels of educational attainment and each exposure variable were added to all regression models to assess whether educational attainment moderated the relationship between dietary outcomes and the consumer nutrition environment. Models were then stratified to identify the separate relationships for low, mid and high education groups. An interaction term for store type and healthfulness score was added before running models stratified by store type. Step-wise backward elimination regression models were used to adjust for covariates, including age, number of children, store type and level of neighbourhood deprivation.

6.3 Consumer nutrition environment results

The response rate for stores across the study area was 99% (601 of a possible 606). Four convenience and two 'world' stores refused to take part in the study. The median time taken to complete the audit in each store, across the

601 stores surveyed was 11 minutes (IQR: 7, 15). Table 6-3 presents the sample by store type and neighbourhood deprivation quintile. The greatest proportion of stores was convenience stores (45%, n=268), followed by small supermarkets (21%, n=127); large supermarkets made up 5% (n=32) of the sample. Most stores were located in the second most deprived and middle deprivation neighbourhoods (26%, n=154 and 28%, n=171 respectively).

Table 6-3 Store sample by store type and level of neighbourhood deprivation

	LSOA deprivation quintiles					Total	
Store type	**Most deprived**	**2**	**3**	**4**	**Least deprived**	**n**	(%)
Premium supermarket	1	5	2	2	0	10	(2)
Large supermarket	7	9	8	4	4	32	(5)
Discount supermarket	8	7	12	3	5	35	(6)
Small supermarket	13	31	34	24	25	127	(21)
‘World’ store	17	20	16	6	2	61	(10)
Convenience store	44	72	77	39	36	268	(45)
Petrol store	10	10	22	8	18	68	(11)
Total n	100	154	171	86	90	601	
(%)	(17)	(26)	(28)	(14)	(15)		(100)

Inter-rater reliability analyses revealed almost perfect agreement[278] for *variety, promotions, healthier alternative, nutrition information* and *single fruit sale* (kappa≥0.85). The inter-rater reliability for *shelf placement* and *store placement* showed substantial agreement (kappa≥0.73). However, *quality* of fruit and vegetables showed moderate agreement between field workers (kappa=0.60). The coefficient of variation observed for *price* was 17%. Figure 6-2 shows the variation in mean price across fieldworkers for each product examined. There was little variation in recorded price for the majority of products. Records for lettuce (product 3) and crisps (product 9) showed greater variation in recorded price across fieldworkers than other products. This variation may be due to the availability of bag and whole lettuce options and crisps being located in multiple locations within stores. The Cronbach’s alpha for the standardised components of the healthfulness score was 0.86.

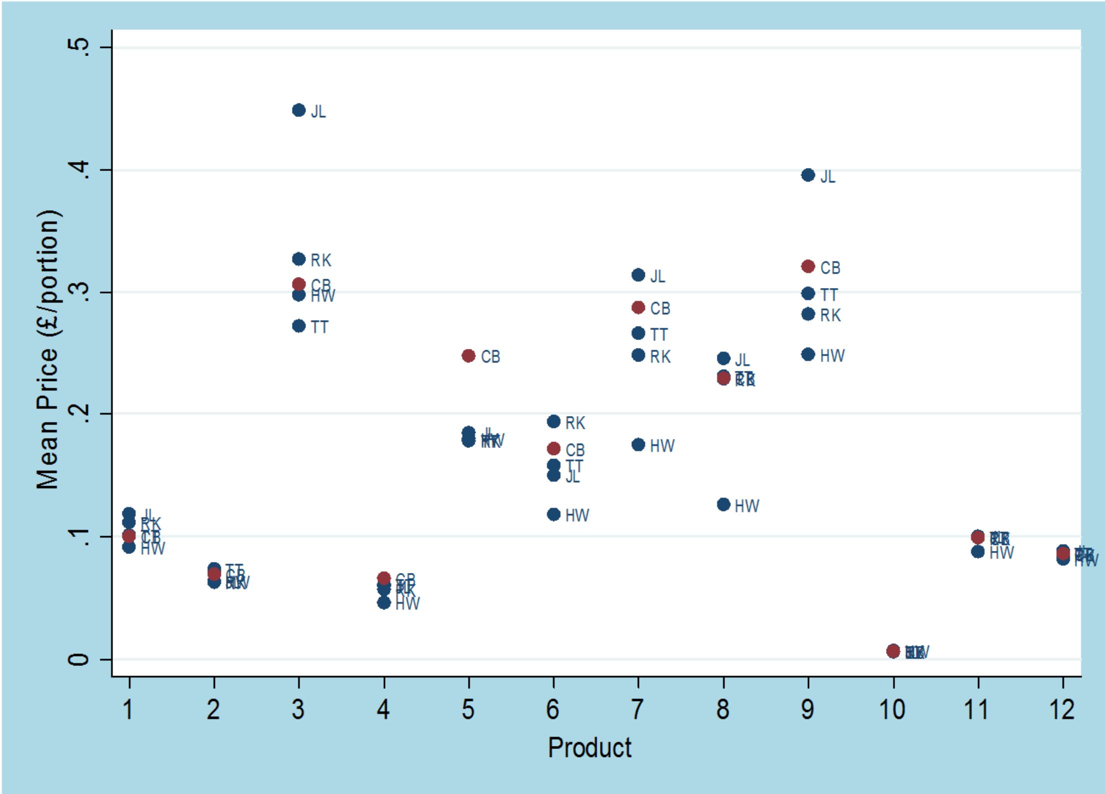


Figure 6-2 Mean price for each of the five fieldworkers[a] across the twelve consumer nutrition environment food products

[a] fieldworkers are represented by their initials

6.3.1 AIM 1: Do healthfulness scores and in-store variables differ by store type and LSOA deprivation quintiles?

In this section, hypothesis one is assessed. Differences in the overall healthfulness, and nine consumer nutrition environment variables, of supermarkets and convenience stores across English quintiles of LSOA deprivation are examined.

6.3.1.1 Store type

The mean healthfulness score was zero (SD: 1), where scores ranged from -1.9 to 2.2. Figure 6-3 indicates that the healthfulness scores were poorer for ‘world’, convenience and petrol stores. Discount supermarkets had the lowest median score of all supermarkets and showed the greatest spread of healthfulness scores for supermarkets. Healthfulness scores were positive for premium and large supermarkets, indicating these stores offered the most healthful environments for consumers. Small supermarkets showed more variation in healthfulness scores than premium and large supermarkets, though scores remained predominantly above zero suggesting better than mean healthfulness. Discount supermarkets, 'world', convenience and petrol stores all showed a varied distribution. Analysis of variance revealed a difference in healthfulness according to store type ($p<0.001$). Store type explained 53% of the variance in store healthfulness. Adding LSOA deprivation quintiles to the model did not change this variance explained.

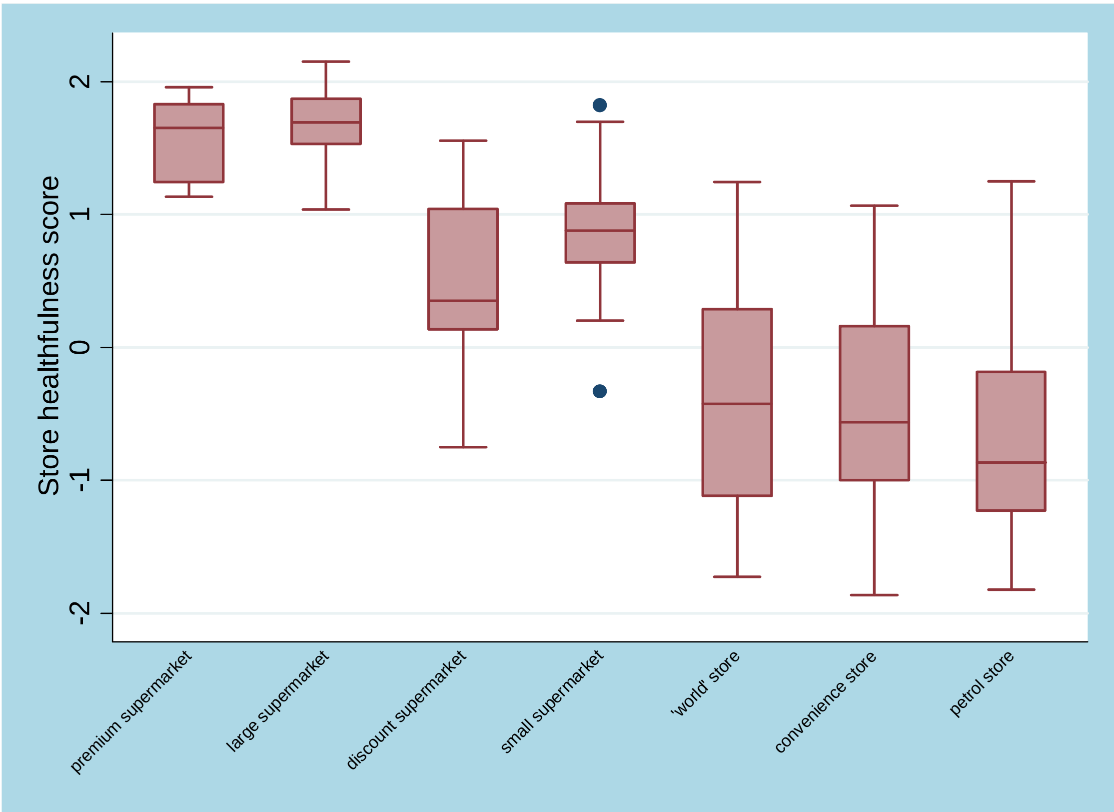


Figure 6-3 Box and whisker plot of store healthfulness by store type

Table 6-4 shows that the nine individual variables followed similar trends to the composite score, showing significant differences across the seven different store types. Premium supermarkets scored highly on all variables. Large supermarkets also scored highly on all variables except *price* where large supermarkets had the lowest price score across all supermarkets. The results indicate that prices of the cheapest products examined in large supermarkets favoured less healthy products by up to £0.07 more than other stores, on a per portion price calculation. Discount supermarkets had price scores that favoured less healthy products showing up to £0.05 difference from other stores. Additionally, discount supermarkets had poorer scores for *variety, healthier alternatives* and *single fruit sale* than other supermarkets. Only premium supermarkets had a positive promotions score, indicating that most store types promoted less healthy products more frequently than healthy products (Figure 6-4).

Figure 6-4 Example of a discount supermarket promoting less healthy products more than healthy products

Table 6-4 Healthfulness score and individual in-store variables by store type

Variable	Store type: Premium supermarket	Large supermarket	Discount supermarket	Small supermarket	'World' store	Convenience store	Petrol store	Possible range[f] Min	Max	p-value
	Median (IQR)[d]									
Composite score	1.7 (1.2, 1.8)	1.7 (1.5, 1.9)	0.3 (0.1, 1.0)	0.9 (0.6, 1.1)	-.04 (-1.1, 0.3)	-0.6 (-1.0, 0.2)	-0.9 (-1.2, -0.2)	-1.9	2.2	<0.001[a]
Variety	8 (7, 8)	8 (6, 9)	-8 (-10, 1)	-6 (-8, -2)	-2 (-5, 0)	-9 (-11, -7)	-7 (-8, -5)	-25	35	<0.001[a]
Price	0.03 (0, 0.05)	-0.03 (-0.04, -0.01)	-0.01 (-0.04, 0.01)	0.02 (0.01, 0.05)	0.04 (-0.12, 0.1)	0.03 (-0.06, 0.08)	0.02 (-0.21, 0.1)	higher score is more healthful		0.002[a]
Promotions	0.5 (-1, 1)	0 (-1, 1)	-1 (-3, 0)	-1 (-2, -1)	0 (-0.4, 0)	-1 (-1, 0)	-1 (-1, 0)	-5	7	<0.001[a]
Shelf placement	5 (4, 7)	7 (5, 9)	7 (4, 9)	5 (4, 7)	0 (-3, 4)	-3 (-6, 3)	-5 (-6, 1)	-15	21	<0.001[a]
Store placement	4 (4, 5)	4 (4, 5)	4 (3, 5)	4 (3, 4)	1 (-4, 5)	-4 (-6, 2)	-4 (-6, 1)	-15	21	<0.001[a]
Quality	17 (17, 17)	17 (16, 18)	17 (15, 18)	17 (15, 17)	5 (0, 10)	5 (0, 13)	0 (0, 8)	0	18	<0.001[b]
Healthier alternative	4 (4, 5)	5 (5, 5)	2 (2, 3)	3 (2, 3)	0 (0, 1)	1 (1, 2)	1 (0, 2)	0	5	<0.001[b]
Nutrition information	13 (10, 13)	14 (12, 15)	13 (13, 14)	15 (15, 15)	4 (2, 7)	11 (9, 13)	9 (9, 12)	0	15	<0.001[b]
Single fruit sale[e]	100%	97%	26%	87%	23%	19%	21%	0	2	<0.001[c]

[a] Oneway analysis of variance, [b] Kruskal-Wallis test, [c] Chi square test, [d] Median and inter-quartile range (IQR) were provided for both parametric and non-parametric variables for ease of reading, [e] Percentage of two fruits available for single sale was provided because this variable was categorical, [f] Possible range of scores for each variable except composite score which shows actual range of composite score values.

6.3.1.2 LSOA deprivation

Figure 6-5 shows a tendency towards higher store healthfulness with increasing levels of neighbourhood affluence. However, the test for trend revealed that this association was weak (p=0.09). Examination of the relationship between individual in-store variables with neighbourhood deprivation highlighted several disparities (Table 6-5). Fruit and vegetable quality declined as level of neighbourhood deprivation increased (p<0.01). The presence of nutrition information on less healthy products was greatest in the most affluent neighbourhoods while promotions favoured less healthy products in all neighbourhoods except the most deprived (both p<0.01). Prominent shelf and store placement of healthy products was slightly better in more affluent neighbourhoods (p=0.04 and p=0.05 respectively). Healthier alternatives were worst in the most deprived neighbourhoods (p=0.03). Product variety, price and single fruit sale were not associated with neighbourhood deprivation (all p>0.1).

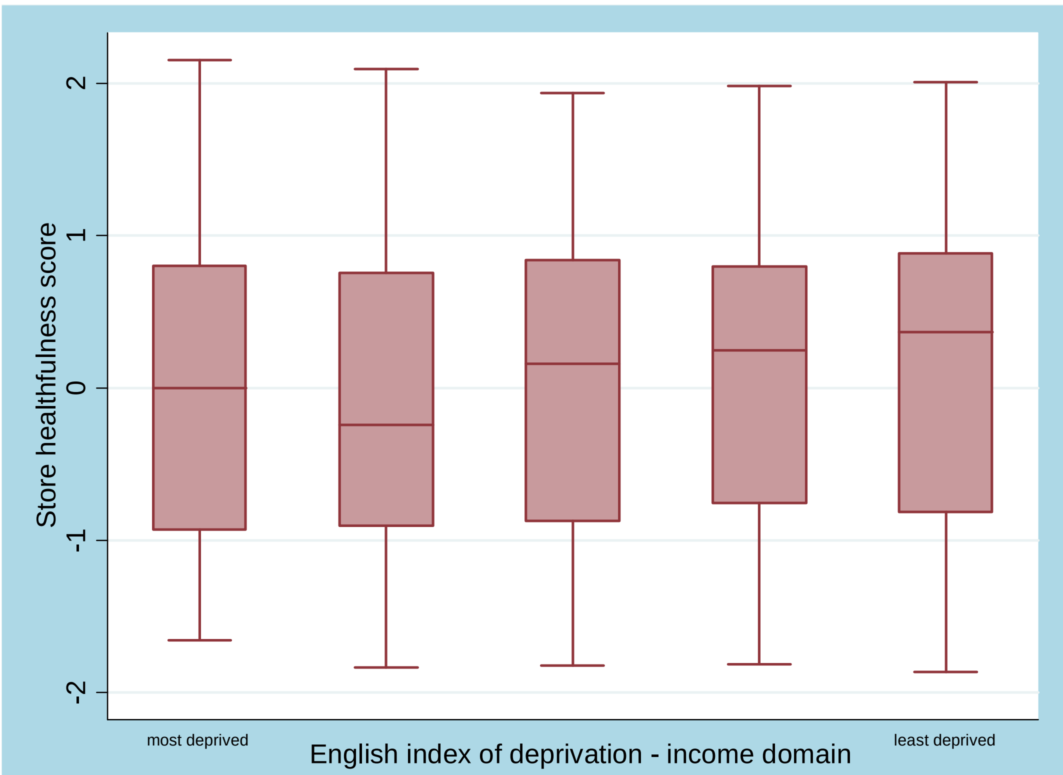


Figure 6-5 Box and whisker plot of store healthfulness by level of LSOA deprivation quintiles

Table 6-5 Healthfulness score and individual in-store variables by LSOA deprivation quintiles

	LSOA deprivation quintiles							
	Most deprived	**2**	**3**	**4**	**Least deprived**	Possible range[e]		
Variable	Median (IQR)[c]					Min	Max	p-value
Composite score	0 (−0.9, 0.8)	−0.2 (−0.9, 0.8)	0.2 (−0.9, 0.8)	0.2 (−0.7, 0.8)	0.4 (−0.8, 0.9)	−1.9	2.2	0.09[a]
Variety	−7 (−9, −2.5)	−7 (−10, −2)	−7 (−9, −2)	−7 (−8, −4)	−7 (−10, −3)	−25	35	0.6[a]
Price	0.02 (−0.04, 0.06)	0.03 (−0.05, 0.08)	0.02 (−0.04, 0.06)	0.03 (−0.01, 0.06)	0.02 (−0.01, 0.06)	higher score is more healthful		0.5[a]
Promotions	0 (−1, 0)	−1 (−1, 0)	−1 (−1, 0)	−1 (−2, 0)	−1 (−2, to 0)	−5	7	<0.001[a]
Shelf placement	2 (−5, 7)	0 (−5, 5)	3 (−4, 6)	3 (−3, 6)	4 (−3, 6)	−15	21	0.04[a]
Store placement	1 (−5, 4)	0 (−5, 4)	2 (−4, 4)	2 (−4, 4)	2 (−4, 4)	−15	21	0.05[a]
Quality	9 (1, 15)	8 (0, 15)	13 (3, 17)	12 (0, 17)	14 (3, 17)	0	18	0.002[a]
Healthier alternative	1 (1, 2)	2 (1, 3)	2 (1, 3)	2 (1, 3)	2 (1, 3)	0	5	0.03[a]
Nutrition information	12 (9, 14)	12 (9, 14)	12 (9, 14)	12 (10, 15)	13 (11, 15)	0	15	0.003[a]
Single fruit sale[d]	42%	36%	39%	43%	43%	0	2	0.4[b]

[a] Spearman test for trend, [b] Chi square test, [c] Median and inter-quartile range (IQR) were provided for both parametric and non-parametric variables for ease of reading, [d] Percentage of two fruits available for single sale was provided because this variable was categorical, [e] Possible range of scores for each variable except composite score which shows actual range of composite score values

6.3.2 AIM 2: Are healthfulness scores and in-store variables associated with dietary quality?

In this section, hypothesis two is assessed. The relationships between overall healthfulness, and nine consumer nutrition environment variables of mothers' main food stores and their dietary quality are examined.

A total of 832 mothers used 52 food stores within the study area as their main source of food shopping. The mean dietary quality score for this sample of mothers was -0.01 (SD: 1), their mean age was 32 years (SD: 6) and most mothers (81%) had one or two children. Table 6-6 shows the types of stores mothers used for their main food shop. The vast majority of mothers (91%) shopped primarily at large supermarkets, with smaller proportions of mothers using discount (5%) and premium (2%) supermarkets. Mothers not included in these analyses either shopped in stores outside the study area (n=38) or used internet shopping (n=48).

Table 6-6 Mothers' main food stores by store type

Type of main food store	n (%)
Premium supermarket	16 (2%)
Large supermarket	760 (91%)
Discount supermarket	43 (5%)
Small supermarket	10 (1%)
'World' store	2 (0.5%)
Convenience store	1 (0.5%)
Total	832 (100%)

The median score of healthfulness for the 52 stores used by mothers was 1.79 (IQR: 1.69, 1.94), with scores ranging from -0.75 to 2.15. Figure 6-6 shows the relationship between mothers' dietary quality and healthfulness of their main stores. The relatively flat line of best fit through the data points indicates, and univariate analysis confirmed, that there was no relationship between mothers' dietary quality and the overall healthfulness of their main stores (β=0.11; 95% CI: -0.09, 0.31).

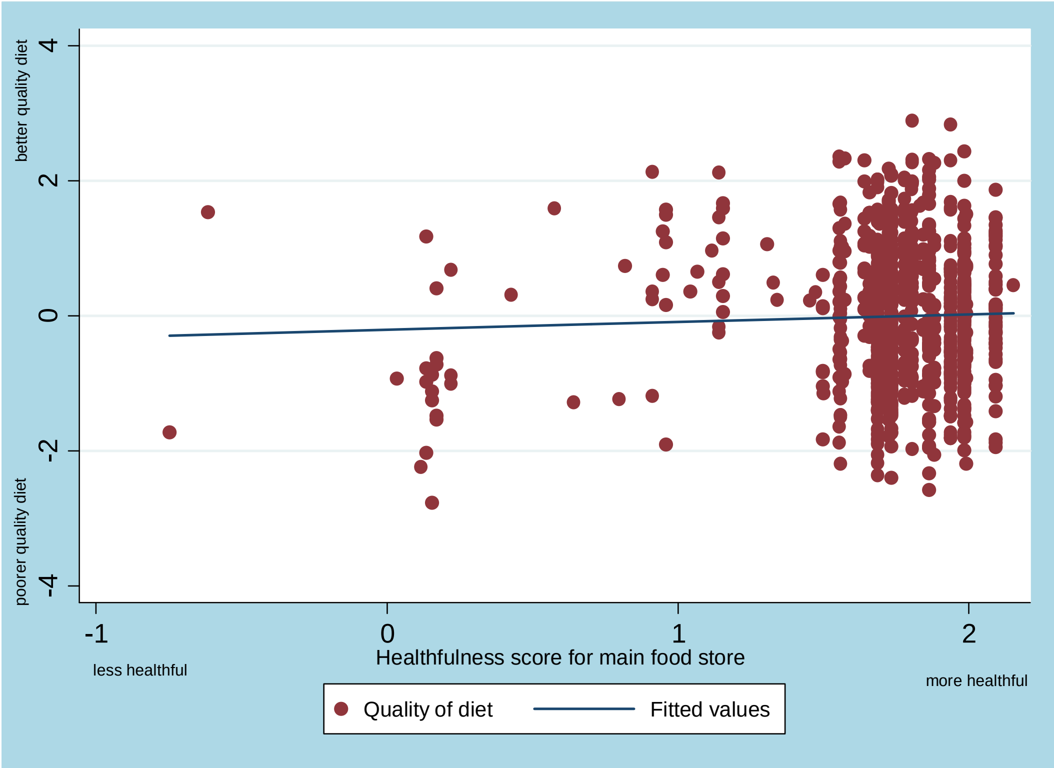


Figure 6-6 Mothers' quality of diet scores by healthfulness score of their main food stores

Univariate regression analyses between each of the nine in-store variables of mothers' main stores and their quality of diet revealed associations at the significance level of p<0.1 for four variables (*price, store placement, promotions and nutrition information*) (Figure 6-7). Higher *price* scores were associated with increased dietary quality scores (β=0.64; 95% CI: 0.33, 0.95), indicating stores where cheapest prices favoured healthy products were associated with better dietary quality. Stores with more prominent *store placement* of healthy products and more *nutrition information* on less healthy products were also associated with better dietary quality (β=0.12; 95% CI: 0.03, 0.20 and β=0.05; 95% CI: 0.01, 0.09 respectively). Unexpectedly, stores with fewer *promotions* (β=-0.06; 95% CI: -0.14, 0.01) on less healthy products were associated with poorer dietary quality, however, this relationship was only weak.

In the multivariate model, only *price* and *store placement* remained predictors of mothers' dietary quality, explaining 3% of the variance in dietary quality. Once covariates were added to the model, the association between dietary quality and *store placement* attenuated. However, *price* remained a significant predictor of mothers' quality of diet whereby a ten pence per portion increase in price difference (calculated as mean less healthy price minus mean healthy price) resulted in a 0.3 increase in mothers' dietary quality score (Table 6-7). The adjusted model explained 22% of the variance in mothers' dietary quality.

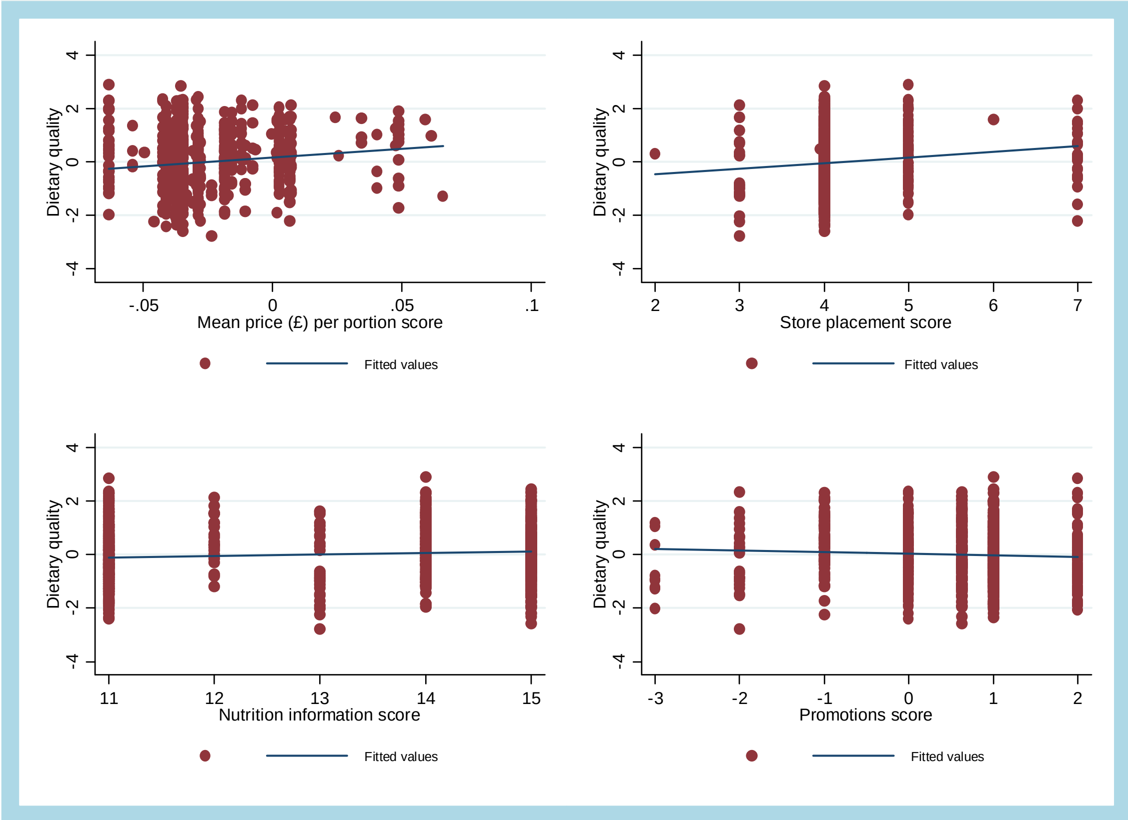


Figure 6-7 Scatter plots of mothers' dietary quality scores by the price, store placement, promotions and nutrition information scores of their main store

Table 6-7 Multivariate regression model of the relationship between mothers' dietary quality and in-store variables of their main food stores

	Dietary quality (SD) β (95% CI)	p-value
Price per portion score (less healthy – healthy)	0.31 (0.02, 0.61)	0.04
Store placement score (healthy – less healthy)	0.07 (-0.01, 0.15)	0.09
Education (7 levels)	0.22 (0.17, 0.27)	<0.001
Age (years)	0.03 (0.02, 0.04)	<0.001
Number of children	-0.09 (-0.16, -0.02)	0.01
Neighbourhood deprivation (quintiles)	0.09 (0.04, 0.15)	<0.001

6.3.3 AIM 3: Is there a modification effect of education on consumer nutrition environment and dietary quality associations?

In this section, hypothesis three is assessed. The moderation effect of three levels of educational attainment on consumer nutrition environment exposure and dietary quality associations are tested. Initially, exposures are described according to mothers' levels of educational attainment.

Mothers with higher educational attainment were more likely than mothers with low educational attainment to shop at stores where *price* scores and *store placement* scores were more favourable towards healthy products (p=0.001 and p=0.003 respectively) and more likely to *sell fruit singularly* (p=0.05). Surprisingly, *variety* and *promotion* scores were poorer in stores used by mothers with higher educational attainment than those of mothers with low education (Table 6-8). Healthfulness scores and the other four consumer nutrition environment variables (*shelf placement, quality, healthier alternative* and *nutrition information*) did not differ by level of educational attainment.

Table 6-8 Consumer nutrition environment exposures by level of educational attainment

	Educational attainment			
	Low (≤GCSE) n=304	**Mid** (A-level/HND) n=295	**High** (Degree) n=222	
	Median (IQR)			p-value[a]
Consumer nutrition environment exposures – main store				
Healthfulness score	1.7 (1.7, 1.9)	1.8 (1.7, 1.9)	1.8 (1.7, 1.9)	0.8
Variety	9 (9, 9)	9 (9, 9)	9 (9, 9)	0.01
Price	-0.03 (-0.04, -0.03)	-0.03 (-0.04, -0.02)	-0.03 (-0.04, -0.01)	0.001
Promotions	0.6 (0, 1)	0.6 (0, 1)	0.6 (0, 1)	0.03
Shelf placement	6 (5, 9)	6 (5, 9)	6 (5, 9)	0.4
Store placement	4 (4, 4)	4 (4, 4)	4 (4, 4)	0.003
Quality	17 (16, 17)	17 (16, 17)	17 (17, 17)	0.7
Healthier alternative	5 (5, 5)	5 (5, 5)	5 (5, 5)	0.9
Nutrition information	11 (11, 15)	13 (11, 15)	14 (11, 15)	0.1
Single fruit sale[b]	6%	3%	1%	0.05

[a] Spearman test for trend, [a] Percentage were no single fruit sale was available

Effect modification of level of educational attainment was tested to assess differences in environmental exposures and dietary outcome association by a covariate known to be associated with dietary inequalities. Evidence of an interaction between education and consumer nutrition environment exposures was considered at the significance level $p<0.1$.

Interactions between healthfulness score and level of educational attainment were observed showing differences between low and mid education groups, and low and high groups ($p=0.004$ and $p=0.002$ respectively). Figure 6-8 presents differences in the relationship between mothers' dietary quality and healthfulness of main food stores across their three levels of education.

Stratified univariate analysis showed: a strong positive relationship between dietary quality and store healthfulness among mothers with low education (β=0.36; 95% CI: 0.10, 0.61), no significant association among mothers with mid education (β=-0.23; 95% CI: -0.55, 0.08), and a strong negative relationship among mothers with degrees (β=-0.58; 95% CI: -1.08, -0.08).

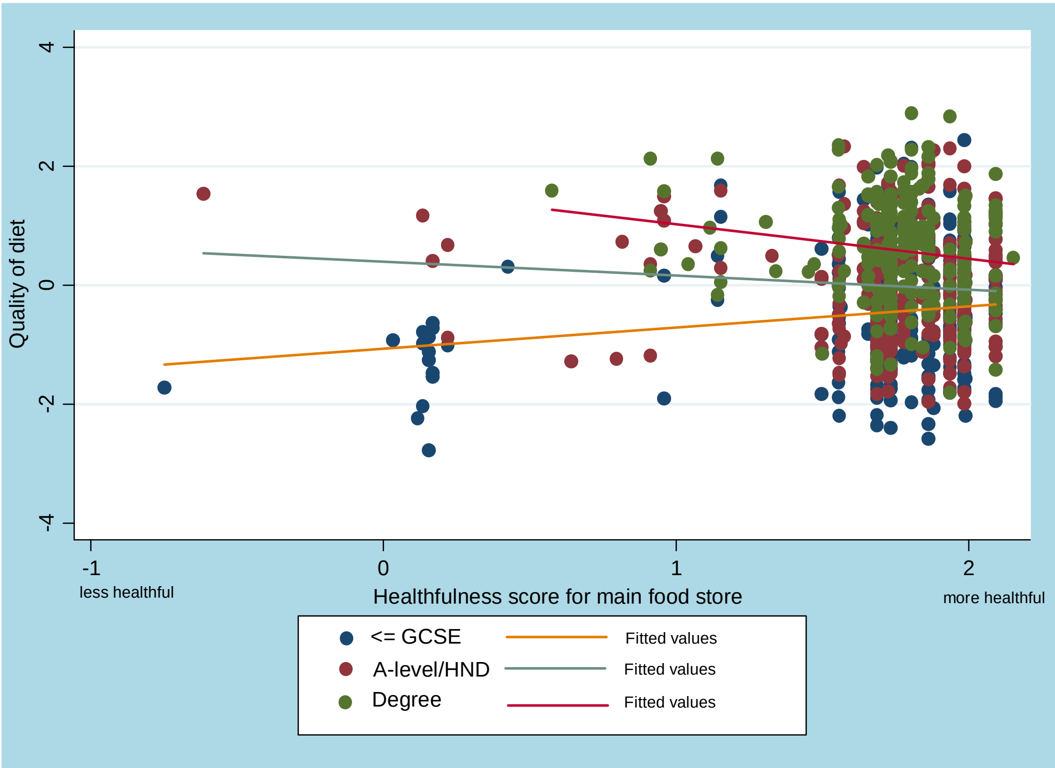


Figure 6-8 Mothers' dietary quality scores and healthfulness of main food stores according to their levels of educational attainment

Adjustment for covariates did not alter the relationship among mothers with high education and only slightly weakened the relationship among mothers with low education (Table 6-9). One standard deviation increase in store healthfulness was associated with a 0.34 *increase* in dietary quality score among mothers with low educational attainment, and with a 0.58 *decrease* in dietary quality score among mothers with high educational attainment. These models explained 19% and 2% of the variance in dietary quality respectively.

Table 6-9 Adjusted regression models of mothers' dietary quality and healthfulness of their main stores by low and high educational attainment

	Dietary quality (SD) **β (95% CI)**	p-value
Low educational attainment (≤GSCE)		
Healthfulness score (SD)	0.34 (0.11, 0.58)	0.005
Age (years)	0.04 (0.02, 0.05)	<0.001
Neighbourhood deprivation (quintiles)	0.21 (0.12, 0.29)	<0.001
High educational attainment (Degree)		
Healthfulness score (SD)	-0.58 (-1.08, -0.08)	0.03

Evidence for effect modification by level of educational attainment was also observed for four in-store variables: *variety, quality, healthier alternative* and *single fruit sale*. Differences were identified between low educational attainment and both mid and high levels of educational attainment. Stratified univariate analyses demonstrated strong positive associations between each of these in-store variables and dietary quality among mothers with low education ($p<0.1$). After multivariate analyses *quality* and *single fruit sale* remained significant positive predictors of dietary quality, along with age and neighbourhood deprivation, among mothers with low education (Table 6-10). By contrast, multivariate analyses among mothers with mid educational attainment showed that *single fruit sale* was a significant negative predictor of dietary quality. Similarly, among mothers with high education *quality* and *variety* negatively predicted dietary quality in the stratified multivariate model.

Table 6-10 Multivariate regression models of the relationship between mothers' dietary quality and in-store variables of main stores by educational attainment

	Dietary quality (SD) β (95% CI)	p-value
Low educational attainment (≤GSCE)		
Quality of fruit and vegetables	0.16 (0.04, 0.28)	0.01
Single fruit sale	0.49 (0.15, 0.83)	0.005
Age (years)	0.04 (0.02, 0.05)	<0.001
Neighbourhood deprivation (quintiles)	0.20 (0.12, 0.29)	<0.001
Store type	0.51 (-0.03, 1.04)	0.07
Mid educational attainment (A level/HND)		
Single fruit sale	-0.45 (-0.76, -0.15)	0.003
Age (years)	0.03 (0.01, 0.05)	0.001
Number of children	-0.13 (-0.26, -0.01)	0.04
Nutrition information	0.05 (-0.01, 0.11)	0.08
High educational attainment (Degree)		
Variety	-0.09 (-0.18, -0.01)	0.03
Quality of fruit and vegetables	-0.18 (-0.36, 0.00)	0.05
Store type	-0.39 (-0.82, 0.04)	0.07

6.3.3.1 Store type

The types of stores used by mothers differed by their level of educational attainment (Table 6-11). Half of the mothers (50%) that used discount supermarkets and more than one third of mothers (37%) who used large supermarkets had lowest educational attainment. Mothers with higher educational attainment were more likely to shop in other store types.

Table 6-11 Type of main food store by level of educational attainment

	Educational attainment			
	Low (≤GCSE)	**Mid** (A-level/HND)	**High** (Degree)	
Store type	n (%)			p-value[a]
Premium supermarket	1 (6)	3 (19)	12 (75)	
Large supermarket	280 (37)	274 (37)	196 (26)	
Discount supermarket	21 (50)	11 (26)	10 (24)	
Small supermarket	2 (20)	5 (50)	3 (30)	
'World' store	0 (0)	1 (50)	1 (50)	
Convenience store	0 (0)	1 (100)	0 (0)	0.003

[a] Chi Square test

There was evidence of effect modification for large and discount supermarkets ($p<0.001$). Figure 6-9 shows differences in the relationship between dietary quality and healthfulness scores for large and discount supermarket shoppers. Stratified univariate analyses did not show an association between dietary quality and store healthfulness among large supermarket shoppers ($\beta=-0.22$; 95% CI: -0.70, 0.27). However, dietary quality was associated with store healthfulness among discount supermarket shoppers ($\beta=1.47$; 95% CI: 0.89, 2.06). This relationship remained significant after adjustment for covariates where dietary quality improved by 1.17 for each standard deviation increase in healthfulness score (Table 6-12). Store healthfulness explained 39% and 52% of the variance in dietary quality in the univariate and multivariate models respectively. Although it should be noted that the sample size of mothers shopping at discount supermarkets was small (n=42).

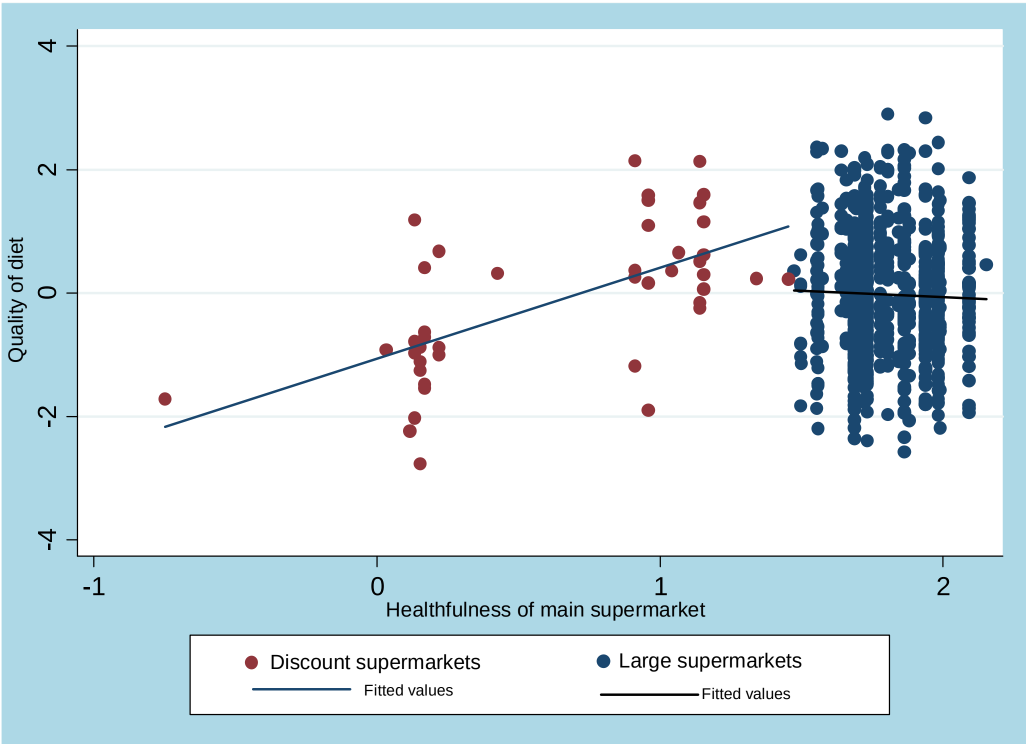


Figure 6-9 Mothers' dietary quality (n=803) and healthfulness of large (n=23) and discount (n=16) supermarkets

Table 6-12 Adjusted regression model of mothers' dietary quality (n=39) and healthfulness of discount supermarket

	Dietary quality (SD) β (95% CI)	p-value
Discount supermarket shoppers		
Healthfulness score (SD)	1.17 (0.58, 1.76)	<0.001
Neighbourhood deprivation (quintiles)	0.32 (0.10, 0.53)	0.005

6.4 Discussion

6.4.1 Summary of findings

The composite score of healthfulness varied across different types of supermarkets and convenience stores. Similar trends were observed for the scores of the nine component variables across the seven store types. These findings suggest that the composite score provided good representation of the individual components. Premium and large supermarkets offered environments that supported more healthful food choices. However, the cost of the cheapest products in large supermarkets favoured less healthy products by up to £0.07 more than other stores, on a price per portion calculation. Discount supermarkets, 'world', convenience and petrol stores offered less healthful environments, though the wide spread of scores indicated that there were examples of better practice for each of these less healthful store types.

The results presented in this chapter provide little evidence to support hypothesis one: level of neighbourhood deprivation did not predict store healthfulness. However, there was a trend towards more affluent neighbourhoods having in-store environments more supportive of healthful food choices. There was strong evidence for poorer quality produce and less nutrition information and weaker evidence for poorer placement of healthy products and fewer healthier alternatives of less healthy products in more deprived neighbourhoods. Unexpectedly, strong associations for healthier price promotion practices were observed in the most deprived neighbourhoods. Neighbourhood disparities were not observed for product variety, price or single fruit sale. These results show that the composite score averages several multi-directional trends across the individual components.

There was some support for hypothesis two: the mean price difference between healthy and less healthy foods was a significant predictor of mothers' dietary quality. Mothers who shopped in stores where prices favoured healthy foods by ten pence per portion had better dietary quality than those whose main store had cheaper less healthy products, equivalent to consuming crisps up to four times less and vegetable dishes up to four times more each week. However, there was no evidence that overall healthfulness of main store or differences in other in-store variables predicted dietary quality in the full sample of mothers.

The findings of this chapter provide strong support for hypothesis three: mothers' levels of education moderated the relationship between their dietary quality and the overall healthfulness, and some individual in-store variables, of their main stores. Among mothers with low educational attainment, those who shopped at more healthful stores had better dietary quality, equivalent to consuming crisps up to four times less and vegetable dishes up to four times more each week, than those who shopped at the least healthful stores. Among mothers with high educational attainment, an inverse relationship was observed where decreasing store healthfulness was associated with better dietary quality. Similar differences were found for individual in-store variables. Better quality of fruit and vegetables, and greater ability to buy single items of fruit were associated with better dietary quality among mothers with low educational attainment but poorer dietary quality among mothers with mid and high educational attainment. These findings suggest greater vulnerability to environmental exposures among more disadvantaged mothers, while those with higher educational attainment show greater resistance to poorer environmental exposures. The results also showed that mothers with low educational attainment were more likely to shop at discount supermarkets than other mothers. Furthermore, mothers who shopped at the least healthful discount supermarkets had considerably poorer diets than other discount supermarkets shoppers, although this sample size was small.

6.4.2 Comparison with previous research

The findings that large and premium supermarkets offered environments that support consumers choosing healthful foods are consistent with prior studies.[48 60 289] Unlike previous research,[97 107 290] store size did not necessarily determine overall store healthfulness. Smaller versions of large supermarkets offered more healthful shopping environments than bigger discount supermarkets. Discount supermarkets offered the least supportive environment for healthy eating of all supermarkets in this study, with the median composite score considerably lower than other supermarkets. Previous research in northern England has shown poorer quality and availability of healthy food in discount supermarkets than in other supermarkets.[126] However, research from Scotland revealed better availability of healthy foods and cheaper prices in discount stores.[100]

The composite measure also highlighted differences within store types as well as between. For example, stores that are generally classified as 'unhealthy', such as petrol and convenience stores,[141 291] revealed a spread of healthfulness scores from poor to good. This finding indicates that there are examples of better, more healthful practices within less healthy store types and may also identify further subgroup categorisation of stores.[292]

The results of this study showed a trend for poorer store healthfulness in more deprived neighbourhoods. However this trend was not significant, providing evidence against hypothesis one. While no prior research has measured the full range of consumer nutrition environment factors included in this study, investigations in the UK and Australia have shown little variation in availability and price according to area deprivation.[109 293] Consistent with the individual component analyses, previous work in these countries have shown fruit and vegetable quality was poorer in more deprived neighbourhoods.[51 294] However, in contrast to the findings of this study, previous work in England found greater promotion of less healthy products by retailers in more deprived areas.[283] In the US disparities in availability, price, variety and quality of healthy food exist and favour more affluent, predominantly white neighbourhoods.[47 48] More frequent, prominent placement of less healthy items in poorer Latino areas compared with wealthier white areas has also been observed, but the findings were not significant.[74] Country differences may be due to the higher levels of urban residential segregation in the US than countries, such as Australia and the UK.[295] The geography of food retailing may also differ across countries. In the UK, over the last two decades major retailers have adopted an urban regeneration agenda locating large stores on the periphery of towns,[296] as well as opening smaller stores in city and town centres.[264 265] These supermarket developments may have addressed some of the socioeconomic area-based disparities in food access in the UK.

The lack of association between overall healthfulness of main food store and dietary quality provides evidence against hypothesis two and is consistent with prior consumer nutrition environment research.[78] As discussed in section 2.4.2.2, most findings (71%) of previous work showed no association between better availability and healthier dietary outcomes and approximately one quarter (24%) revealed a positive association. Similar results were identified for associations between dietary outcomes and in-store variety or quality, though previous research investigating these variables is limited.[59] Previous in-store audit tools have not comprehensively assessed the additional components, such as product promotions or placement, against dietary outcomes.[297] The results of this chapter showed that better store placement of healthy products relative to less healthy products was associated with better dietary quality, although the relationship attenuated after adjustment for individual covariates including age and level of educational attainment. The placement of fruit and vegetables at the entry of supermarkets was considered a favourable store feature in this study. However, such actions have been cited as conscious decisions by supermarkets to create the illusion of a healthy store, while other staples, such as bread, are located on the opposite side of the store and increases the likelihood of impulse purchases of less healthy food commonly placed on end of aisle displays.[298] A review of in-store marketing strategies highlighted the importance of measuring multiple aspects of the in-store environment because marketing techniques including product placement, price and promotion commonly occur together.[297]

Of the nine factors measured in this study, price difference was the strongest predictor of mothers' dietary quality. As described in section 2.4.2.2, prior research has largely shown no relationship between food price and dietary intake,[78] although a number of studies have found that higher prices of healthy foods were associated with better dietary and weight outcomes[140 299 300] and longitudinal analyses have shown increases in the price of less healthy food related to reduced intake of some foods.[128 129] The findings of this study showed that the differential price of food products indicative of healthy and less healthy dietary behaviours was an important predictor of dietary quality. Previous work has shown that healthier dietary patterns cost more than less nutritious, energy dense dietary patterns,[45 301 302] though little difference has been shown between standard and healthier items within a product category.[303] When examining price variations by type of supermarket, research from northern England found that large and discount supermarkets had cheaper prices for healthy and less healthy food baskets, while premium supermarkets and smaller grocery stores were more expensive.[126] The findings of the current study provide additional insight into supermarket pricing by revealing that large and discount supermarkets had the least healthy price difference of all store types, being the only store types to price the cheapest healthy items more expensively than the cheapest less healthy items. Therefore, while individuals with better quality diets may be paying more for their food, the cheaper large and discount supermarkets have pricing structures that appear to be encouraging poorer dietary patterns. Cost and value for money have been reported as an important influence on food choice,[304] more important than nutrition, particularly in the recent years of recession[297] and among those with greater financial concerns.[39 269]

The significant interaction observed between mothers' levels of educational attainment and overall healthfulness of their main food stores provide support hypothesis three: the relationship between dietary outcome and in-store exposures differ by level of educational attainment. Few studies have investigated the moderation effects of education on associations between the consumer nutrition environment and diet. However, research among a multi-ethnic population in the US showed that lower availability of healthy foods in stores in residential neighbourhood was associated with the poorer dietary pattern group but not the better dietary pattern group.[145] Only a small number of studies have previously linked data on individual's main food store to their dietary data.[59] One study from the US involving 186 low-income women aged 40-64 years found no association between healthy food availability in their main food store and daily fruit and vegetable intake.[138] Another US study of 121 highly educated men and women, found that a higher composite score of their main food store (considering healthy food availability, price and quality) related to consumption of fewer sweetened beverages, but was not associated with intake of fruit, vegetables, milk, meat, sweets or cereals.[137] These findings differ from those of the current study which showed a positive association between store healthfulness and diet among mothers with low education and a negative association among mothers with degrees. These discrepancies may be explained by methodological differences. The US studies focused on the availability of healthy products only while the current study surveyed a range of healthy and less healthy products and included nine in-store factors that may affect food choice. However, the differences may be indicative of variations between countries because similar trends to overall healthfulness were observed for the individual component variables of quality and single fruit sale in this study.

The differences observed in associations between in-store environment exposures and dietary quality by level of educational attainment suggest that mothers with low educational attainment may have greater susceptibility to the environment of their main food store than other mothers. Qualitative research with low-income residents in the US identified two levels of influence on food shopping behaviour.[43 305] First, limited economic resources created a need to plan for cost-effective choices that would provide enough food for their family. Second, the marketing activities within the supermarket environment prompted unplanned purchases of less healthy products. Similar concerns about the cost of healthy foods, frequent promotion of less healthy foods and limited choice of fruit and vegetables in heavily discounted stores have also been reported among disadvantaged women in the UK.[39 225] In addition, women with lower educational attainment have reported poorer knowledge of diet-disease relationships, lower control over family food choices and less social support than women with higher educational attainment.[39 40] This combination of individuals with higher levels of educational attainment having a greater sense of personal control, a supportive social environment, and full-time, higher-paid work suggests that these additional economic and psychosocial resources may be protective against environmental exposures that those without these resources are more susceptible to.[188]

The unexpected inverse association observed between main store healthfulness and dietary quality among mothers with high educational attainment may be further explained by the increased use and growing market share of discount supermarkets, particularly Aldi and Lidl.[266] Sales data from the UK show that, in response to the financial pressures of the recent recession, consumers are economising on grocery items and spending more at discount supermarkets to make their household budgets go further.[306] Although only a small number of mothers in this study identified discount supermarkets as their main food store, discount supermarkets now hold almost ten percent of all UK grocery sales. [266 306 307] Over a third of British households are shopping at discount supermarkets each month, with many using discount supermarkets to supplement trips to large supermarkets. Discount supermarkets offered environments least supportive of healthful food choices in this study, with some being considerably poorer. The spread of healthfulness scores identified for discount supermarkets may be explained by previous research in Glasgow which showed that discounter chains, such as Aldi, had better availability and cheaper prices of all supermarkets, while freezer chains, such as Iceland, were more expensive and offered a poorer variety of healthy foods.[100] Interestingly, mothers with high educational attainment did not shop at the least healthful supermarkets in this study but mothers with lower educational attainment were more likely to use these stores. It could be speculated that mothers who are highly educated and highly health conscious are choosing to shop at more healthful discounter chains which offered cheaper prices than large supermarkets but their psychosocial resources are protective against less healthy environmental exposures. In contrast, mothers with lower educational attainment with fewer financial and psychosocial resources are likely to be more vulnerable to their store environment, with those using the least healthful discount supermarkets most affected.

6.4.3 Strengths and limitations

This study is the first to develop an overall measure of the consumer nutrition environment, combining nine different variables into a single standardised score. The healthfulness score showed high internal consistency (α=0.86) which indicates that the components measure one internally consistent underlying construct. The composite score characterised multiple environmental factors independent of measurement type; categorical, dichotomous and continuous measures were all represented equally in an overall score that was normally distributed. Using a standardised score provides a robust measure to conduct and interpret analyses. The foods selected in this study are items that account for the most variance in tools used to discriminate between better and poorer dietary patterns among young women, young children and older adults. This selection enabled assessment of the environmental exposures of foods measured in the dietary assessment of mothers participating in this study.

This study measured a much larger sample of stores than previous work,[91 279 282] covering 99% of retail food stores in the study area. This coverage provides a thorough representation of the variation in healthfulness of supermarkets and convenience stores and enhances confidence in the accuracy of the study results. The use of environmental exposures from main food store and the temporal connection of data collection in stores and from mothers also provide advancements on previous research methods.

Inter-rater reliability results showed good to excellent kappa statistics (kappa 0.73-0.95) for almost all variables. These results are similar to other in-store audit tools (kappa >0.70).[308] The sample of stores included in this reliability test however was small (n=14) compared to similar studies (n=30 to 85).[74 279 281] The reliability (kappa 0.60) for fruit and vegetable quality was higher than the results reported in some studies,[281] but lower than the results of others.[309] Future work using photos or a simple two-point scale of acceptable/unacceptable could provide a more consistent measure of quality, as has been used previously.[134 281] Convergent validity against an alternative observational tool was not tested due to the need for intensive resources to conduct in-store audits. Data were collected from all store types and all levels of national neighbourhood deprivation over eleven months. Some aspects of seasonality or small price fluctuations may have been accounted for; however, test-retest reliability and stability of items over time were not measured.

While the assessment of nine different in-store variables was novel, three variables were restricted in their assessment. Shelf placement, store placement and nutrition information were all measured on the cheapest item available for each product assessed. This restriction may have missed the opportunity to appropriately score the location of heavily promoted less healthy branded products, particularly in supermarkets that sell own-brand products. Other studies have assessed a specific brand and size of product,[310] however, this approach is limited if not all stores stock that particular brand and size. The exclusion of specialty stores and the geographical area covered are additional weaknesses that may limit the generalisability of the study findings to other parts of the UK and other countries. Due to the cross-sectional nature of these data, causal relationships between in-store exposures and diet cannot be determined.

Possible psychosocial confounders, such as perceived control, or other individual factors, such as taste, were excluded from these analyses and these factors may be associated with variations in dietary quality. The mediating role of psychosocial and environmental perception factors in the relationship between local food environment exposures and dietary behaviour is further explored in Chapter 8.

6.4.4 Policy and research implications

The supermarket is a non-neutral environment that largely directs the food choices of an almost captive market in favour of products with the greatest profit margin, typically energy-dense processed foods.[298] The results of the current study showed that discount supermarkets in particular had environments that encouraged less healthful food choices, having greater variety and price promotion of less healthy products and having fewer healthier alternatives of less healthy foods than other supermarkets. However, even large supermarkets, one of the most healthful store types in this study, were shown to have a pricing structure that favoured less healthy products. With rising food prices it is not surprising that consumers are substituting healthy foods for cheaper and more heavily promoted energy-dense processed foods.[311 312] The switch from fruit and vegetable purchases towards processed sweet and savoury foods in recent years has been greatest in low-income households and those with young children.[222 313]

The results of this study suggest that improving the price differential between healthy and less healthy products in the major supermarket chains, where most mothers in this study shopped, could lead to significant improvements in dietary quality. There is much debate about regulatory action to tax unhealthy foods or subsidise healthy foods to improve dietary and health outcomes. While the food industry are opposed to food taxation policies,[314] empirical evidence suggests that price increases on less healthy foods reduce purchases of these foods.[315 316] However, modelling results indicate that to have a significant effect on population health the tax on less healthy food would need to be at least 20%, which is higher than current taxes imposed by governments in some countries.[316 317] The current UK government has supported voluntary action by industry to encourage healthier food choices. However, the UK Chief Medical Officer reported that if voluntary efforts fail to deliver health benefits, then regulatory approaches should be considered.[235] There is also evidence that subsidising healthy food is effective in improving dietary behaviour, with a 10% subsidy proving to be the minimum level of subsidy required to induce meaningful increase in consumption and higher subsidies relating to greater increases in intake.[318] In the UK, the Healthy Start scheme offers low-income families with young children vouchers of £3.10 to spend on fruit, vegetables and milk.[319] The scheme has been well received by food retailers and participants have reported consuming more fruit and vegetables,[320] however, uptake of the program has been poorer than desired.[321]

The results of this study provide evidence for further action by food retailers and governments to make healthier choices easier for consumers, particularly those with the greatest financial constraints. Expanding initiatives, such as the UK Public Health Responsibility Deal, to include strategies on pricing structure, prominent placement and promotion of healthy foods, or increasing the Healthy Start subsidy to encourage greater fruit and vegetable intake, fit comfortably within the current policy framework. Further research exploring the effect of modifying marketing strategies within supermarkets on diet is needed, particularly in the UK. Additional evidence about the differential prices of foods indicative of better and poorer dietary patterns is needed to inform future governmental action to promote the consumption of healthier foods.[322] The tool used in this study could be useful for local studies to monitor change in relative price difference and the overall in-store environment, particularly if used in combination with related dietary measures.

6.5 Conclusion

This chapter used a large sample of supermarkets and convenience stores to develop a composite measure of the consumer nutrition environment, incorporating the interplay of nine in-store factors. This novel measure of healthfulness discriminated between and within store types but did not vary across five levels of area deprivation. Some individual component variables were poorer in more deprived areas, including poorer fruit and vegetable quality, less nutrition information, fewer healthier alternatives and more prominent placement of less healthy foods. There was some evidence that more healthful environments of mothers' main food stores related to better dietary quality. Mothers who shopped at stores where healthy foods were priced less expensively than less healthy products had better quality diets. Overall healthfulness of main supermarket was not associated with dietary quality among the full sample of mothers. However, the consumer nutrition environment had differing effects on mothers with low educational attainment and those with high educational attainment. Among mothers with low educational attainment, those who shopped at more healthful stores had better dietary quality, equivalent to consuming crisps up to four times less and vegetable dishes up to four times more each week, than those who shopped at the least healthful supermarkets. Among mothers with high educational attainment, decreasing store healthfulness was associated with better dietary quality. Similar differences by level of educational attainment were found for individual in-store variables. Mothers with low educational attainment showed greater vulnerability to in-store exposures than mothers with high educational attainment. This difference may relate to mothers with low educational attainment having fewer financial and psychosocial resources. These educational differences in the relationships between environmental exposures and dietary outcome by level of educational attainment are similar to the findings in the previous chapter (Chapter 5). The next chapter (Chapter 7) will explore associations between the organisational nutrition environment of mothers' Sure Start Children's Centres and their dietary quality and investigate whether this relationship also differs by level of educational attainment.

Chapter 7 Organisational nutrition environment

The organisational nutrition environment describes institutional settings where defined groups of people consume food or can learn about healthy eating, such as workplaces or early childhood facilities. Sure Start Children's Centres have been selected as the target organisation in this study because mothers with children under the age of five years frequently visit these centres.[178 179] In addition, assessing differences in the nutrition environment of Sure Start Children's Centres by area deprivation and associations between this environment and mothers' dietary quality addressed current gaps in the literature as highlighted in Chapter 2 (section 2.4.3.3). There is little evidence about the nutrition environment of Sure Start Children's Centres and therefore a need for a tool to assess centres systematically. This chapter describes the development of a tool to assess four key domains of the nutrition environment of Sure Start Children's Centres and the creation of a standardised overall score. Results are presented against the first three hypotheses of this study in terms of the nutrition environment of Sure Start Children's Centres in the study area:

1. **Disadvantaged neighbourhoods have significantly poorer Sure Start Children's Centre nutrition environments than more affluent neighbourhoods.**

2. **Sure Start Children's Centre nutrition environment exposures are associated with mothers' dietary behaviours.**

3. **Mothers' levels of education have a moderating effect on associations between Sure Start Children's Centre nutrition environment exposures and their dietary behaviours.**

The discussion summarises the findings, compares them with previous research, and addresses the policy and research implications.

7.1 Background

The organisational nutrition environment describes institutional settings where defined groups of people consume food or can learn about healthy eating, such as workplaces, churches, health facilities or early childhood facilities.[1] The organisational environment has long been recognised as an important component of health promotion because these settings can play a central role in an individual's daily activities and can influence their lifestyle behaviours.[76]

The literature review in Chapter 2 (section 2.5.3) identified that healthier organisational nutrition environments of workplaces, churches and early childhood facilities were associated with better dietary behaviours. Across settings, three key factors were identified as important determinants of the quality of the organisational nutrition environment: *i)* food provision and food policies, *ii)* staff food knowledge and behaviours, and *iii)* healthy eating information and activities. More health promoting organisational environments were those that had nutrition policies and provided healthy food, management and staff that supported healthy dietary habits, and nutrition education and information were readily available.

Sure Start Children's Centres were the focus of the organisational nutrition environment in this study because they are an important setting for promoting healthy behaviours to families with young children, particularly those from more deprived backgrounds.[323] Sure Start Children's Centres were introduced as part of the Blair Labour government initiative (1998) to address health and social inequalities.[324] The centres were founded on evidence that supporting parents in the earliest years can improve the life prospects of younger children. Initially, Sure Start Children's Centres targeted disadvantaged families but were expanded to reach all families with children under the age of five. Services offered by Sure Start Children's Centres include educational and health services for children and parents, advice on parenting and social services.[323] Through their activities, Sure Start Children's Centres make an important contribution to delivering health promotion activities, including promoting improved nutrition and dietary behaviours, and reducing inequalities in health.[178 185]

The literature review of early childhood settings (section 2.4.3.3) identified that organisational nutrition environment research has focused on childcare as opposed to children's development centres. Children generally spend long periods of time away from parents in childcare facilities. In contrast, children's development centres, such as Sure Start Children's Centres, encourage interaction between parents and children and therefore parents have greater exposure to the centres' environments.[323] Each Sure Start Children's Centre, however, offers different services and activities according to the needs of the community it serves, which can vary the amount of time that children and their parents visit or remain at their centre.[178]

Promoting healthy eating is a key priority area for Sure Start Children's Centres.[185] Information and guidance on nutrition and related areas, such as breastfeeding, weaning and healthy eating are regularly provided by Sure Start Children's Centres. The National Evaluation of Sure Start and local research has shown that centres, nationally and in Southampton, have reported promoting and supporting breastfeeding and good weaning practices.[162 185 325] The provision of educational material to parents about healthy diets and providing children with healthy food and drinks has also been reported. However, systematic assessment of the nutrition environment of Sure Start Children Centres has not been carried out. Nor has the relationship between Sure Start nutrition environment and dietary outcomes been previously assessed. Understanding the association between nutrition environments of early childhood settings and parental diet is a particular gap in the literature (section 2.4.3.3) that needs to be addressed to enhance understanding of whether these setting provide opportunity for addressing dietary inequalities.

A number of assessment tools to evaluate the organisational nutrition environments of early childhood settings have been developed for use in the US, Australia, the Netherlands and Ireland.[159 278 326 327] Most tools have been self-report or interview surveys completed by management or staff, though observational audits have also been used.[279] Several key aspects of health promotion have been identified as essential in early childhood settings, including the types of food provided, nutrition or food policies, the physical environment, staff attitudes, knowledge and behaviour, nutrition information or activities, and parental engagement.[159 278] These factors are consistent with recommendations by the National Institute for Health and Care Excellence (NICE) for improving the nutrition of mothers and children in low-income households. In particular, having a food policy to guide the provision of healthy foods and supporting children and their families to try new foods and adopt healthy mealtime behaviours.[328]

Some tools have evaluated the nutrition environment of early childhood settings by calculating composite scores for environmental domains (i.e. food policy content) or the overall environment.[329–331] The Nutrition and Physical Activity Self-Assessment for Child-Care instrument, for example, has been used in the US to evaluate and improve childcare nutrition environments. It has been shown to be a stable and reasonably accurate instrument for use in childcare centres.[332] In Arizona, overall scores characterising the nutrition environment for each facility were fed back to coordinators and subsequently led to improvements in practices affecting the nutrition environment.[331] Another instrument, The Environmental Audit, was developed by the World Health Organisation Collaborating Centre on Obesity Prevention to evaluate the Romp & Chomp intervention in Australia. This intervention targeted preschool children and was a component of the community-based obesity prevention demonstration project in the city of Geelong, Australia.[333 334] Content analysis of nutrition policies across intervention and control sites was completed by creating a score of the total number of elements that policies contained, such as restrictions on providing sugar-sweetened beverages.[329] Summary measures of environmental domains or the overall nutrition environment provide simple quantitative methods for evaluating changes in the nutrition environment, differences in the nutrition environment across areas or the effects of the nutrition environment on dietary or weight outcomes.[330 331 334]

There is not a comprehensive tool to systematically measure healthy eating domains and the overall nutrition environment of Sure Start Children's Centres. Such a tool could provide a thorough evaluation of differences in nutrition environments across areas, highlight areas for intervention or be used to examine the association between Sure Start Children's Centre nutrition environment and dietary behaviours of parents or children.

This study addresses a gap in the literature by developing a comprehensive organisational nutrition environment assessment tool to measure Sure Start Children's Centres in the UK. More specifically, the aims of this chapter were to:

i) Examine differences in the organisational nutrition environment variables, of Sure Start Children's Centres across English quintiles of LSOA deprivation (hypothesis one)
ii) Determine the relationship between the organisational nutrition environment variables of mothers' Sure Start Children Centres and their dietary quality (hypothesis two)

iii) Test the moderation effects of level of educational attainment on Sure Start Children's Centre organisational nutrition environment exposures and dietary outcome associations (hypothesis three)

7.2 Organisational nutrition environment methods

7.2.1 Mothers

Participants were mothers who completed the Southampton Initiative for Health follow-up survey. Mothers' nominated Sure Start Children's Centres were the centres from which they were recruited. Mothers were asked how often they had attended their Sure Start Children's Centre over the past 18 months. Responses ranged from never (zero) to more than once a day (six). Questions about age, number of children, highest educational attainment and home postcode were also asked. Home postcode was used to determine residential LSOA deprivation quintile.

7.2.2 Dietary outcome

Quality of diet score, assessed via a validated food frequency questionnaire (FFQ), was the primary outcome variable. The FFQ was included in the Southampton Initiative for Health follow-up survey. Section 4.2.2.1 describes the creation of the dietary quality score. Positive dietary quality scores characterised better quality diets that had higher intakes of vegetables and wholemeal bread. Negative scores characterised poorer dietary quality that indicated higher intakes of processed meats, crisps and sugar.

7.2.3 Sure Start Children's Centres

A cross-sectional telephone survey with staff from all Sure Start Children's Centres in Southampton, Gosport and Havant were completed from August to October 2011. Data collection closely followed the Southampton Initiative for Health follow-up survey and was completed by two researchers. Permission was sought from all Sure Start Children's Centre managers to complete telephone interviews with a convenience sample of three staff members from their centre.

7.2.4 Organisational nutrition environment tool development

An audit tool was designed to assess three exposures within Sure Start Children's Centres that were identified in the literature review (section 2.5.3) as contributing to healthier organisational nutrition environments: *food policies (or guidelines), healthy eating ethos* and *healthy eating information. Barriers to promoting healthy eating* were also assessed in order to identify potential areas for future intervention. The audit tool and survey protocol are available in Appendices I and J.

The existence and content of *food policies* were assessed using 21 questions adapted from two previous scales designed to assess childcare centres and kindergartens.[332 333] One question asked about the existence of a food policy and whether it was verbal or written. Thirteen questions were about the foods included in the policy, where response options were yes, no or unsure. Five questions were about who the policy was applicable to – children, parents and/or staff. One question asked whether staff explained the policy to parents. A final question asked how often parents provide food contradicting the policy. Response options for these questions ranged from never (zero) to always (three).

Each centre's *healthy eating ethos* was examined by 14 questions that were adapted from three previous scales used to assess childcare centres and kindergartens.[332 333 335] Eleven questions asked about practices during meal or snack time. Two questions were used to ask how often healthy eating was discussed with parents and how often activities were specifically about healthy eating. Response options for these questions ranged from never (zero) to always (three). Negatively worded questions were reverse coded. A final question used a ten-point Likert scale to measure how important healthy eating was relative to other educational topics.

The availability of *healthy eating information* within each centre was assessed via six questions adapted from a previous scale.[332] The questions asked about the availability of printed material, courses/activities and healthy food access schemes. Response options ranged from not available (zero) to readily available (two).

Barriers to promoting healthy eating were assessed via seven questions adapted from a tool to examine kindergartens,[333] such as food safety regulations, confidence in discussing healthy eating and access to nutritional expertise. Response options ranged from not a problem (zero) to major problem (two).

The tool was piloted with staff working at the Medical Research Centre Lifecourse Epidemiology Unit to assess the face validity of the questionnaire and duration of the interview. Four staff members participated: two administrative personnel and two junior researchers. On average, the survey took 11.30 minutes to administer, with times ranging from 9.45 to 15.40 minutes. Minor wording changes were made to three questions to improve comprehension.

7.2.5 Score development

Responses from participating staff members of the same centre were averaged to provide a single response from each centre for each question in the survey. Scores for the four organisational nutrition environment domains were then calculated for each centre by summing the mean response to the relevant questions for each domain. Higher scores represented healthier nutrition environments for *food policy, healthy eating ethos* and *healthy eating information*. Lower scores for *barriers to promoting healthy eating* characterised healthier environmental exposure.

An overall Sure Start Children's Centre nutrition environment score was created for each centre. Factor analysis showed that the four domains represented a single factor (eigenvalue >1.0). Additionally, results from a principal components analysis on the four domain scores were highly correlated on the final summed score (r=0.99). Three steps were involved in calculating the overall score: *i)* standardising the total score for each domain, *ii)* summing the standardised *food policy, healthy eating ethos* and *healthy eating information* scores, and then subtracting standardised *barriers to promoting healthy eating* scores, and *iii)* standardising the overall scores to have a sample mean of zero (SD: 1).

7.2.6 Statistical analyses

Descriptive characteristics about the Sure Start Children's Centres surveyed were presented in tables or histograms. In order to test hypothesis one, Spearman test for trend was performed to examine differences in the four organisational nutrition environment domains and the overall score across the five levels of LSOA deprivation.

Linear regression was used to test the second hypothesis, the relationship between mothers' dietary quality and the four organisational nutrition environment domains and overall score. A multivariable linear regression model, containing variables univariately associated with dietary quality at the level of $p<0.1$, explored the relative relationship between each of these variables and dietary quality. The final model involved step-wise backward elimination that included the covariates of age, number of children, seven levels of education, five levels of neighbourhood deprivation and Sure Start Children's Centre attendance over the past 18 months. All covariates were treated as continuous variables to test for trend.

Differences in organisational nutrition environment exposures across three levels of education were assessed using Spearman correlation to test for trend. To test hypothesis three, an interaction term for three levels of educational attainment and each exposure variable were added to all regression models. These models assessed whether educational attainment moderated the relationship between dietary outcomes and the organisational nutrition environment. Models were then stratified to identify the separate effects across low, mid and high educational attainment.

7.3 Organisational nutrition environment results

Information about the nutrition environment of all 28 Sure Start Children's Centres in the study area was collected; 14 centres were located in Southampton, eight in Havant and six in Gosport. Only five centres (18%) sold food from a café onsite. However, 86% of centres reported providing food.

A total of 86 staff completed the telephone interviews where two to five staff participated from each centre and 57% of centres had three staff members who participated. Table 7-1 describes the distribution of staff positions who participated in the surveys.

Table 7-1 Distribution of staff positions that participated in the organisational nutrition environment survey

Staff position	**n**	**%**
Management	20	23
Health staff	8	9
Community staff	14	16
Family support staff	15	18
Play staff	15	18
Administration support	14	16
Total	86	100

The median *food policy* score was 39 (IQR: 34, 41), where scores could theoretically range from zero to 49. Figure 7-1 illustrates that most Sure Start Children's Centres had high *food policy* scores and reported that healthy eating considerations were made when providing food.

The mean *healthy eating ethos* score was 40 (IQR: 37, 42), with the possible range from zero to 49. Figure 7-1 shows that many Sure Start Children's Centre activities promoted healthy eating and that healthy eating was a priority area within these centres.

The median *healthy eating information* score was nine (IQR: 8, 10), where scores could theoretically range from 0 to 12. Figure 7-1 shows that many Sure Start Children's Centres had high information scores indicating that information about healthy eating was generally readily available in these centres.

The median *barriers to promoting healthy eating* score was three (IQR: 2, 4), with possible scores ranging from zero to 21. Figure 7-1 shows that staff across Sure Start Children's Centres reported few barriers to promoting healthy eating.

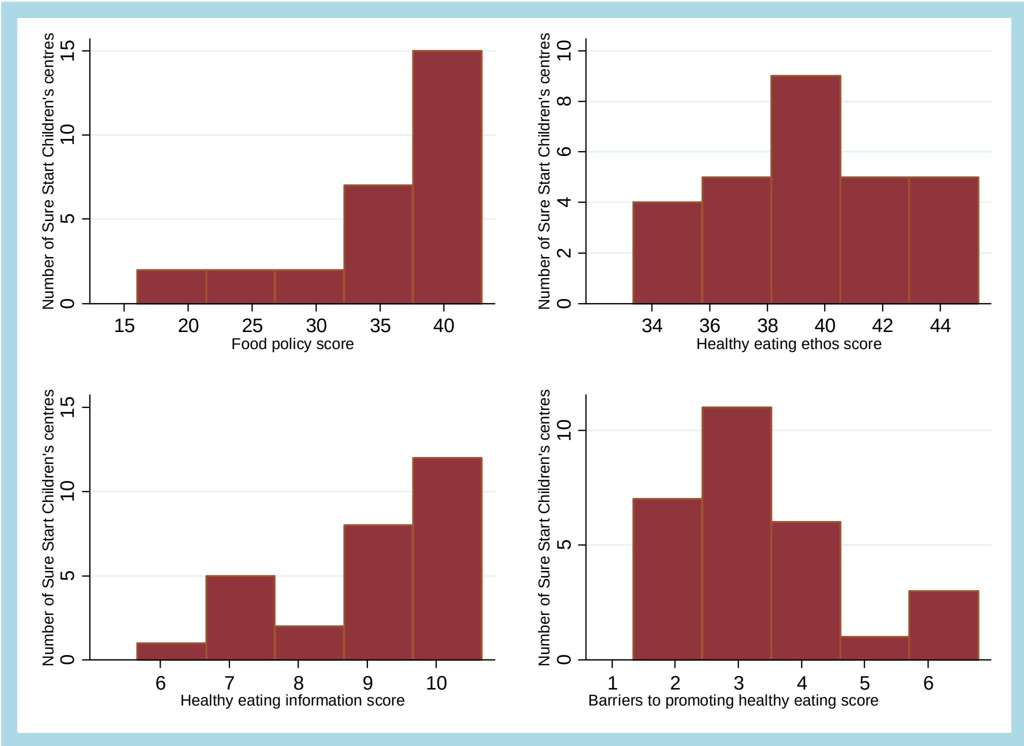


Figure 7-1 Distribution of food policy, healthy eating ethos, healthy eating information and barriers to promoting healthy eating across 28 Sure Start Children's Centres

The mean score for the overall nutrition environment was zero (SD: 1), where scores ranged from -2.7 to 1.8. Figure 7-2 illustrates the overall nutrition environment of Sure Start Children's Centres across the study area. The nutrition environments of some centres were noticeably worse than others.

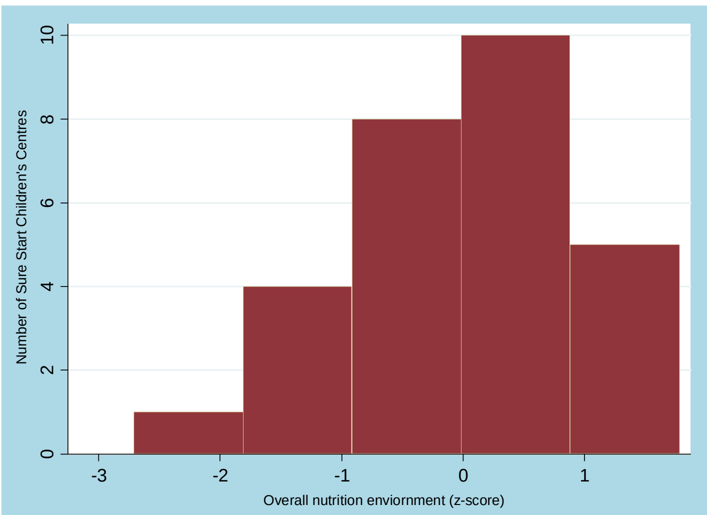


Figure 7-2 Distribution of the overall nutrition environment in Sure Start Children's Centres in the study area

7.3.1 AIM 1: Does the nutrition environment of Sure Start Children's Centres differ by LSOA deprivation quintiles?

In this section, hypothesis one is assessed. Differences in the overall nutrition environment, and the four domains, of Sure Start Children's Centres across English quintiles of LSOA deprivation are examined.

Table 7-2 presents the distribution of Sure Start Children's Centres across LSOA deprivation quintiles. More than half of all centres (60%) considered in this study were located in the most deprived and second most deprived neighbourhoods. Less than five per cent of centres were located in the most affluent neighbourhoods.

Table 7-2 Distribution of Sure Start Children's Centres within the study area across LSOA deprivation quintiles

LSOA deprivation quintiles	n	%
Most deprived	11	39
2	6	21
3	8	29
4	2	7
Least deprived	1	4
Total	28	100

Table 7-3 shows the differences in the four organisational nutrition environment domains and the overall score according to level of LSOA deprivation. Reported *barriers to promoting healthy eating* decreased as neighbourhood affluence increased ($p=0.004$, Figure 7-3). *Food policy, healthy eating ethos* and *healthy eating information* did not differ according to neighbourhood deprivation (all $p>0.1$). The overall score showed a trend towards higher scores and healthier nutrition environments for centres located in more affluent neighbourhoods. However, the association was not significant ($p>0.1$).

Table 7-3 Median, interquartile range and correlation of the nutrition environment domains of Sure Start Children's Centres across LSOA deprivation quintiles

Nutrition environment domains	LSOA deprivation quintiles					
	Most deprived	**2**	**3**	**4**	**Least deprived**	
	Median (IQR)					p-value[a]
Food Policy	40 (23, 41)	38 (30, 41)	35 (34, 37)	42 (41, 43)	41 (41, 41)	0.6
Health eating ethos	40 (39, 43)	40 (35, 42)	39 (37, 40)	43 (40, 45)	36 (36, 36)	0.4
Healthy eating information	9 (9, 10)	10 (9, 10)	8 (7, 9)	10 (10, 11)	9 (9, 9)	0.9
Barriers to promoting healthy eating	4 (3, 6)	3 (1, 4)	3 (2, 3)	2 (2, 3)	2 (2, 2)	0.004
Overall score	-0.1 (-1, 0.3)	0.5 (-0.7, 1)	-0.1 (-0.6, 0.2)	1.3 (0.9, 1.8)	0.2 (0.2, 0.2)	0.4

[a]Spearman test for trend across

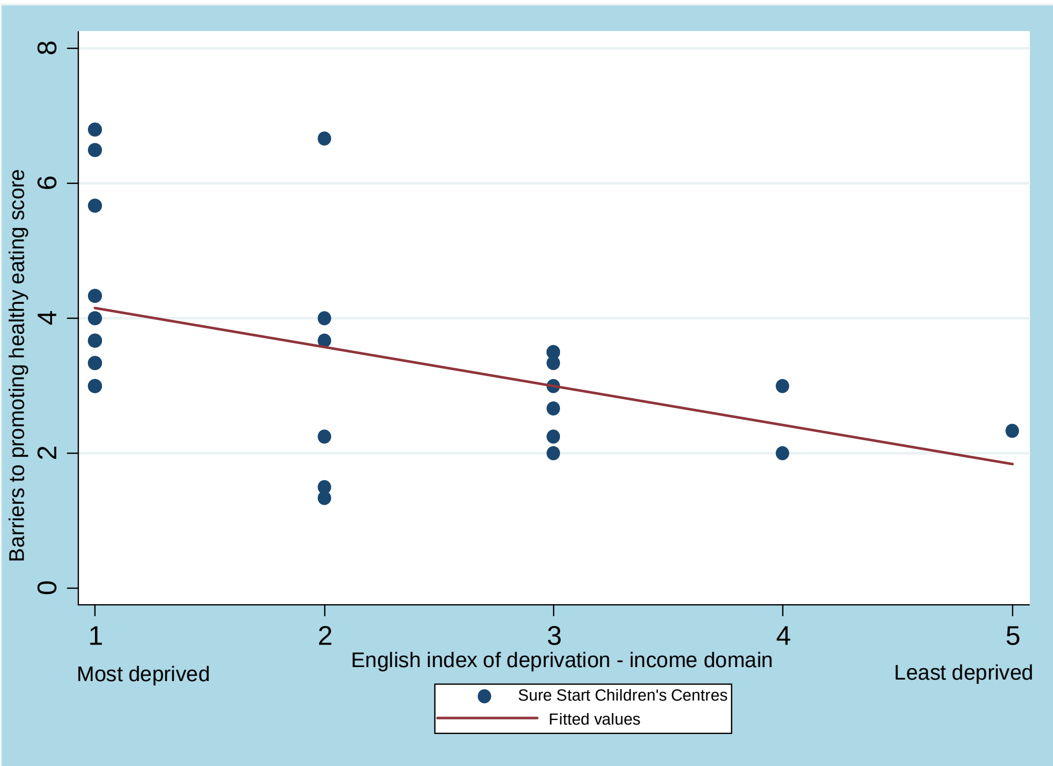


Figure 7-3 Scatter plot of the relationship between barriers to promoting healthy eating scores by LSOA deprivation quintiles

7.3.2 AIM 2: Is the Sure Start Children's Centre nutrition environment associated with dietary quality?

In this section, hypothesis two is assessed. The relationships between the overall nutrition environment, and the four domains, of mothers' Sure Start Children's Centres and their dietary quality are examined.

The data from 921 mothers were matched with 27 surveyed Sure Start Children's Centres: 14 located in Southampton, seven in Havant and six in Gosport (one centre in Havant was not used by this sample of mothers). Mean dietary quality score for this sample of mothers was zero (SD: 1), mean age was 32 years and most mothers (80%) had one or two children. The greatest proportion of mothers (39%) attended their Sure Start Children's Centre one or two times a week. One sixth of mothers reported never attending their Sure Start Children's Centre in the past 18 months. Only 1% reported attending their centre once a day or more.

The distribution of the four organisational nutrition environment domains of the 27 matched centres mirrored the distributions of the scores described above (Figure 7-1). Most centres had high scores for *food policy, healthy eating ethos* and *healthy eating information,* and reported few *barriers to promoting healthy eating*. The overall organisational nutrition environment score was slightly lower than observed above (Figure 7-2) for the full sample of Sure Start Children's Centres, with a median overall score of -0.1 (IQR: -1, 0.9).

Figure 7-4 shows the relationship between mothers' dietary quality and the four organisational nutrition environment domains. These graphs suggest that better *food policies* and greater availability of *healthy eating information* were related to poorer dietary quality, while centre's *healthy eating ethos* and *barriers to promoting healthy eating* were not associated with diet.

Univariate analyses confirmed a significant negative relationship between dietary quality and *food policy* scores ($\beta = -0.02$; 95% CI: -0.03, -0.01) and the availability of *healthy eating information* ($\beta = -0.1$; 95% CI: -0.14, -0.05). Centre's h*ealthy eating ethos* and *barriers to healthy eating* scores were not associated with mothers' dietary quality (both $p > 0.1$). In the multivariate model, only *food policy* remained a significant predictor of dietary quality, however, the effect size was small (Table 7-4). The univariate food policy model explains two percent of the variance in dietary quality and the multivariate model explained 21%.

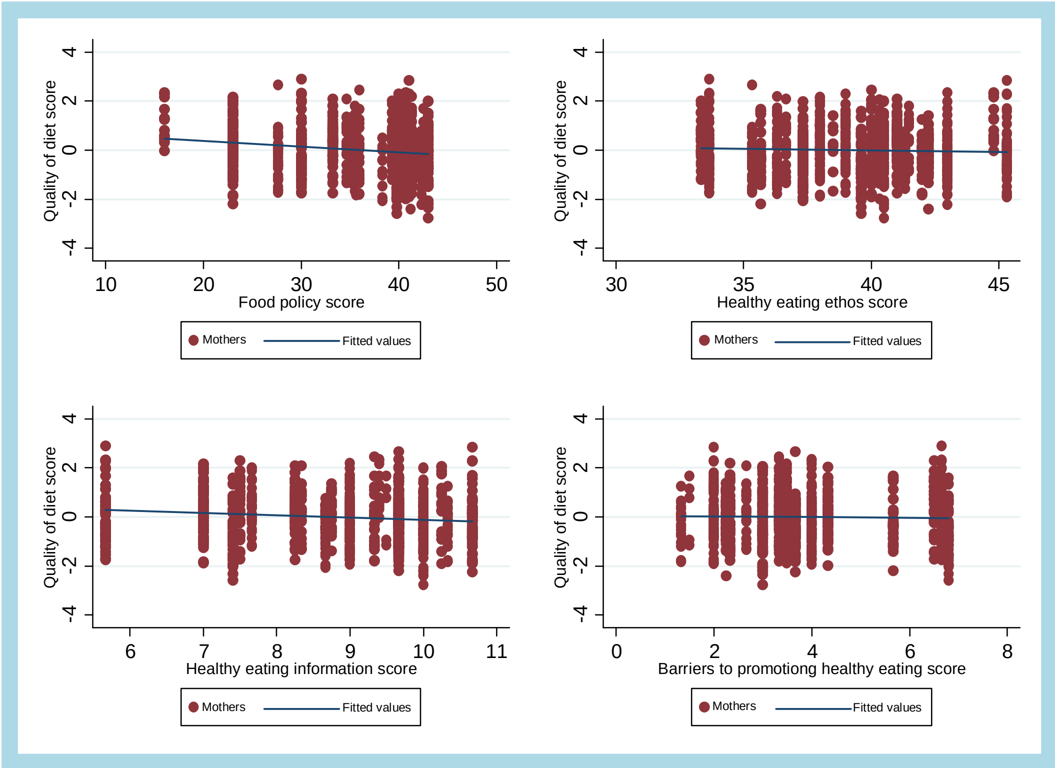


Figure 7-4 Scatter plots of mothers' quality of diet scores by four domains of the nutrition environment of their Sure Start Children's Centres

Table 7-4 Multivariate regression model of mothers' dietary quality and the food policy scores of their Sure Start Children's Centres

	Dietary quality (SD) **β (95% CI)**	p-value
Food policy score	-0.01 (-0.02, 0.02)	0.01
Education (7 levels)	0.22 (0.17, 0.26)	<0.001
Age (years)	0.03 (0.02, 0.04)	<0.001
Number of children	-0.08 (-0.15, -0.02)	0.01
Neighbourhood deprivation (quintiles)	0.08 (0.03, 0.13)	0.003

Figure 7-5 presents the relationship between overall nutrition environment of Sure Start Children's Centre and mothers' dietary quality. This graph suggests that mothers attending Sure Start Children's Centre with more health promoting nutrition environments have poorer dietary quality. Univariate analysis confirmed this relationship (β= -0.09; 95% CI: -0.15, -0.03). The adjusted model showed that for each standard deviation increase in overall organisational nutrition environment score, mothers' dietary quality decreases by 0.07 SD (Table 7-5). This adjusted model explained 21% of the variance in dietary quality and the univariate model explained two percent of the variance.

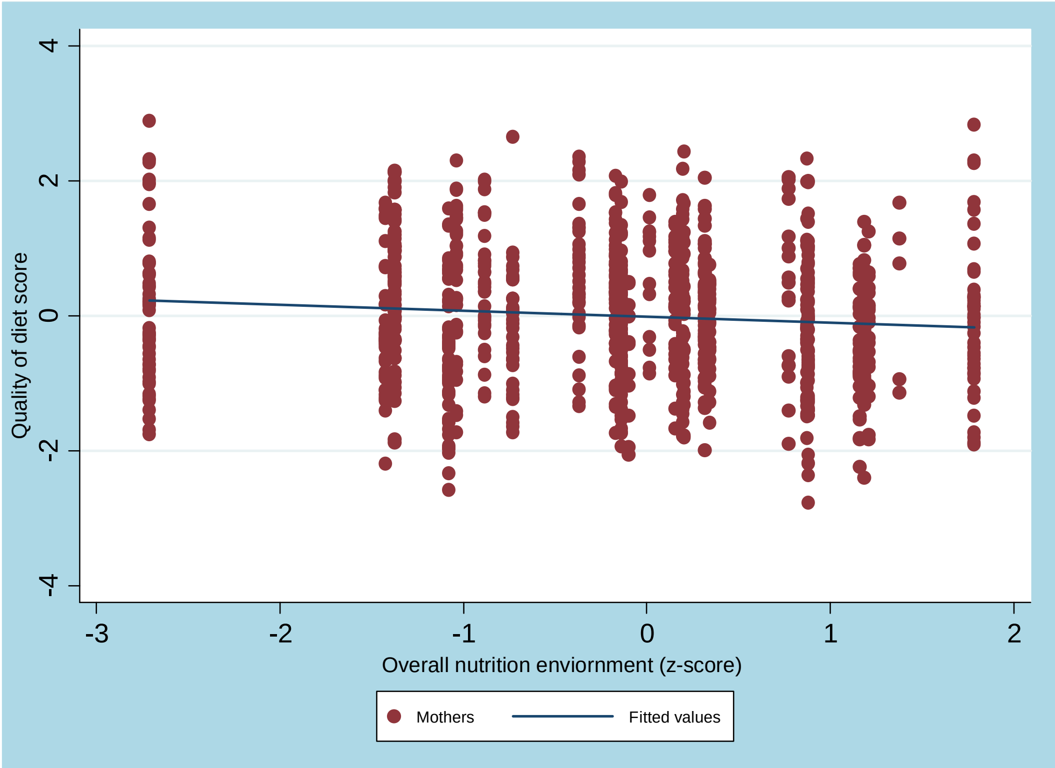


Figure 7-5 Scatter plot of mothers' quality of diet scores by the overall nutrition environment of their Sure Start Children's Centres

Table 7-5 Multivariate regression model of mothers' dietary quality and the overall nutrition environment of their Sure Start Children's Centres

	Dietary quality β (95% CI)	p-value
Overall nutrition environment score	-0.07 (-0.13, 0.02)	0.01
Education (7 levels)	0.22 (0.17, 0.26)	<0.001
Age (years)	0.03 (0.02, 0.04)	<0.001
Number of children	-0.09 (-0.15, -0.02)	0.01
Neighbourhood deprivation (quintiles)	0.08 (0.03, 0.13)	0.001

7.3.3 AIM 3: Is there a modification effect of education on the Sure Start Children's Centre nutrition environment and dietary quality associations?

In this section, hypothesis three is assessed. The moderation effect of three levels of educational attainment on Sure Start Children's Centre nutrition environment exposure and dietary behaviour associations are tested. Initially, exposures are described according to mothers' levels of educational attainment.

Sure Start Children's Centre attendance differed by mother's level of educational attainment ($p=0.05$). Mothers with low educational attainment were more likely than mothers with higher educational attainment to attend their centre once a day or more, but were also more likely to never attend.

Almost all organisational nutrition environment exposures showed variation by mothers' levels of educational attainment (Table 7-6). *Food policy, healthy eating ethos, healthy eating information* and overall nutrition environment scores were poorer in Sure Start Children's Centres attended by mothers with high educational attainment than for mothers with lower educational attainment. Conversely, *barriers to promoting healthy eating* were greater in Sure Start Children's Centres attended by mothers with low educational attainment than by those with higher educational attainment.

Effect modification of level of educational attainment, a known associate of dietary inequalities, was tested to assess differences in environmental exposures and dietary outcome. Evidence of an interaction between education and organisational nutrition environment exposures was considered when $p<0.1$.

Table 7-6 Organisational nutrition environment exposures by level of educational attainment

	Educational attainment			
	Low (≤GCSE) n=327	**Mid** (A-level/HND) n=321	**High** (Degree) n=260	
	Median (IQR)			p-value[a]
Nutrition environment exposures of Sure Start Children's Centres				
Food policy	40 (35, 41)	41 (35, 41)	36 (30, 41)	<0.001
Health eating ethos	40 (37, 41)	40 (37, 42)	39 (37, 41)	0.3
Healthy eating information	9 (7, 10)	10 (8, 10)	8 (7, 10)	0.003
Barriers to promoting healthy eating	4 (3, 6)	3 (3, 4)	3 (3, 4)	0.01
Overall score	-0.1 (-1.1, 0.9)	0.2 (-0.7, 0.9)	-0.2 (-1.0, 0.3)	0.05

[a] Spearman test for trend

Evidence for effect modification by level of educational attainment was observed for relationships between dietary quality and *barriers to promoting healthy eating* and overall organisational nutrition environment (p=0.004 and p=0.02 respectively). For both of these interactions, differences were identified between low and high levels of educational attainment.

Figure 7-6 displays the stratified analyses for *barriers to promoting healthy eating* which had: a weak negative association with dietary quality among mothers with low educational attainment (β= -0.06; 95% CI: -0.12, 0.01), no significant association with dietary quality among mothers with mid educational attainment (β= 0.0; 95% CI: -0.07, 0.07), and a positive association among mothers with degrees (β= 0.09; 95% CI: 0.01, 0.16). After adjustment for covariates, the relationship among mothers with low educational attainment attenuated (p>0.1). However, the relationship among mothers with high educational attainment was retained (β= 0.18; 95% CI: 0.10, 0.27). This model explained four percent of the variance in dietary quality.

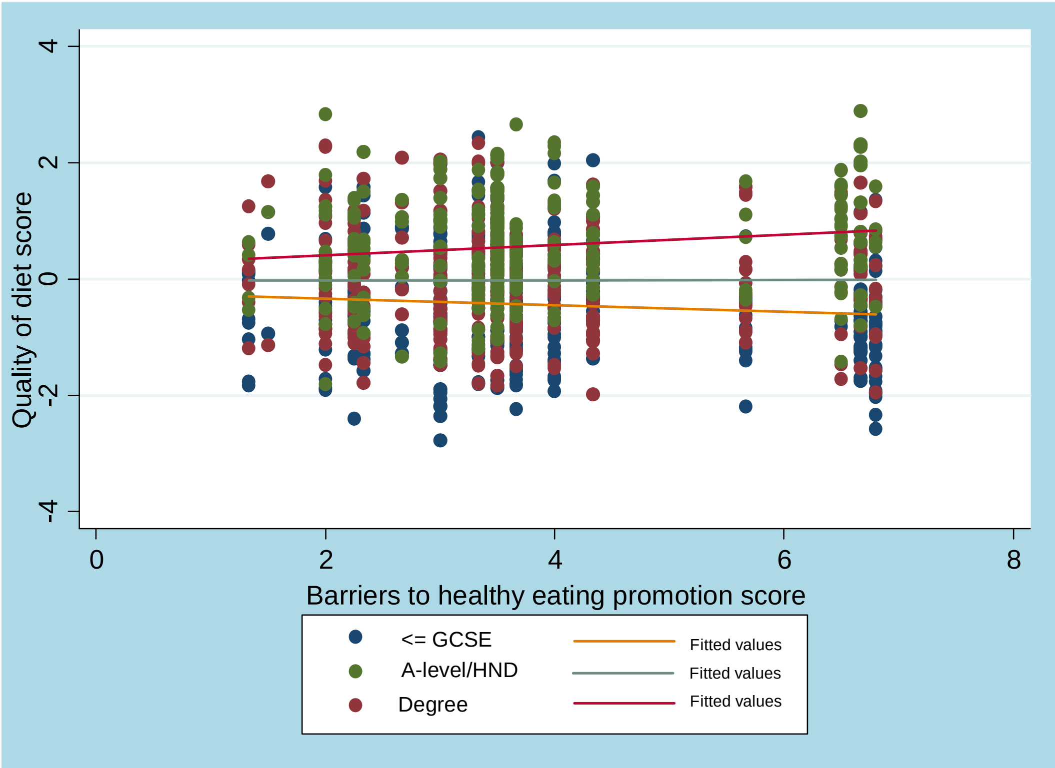


Figure 7-6 Mothers' dietary quality scores and the barriers to promoting healthy eating scores for their Sure Start Children's Centres according to level of educational attainment

Differences in the direction of the relationships between dietary quality and overall nutrition environment score by level of educational attainment were observed. The associations among mothers with low and mid educational attainment were not significant ($p>0.1$). A positive trend was identified among mothers with low educational attainment, while the direction of association was negative among mothers with higher levels of education. After adjustment for covariates, healthier Sure Start Children's Centre nutrition environments were associated with poorer dietary quality among mothers with degrees (β= –0.19; 95% CI: –0.29, –0.09).

7.4 Discussion

7.4.1 Summary of findings

Most Sure Start Children's Centres (60%) in the study area were located in the most deprived and second most deprived neighbourhoods according to English quintiles of deprivation.

The findings from this chapter provide weak support for hypothesis one. The food policies, healthy eating ethos and information, and overall nutrition environment of Sure Start Children's Centres did not differ by level of neighbourhood deprivation. However, there was a trend towards centres located in more affluent neighbourhoods having better overall nutrition environments. There was also strong evidence for staff in centres located in more affluent neighbourhoods reporting fewer barriers to promoting healthy eating than those in more deprived neighbourhoods.

There was support for hypothesis two. Healthier Sure Start Children's Centre nutrition environments were associated with dietary quality, but in the opposite direction to expected. Mother's that attended Sure Start Children's Centres with healthier overall nutrition environments consumed green salad vegetables up to four times *less* per week than mothers who attended centres with poorer overall nutrition environments. Of the individual domains, only the content of food policies was associated with mother's dietary quality. This association was also negative, where healthier food policies corresponded with poorer quality diets, though the effect size was small.

There was some support for hypothesis three: level of educational attainment moderated the relationship between mothers' dietary quality and the nutrition environment of their Sure Start Children's Centres. Among mothers with low educational attainment, those who attended Sure Start Children's Centres where staff reported fewer barriers to promoting healthy eating consumed green salad vegetables up to four times *more* each week than those who attended centres where staff reported more barriers. This relationship attenuated after adjustment for individual covariates, such as age and neighbourhood deprivation. Among mothers with high educational attainment, the opposite relationship was observed: higher reported barriers to promoting healthy eating was associated with better dietary quality. Similar directional differences by level of educational attainment were observed for the relationship between overall Sure Start Children's Centre nutrition environment and dietary quality. Among mothers with low educational attainment, healthier overall nutrition environments were associated with better dietary quality, while among mothers with degrees, healthier overall nutrition environments were associated with poorer dietary quality. However, only the relationship among mothers with degrees was statistically significant.

7.4.2 Comparison with previous research

This study is the first, to the author's knowledge, to assess differences in the nutrition environment of early childhood facilities according to area deprivation. The results showed a trend for poorer nutrition environments in Sure Start Children's Centres located in more deprived neighbourhoods. However, this trend was not significant, providing evidence against hypothesis one. Regional differences in obesity-related practices in the Head Start programme in the US, which provided the model for Sure Start in the UK, have been assessed. A summary score from 15 questions to represent the healthy eating practices in each centre nationally were created.[330] Healthy eating scores differed significantly according to geographic region although they did not vary according to a rural/urban classification continuum. The healthy eating scores for New England, Pacific and Middle Atlantic regions were higher than other regions. The authors speculated that these differences related to variations in regional policies, socioeconomic norms or economic conditions.

All centres in the current study had some form of written or verbal food policy. This finding was better than an evaluation of food and health activities in Sure Start Children's Centre in the West Midlands, which found that 68% of the 162 participating centres had a food policy.[325] The high prevalence of food policies in the current study differs from previous qualitative research in Southampton which found that only one out of the eight centres interviewed reported having a food policy.[162] The differences in these Hampshire based studies may relate to a range of early childhood settings being included in the qualitative study, such as child-minders and pre-schools, in addition to Sure Start Children's Centres. The literature review for this study (section 2.4.3.3) identified considerable variation in food policy existence and content across geographic locations. However, the results in this chapter showed no difference in food policy existence or content by neighbourhood deprivation quintiles. Similarly, no differences in centres' healthy eating ethos or availability of healthy eating information and activities related to healthy eating according to neighbourhood deprivation were observed in this study. The medium to high ethos and information scores across the centres in this study suggest that staff and management generally support families to adopt healthy dietary behaviours and that nutrition-related information and activities are available to parents. These results are consistent with the evaluation of Sure Start Children's Centres in the West Midlands which found that 86% of responding centres delivered cooking activities, 54% delivered weight management programmes and 57% offered food-related gardening activities.[325] Additionally, qualitative work with early childhood facilities in Southampton found that staff generally reported modelling good meal and snack time behaviours by sitting with children and consuming some of the provided food.[162]

Interestingly, the results of this study showed that barriers to supporting healthy eating were reported more frequently in Sure Start Children's Centres located in more deprived areas than those located in more affluent areas. This finding may be interpreted from qualitative research with practitioners working in early childhood settings.[162] Interviews with a range of practitioners in Southampton identified that integrated centres, such as Sure Start Children's Centres, which provide a range of services including health, social and training services, frequently find that competing interests, such as child protection, take priority over nutrition.[162] Focus groups with Sure Start Children's Centre staff also highlighted that barriers to healthy eating that are raised by mothers often include issues, such as the cost of healthy food or finding the time to cook from scratch. These barriers were considered challenging for staff and beyond the scope of the centres' sphere of influence.[336] In addition, Sure Start Children's Centre staff commonly live in the same communities as their centre and those in more deprived neighbourhoods may be experiencing similar barriers to healthy food choices as the families they work with. Furthermore, access to and utilisation of professional nutrition advice has been reported as an issue, with many staff members reporting they rely on magazines, the internet or parents for nutrition information.[162] Poor nutrition knowledge has been cited as a factor that may inhibit staff confidence to discuss healthy eating with parents.[159]

The association between healthier overall nutrition environment of Sure Start Children's Centres and poorer dietary quality provides evidence for hypothesis two but in the opposite direction. Although no previous study has investigated the relationship between the nutrition environment of children's development centres and parental dietary behaviours, the findings of this study differs from previous research on children's diets. In the Netherlands, an observational investigation showed that several environmental factors of childcare facilities were associated with the dietary intake of two and three year old children.[327] In particular, children ate more food when staff sat with them and ate more fibre when staff spoke about healthy eating. Several intervention studies have also shown associations that differ from the finding of this study, although parental dietary behaviour were not assessed. Interventions containing nutrition education for parents and children, healthier food provision and adoption of food policies were associated with better dietary behaviours among children.[159 334]

The results of this chapter revealed that food policy was the only individual nutrition environment domain that significantly predicted mothers' dietary quality, although the effect size was small and the relationship was negative. These unexpected relationships between healthier environmental exposures and poorer dietary quality may in part be explained Sure Start Children's Centres being initially established in communities of very high deprivation.[178] Sure Start Children's Centres in the most disadvantaged areas of Southampton[179] were among the first to be opened, before the programme was expanded in an attempt to reach all families with children under the age of five years.[337] The older Sure Start Children's Centres were often purpose built buildings,[338] and are more likely than newer centres to have developed food policies, facilities for cooking and weight management courses, and provided staff with nutrition training opportunities. However, despite these healthy environmental exposures in Sure Start Children's Centres, areas of higher deprivation are known to have greater numbers of takeaway and fast food outlets,[78 235] and poorer variety and quality of healthier foods[110] than more affluent areas, which may exert greater influence over mothers' dietary intake. Individuals living in disadvantaged neighbourhoods have poorer dietary patterns and cite more barriers to healthy eating than those in more affluent neighbourhoods.[35 39] While national evaluation of Sure Start Children's Centres indicate positive outcomes in children and families who use these services,[339] significant changes in health and behavioural outcomes may take decades to be observed.[338]

The results of this study identified differences in three nutrition environment domains and overall nutrition environment of Sure Start Children's Centres by mothers' levels of educational attainment. These findings contrast with research in the US which found no difference in nutrition environment summary scores of 1810 Head Start programmes by highest parental education.[330] The variation in results between studies may be partly explained by the focus of the Head Start programme on socioeconomically disadvantaged families, unlike Sure Start which was broadened to reach all families.[337] Additionally, Head Start programmes are required to abide by federal program performance standards.[330]

The results of this chapter also identified significant interactions between mothers' levels of educational attainment and two nutrition environment exposures of their Sure Start Children's Centres which provides evidence to support hypothesis three. Among mothers with low educational attainment, fewer barriers and healthier overall nutrition environments were linked to better dietary quality. However, among mothers with degrees these relationships were reversed, such that fewer barriers and healthier overall scores were associated with poorer dietary quality. These results are consistent with the stratified analyses for the community nutrition environment (section 5.4.2) and the consumer nutrition environment (section 6.4.2). In each of the data chapters, directional differences in relationships between environmental exposures and dietary outcomes have been observed, where healthier environments are linked with better dietary behaviours among mothers with low education but poorer dietary behaviours among mothers with high educational attainment. These results suggest that interactions with environmental exposures differ according to level of educational attainment and may indicate greater susceptibility to environmental exposures among more disadvantaged mothers, while those with higher educational attainment show greater resistance to poorer environmental exposures.

7.4.3 Strengths and limitations

This study is the first to assess differences in the nutrition environment of Sure Start Children's Centres by level of neighbourhood deprivation. The nutrition environment was measured using a novel score that characterised several domains that represent the nutrition environment across other organisations including early childhood facilities, workplaces and churches. The overall score was standardised to provide a robust measure that could be used to quantitatively assess associations between the nutrition environment and dietary quality. The overall measure could also be useful in future research to assess environmental changes over time or evaluate the effects of nutrition focused interventions in Sure Start Children's Centres. Previous studies have not investigated the relationship between the nutrition environment of children's development centres and parental dietary intake. Unlike childcare facilities, parents attend children's development centres with their children and many activities are targeted towards parents. Exposure to such environments has been shown to influence parenting behaviours[339] and could also affect healthy lifestyle behaviours.

The tool used in this study was designed specifically to measure the nutrition environment of Sure Start Children's Centres and included questions relating to staff and parents. One limitation of this study is that the reliability and validity of this novel tool was not assessed. However, tools which had shown adequate reliability and validity formed the basis of questions included in the current study's questionnaire.[332 335] A further limitation was the reliance on self-reported data from staff. This study did however obtain responses from a number of staff from each centre in an attempt to increase the accuracy of results. This approach is likely to be advantageous when compared to previous work that relied solely upon director/manager responses.[326 330] The use of interviews by trained researchers according to a survey protocol was also a strength that ensured questionnaires were completed and that responses were not missed as can occur with self-completion questionnaires. However, the results of this study remain subject to response bias and are unlikely to be as accurate as studies which conducted observations of practices within early childhood facilities.[327 340] Another limitation was the use of a convenience sample of staff from each centre and the variations in the number of staff recruited from each centre. Staff were identified through managers, who may have introduced selection bias by choosing staff that would answer the questionnaire in a manner that positively reflected the centre and/or limiting the number of staff members involved. The number of centres included in this study was small compared to previous studies in childhood settings.[325 326 330] Moreover, the areas included in this study may not be representative of other areas across England thus limiting the generalizability of these findings. Finally, the use of an aggregated overall score to measure the nutrition environment may obscure meaningful differences in individual items, although the calculation of domain scores for food policy, healthy eating ethos, healthy eating information and barriers to promoting healthy eating somewhat overcomes this limitation.

7.4.4 Policy and research implications

Sure Start Children's Centres were a fundamental component of the Blair/Brown Labour government (1997–2010) efforts to tackle child poverty and prevent transmission of inequalities in health.[178] Under the Cameron conservative coalition government (2010–), funding for Sure Start Children's Centres has not been protected from wide-spread cuts.[341] Ministers have elected to allow parents to choose their own care-providers supported by tax credits rather than a centrally run service[342] and have opted for the more traditional early childhood health service delivery through health visitors.[17] This change in service delivery threatens to further increase health and social inequalities in England. A recent review of National Health Service (NHS) expenditure highlighted that an absolute reduction in health inequalities occurred as a result of increasing the proportion of resources allocated to deprived areas compared with more affluent areas.[343] Improving the life chances of poor children and their families also requires additional funding above that allocated generally.[338] Sure Start Children's Centres have offered the most deprived neighbourhoods a place for young families to meet, learn and expand their life opportunities. Markers of progress have been observed through improved aesthetics of deprived communities, enhanced social development, and lower body mass index of children, better parenting behaviours and decreased workless household status.[338 339 344]

The results of this study showed that Sure Start Children's Centres generally offered healthy nutrition environments by providing healthy food and activities and information about healthy dietary habits. However, the results also highlighted that perceived barriers to promoting healthy eating are significantly greater among staff in centres located in the most deprived areas than those in more affluent areas. In deprived areas, the problems are many, and range from issues of violence, addiction, neglect and illiteracy to poor health. Lack of funding and limited resources means staff working in these areas have to prioritise certain activities to ensure the welfare of the families they are working with.[162 345] In addition, the barriers to eating healthily that are raised by parents are often considered beyond the influence or remit of Sure Start Children's Centre staff. In particular, the cost of healthy food, easy access to takeaway and fast food outlets, and time needed to prepare healthy meals.[39 345] Coming from the communities which they serve, some staff may be faced with these same challenges, thus further compounding the ability to support others make healthier food choices. Lack of staff knowledge and/or confidence in nutrition recommendations has also been cited as a potential barrier to staff promoting healthy eating.[162]

Providing regular training opportunities in nutrition is essential for staff at all levels, and particularly for those working in deprived areas. However, training alone does not necessarily increase staff members' confidence to engage in conversations about healthy eating with parents or promote healthy eating practices.[334] Support from managers and colleagues who have also been trained can provide an encouraging environment and further facilitate health promotion practices. Training in nutrition guidelines would be best supplemented with behaviour change training to motivate mothers to identify their barriers and possible solutions, which can enable them to make healthier food choices for their families.[180] Such exchanges can build trust between and self-confidence in both, practitioners and mothers.

The negative association that was observed in this study between healthier nutrition environments of Sure Start Children's Centres and poorer dietary quality may indicate that mothers' exposures to these centres was not enough to affect their dietary choices. Although over a third of mothers reported attending their Sure Start Children's Centre once or twice a week, few mothers would spend the entire day at the centre because activities generally last no longer than two hours. Parental involvement in activities, such as developing or updating a food policy, determining the foods to be provided during workshops or voting on activities to run could further increase attendance and even enhance a sense of ownership in their centre. Gaining the trust of mothers from disadvantaged backgrounds is essential to successful service delivery and trust comes when services are permanent and adequately funded.[345] Sure Start Children's Centres in the most deprived areas of Southampton have been shown, over the decade they have been in place, to narrow the proportion of families they do not reach. To enable local successes in reducing inequality to continue, both local and national governments need to ensure Sure Start Children's Centres in the most disadvantaged communities are given adequate resources and financial support. Local health agencies could further support centres with regular training opportunities in nutrition and behaviour change. Researchers can also help to build the evidence for adequate funding by using measures, such as the tool developed in this study, to monitor changes in centres' nutrition environments over time, help design and evaluate interventions, and assess the relationship between nutrition environment and diet in children, parents and staff.

Future research could also explore the effect of other organisational nutrition environments, such as workplaces, on the dietary quality of mothers with young children. Of the total sample in this study, 41% of mothers reported working. The workplace nutrition environment may be another important local food environment exposure on the dietary behaviours of some mothers, particularly as the literature review (section 2.4.3.1) showed that better workplace nutrition environments had small positive effects on employees' dietary behaviours. The nutrition environments of other organisations, such as churches, schools or other early childhood settings, may also affect mothers' dietary behaviours.

7.5 Conclusion

This chapter examined the nutrition environment of Sure Start Children's Centres in the study area where mothers participating in this study were recruited. Four domains of the nutrition environment were measured, including food policy existence and content, healthy eating ethos, healthy eating information and barriers to supporting healthy eating. A standardised overall score including all four domains was calculated. A trend indicating poorer overall nutrition environments in Sure Start Children's Centres in more deprived neighbourhoods was observed but was not significant. Staff in centres located in the most deprived neighbourhoods reported more barriers to promoting healthy eating than those located in more affluent neighbourhoods. Mothers attending Sure Start Children's Centres with healthier overall nutrition environments consumed green salad vegetables up to four times less per week than mothers who attended centres with poorer overall nutrition environments. This result was surprising but may be partly explained by Sure Start Children's Centres initially bring established in communities of very high deprivation. These centres are likely to have well established policies and practices yet mothers living in these neighbourhoods may be exposed to greater numbers of takeaway and fast food outlets and poorer variety and quality of healthy foods, which, as reported in the two previous chapters, have stronger effects on their dietary behaviours. The nutrition environment of Sure Start Children's Centres showed differing effects on mothers with a low educational attainment and those with higher educational attainment. Among mothers with low educational attainment, fewer barriers and healthier overall nutrition environments were linked to better dietary quality. Among mothers with high educational attainment these relationships were reversed such that fewer barriers and healthier overall scores were associated with poorer dietary quality. These results suggest that interactions with environmental exposures differ according to level of educational attainment and may indicate greater susceptibility to environmental exposures among more disadvantaged mothers. Adequate committed funding and training opportunities in nutrition and behaviour change are crucial for Sure Start Children's Centres in the most disadvantaged communities to continue to support disadvantaged families. However, Sure Start Children's Centres are only one local food environment exposure and may not have as strong a relationship with dietary quality as other environmental or individual factors. The next chapter will concurrently examine the relative influence of the three local food environment exposures assessed in this study, as well as psychosocial and environmental perception factors on mothers' dietary behaviours.

Chapter 8 Combined model: the relative association between environmental, psychosocial factors and dietary quality

The conceptual model of the local food environment that has guided the hypotheses and design of this study posits that environmental determinants act on dietary behaviours directly and indirectly through individual factors (section 3.1 and Figure 3-1). The four previous chapters have examined how multiple variables which characterise mothers' individual determinants (psychosocial and environmental perceptions) and environmental determinants (the community, consumer and organisational nutrition environments) are associated directly with dietary quality, and how these associations vary according to level of educational attainment. In this chapter, hypothesis four of this study is tested.

4. **Psychosocial and environmental perception factors mediate associations between local food environment exposures and mothers' dietary behaviours.**

The indirect relationships between local food environment exposures and mothers' dietary behaviours through individual factors are assessed simultaneously alongside the direct relationships using structural equation modelling (SEM). SEM is a statistical technique that enables assessment of multiple and interrelated relationships and uses latent constructs to estimate relationships free of measurement error. The nutrition environments and individual factors examined in this study are characterised by several measured variables and latent constructs offer a valuable method of summarising such variables. A total of 22 observed variables significantly and adequately characterised seven constructs: community, consumer and organisational nutrition environments, mothers' psychological attitudes to healthy eating, perceived food affordability, perceived food accessibility and dietary behaviours. The results section shows how well the data explain the conceptual model, and describes the interrelationships observed between environmental, individual and dietary constructs for the full sample of mothers and for the three educational groups. The discussion summarises the chapter findings and highlights the policy and research implications of this work.

8.1 Background

As discussed in section 2.1, ecological models of health posit that health outcomes and behaviours are determined by a collection of fixed factors (i.e. age) and modifiable factors.[64] Modifiable determinants occur at several levels including environmental, social and individual, where multiple factors are nested within each level.[346] The Glanz model of nutrition environments is an ecological model that has been widely used to guide food environment research.[1] As highlighted in section 3.1 and in Figure 3-1, the conceptual framework underpinning the design and hypotheses of this thesis is an adaptation of the Glanz model for mothers with young children. The framework purports that three aspects of the physical environment – community, consumer and organisational nutrition environments – can affect dietary behaviours both directly and indirectly through individual factors. Chapters 4 to 7 described the direct relationships between dietary quality and a range of variables that characterise psychosocial and environmental perception factors, and the three nutrition environments. This chapter explores the indirect associations of the local food environment on dietary outcome, through both psychosocial and environmental perception factors. Few studies have investigated the mediation effects of both psychosocial and perceived environmental factors or the relative influence of these individual factors and environmental measures on dietary behaviours, and none have been from the UK.[56 111 114] Comprehensive assessment of relationships between environmental and individual factors, and dietary behaviour could help to identify the most effective points for future intervention to improve dietary choices.[78 210] SEM offers a useful analytical approach to understanding and untangling the complex web of direct and indirect associations the local food environment can have on health behaviours, such as diet.[79]

SEM is a statistical technique that enables assessment of multiple and interrelated relationships among variables.[347] As such, complex conceptual models outlining theoretically determined relationships between multiple variables can be tested.[348] SEM is the preferred method for confirming conceptual models quantitatively in psychological and social sciences, and is increasingly being used in biological and health research.[348 349] Advantages of using SEM over other multivariate analysis techniques include: *i)* simultaneous estimation of a series of separate but interdependent multiple regression equations, *ii)* better representation of theoretical constructs by using multiple observed measures thus reducing measurement error, *iii)* improved estimation of relationships between constructs by removing measurement error, and *iv)* an ability to examine group differences in complex conceptual models.[347–349]

SEM is based on linear regression and incorporates factor analysis for the creation of latent constructs. A latent construct, or factor, is an unobserved concept that is represented by a group of observed or measured variables with internal consistency. Latent constructs can provide better representation of theoretical concepts than single measures.[347 350] For example, the composite effect of the community nutrition environment represented by several measured variables (i.e. density, proximity and variety of food outlets and activity space spatial area) can be assessed. Using latent constructs in SEM also enables relationships between constructs to be estimated free of measurement error because the error for each construct is estimated and removed, leaving only common variance to calculate more accurate relationship estimates. The statistical goal of SEM is to test the entire set of relationships represented in the model using multiple equations. The observed covariance matrix among measured variables plus the hypothesised model are used to estimate parameters (path coefficients, variances and covariances of the independent variables). These estimated parameters are then combined using covariance algebra to produce an estimated population covariance matrix. Model fit is determined by the correspondence between the observed covariance matrix and the estimated population covariance matrix. If the hypothesised model accurately predicts all of the substantive relationships between constructs and the measured variables adequately define the constructs then the two covariance matrices should be closely matched and the relative relationships between constructs can be examined and interpreted.[347]

Defining a model in SEM involves a number of stages.[347] Initially, a conceptual framework or model explains a systematic set of relationships to provide predetermined hypotheses about a phenomenon. This model may have been informed by empirical evidence but is theoretical in nature. The model for this analysis is the model of the local food environment (described below in Figure 8-1). In SEM, a conventional model is then split into two models: *i)* **measurement model**–representing constructs and their measured variables, and *ii)* **structural model**–representing the relationships between constructs.

The next stage of SEM involves specifying and validating the measurement model. Specification refers to identifying the measured variables that represent each construct in the model. For example, ensuring that the five psychosocial variables (perceived control, self-efficacy, outcome expectancies, food involvement and social support) all represent the same underlying psychosocial process. The observed variables must be theoretically founded and show adequate relationship to the construct. Predefined scales can inform the selection of particular measured variables. However, in developing fields of research exploratory factor analysis is used to identify coherent subsets of measured variables to best represent a construct. Eigenvalues are commonly used to determine the number of factors a set of variables explains. Eigenvalues are the variance explained by the individual variables; values greater than one are considered to explain adequate variance (at least the variation of one measured variable).[350] Validation involves establishing acceptable goodness of fit for the measurement model and ensuring dependent measured variables are significantly and adequately related to their construct. In the final stage of SEM, the relationships between constructs are specified according to the conceptual model, and the goodness of fit of the structural model is tested. If the model fit is adequate, the significance and effect of the structural relationships can be interpreted as providing empirical evidence for or against the hypotheses. Both direct and indirect (or mediated) hypothesised relationships can be assessed in structural models.

Evaluating goodness of fit is traditionally indicated by non-significant Chi Squared statistic which confirms that the sample covariance matrix does not differ from the estimated covariance matrix.[350] However, with large samples trivial differences between the sample and population covariance matrices are often significant because the minimum of function is multiplied by the sample size minus one. Alternative goodness of fit measures, including the Comparative Fit Index (CFI), Goodness of Fit Index (GFI) and Adjusted Goodness of Fit Index (AGFI), are more reliable for larger samples.[350] Higher values are indicative of better fitting models. Root Mean Square Error of Approximation (RMSEA) and standardised Root Mean Square Residual (sRMR) are measures of badness of fit in which high values indicate poor model fit. These fit measures are also reliable for larger sample sizes. CFI and RMSEA are the most frequently reported fit indices and sRMR is recommended as a reliable measure to assess model fit.[351] If these fit indices indicate poor fit, post hoc modifications can be made to improve model fit.[347 350] A common modification technique is to add a covariance between the error terms of two measured variables, providing there is a theoretical justification for such a relationship. The most effective modifications that will improve model fit are those which will elicit the greatest change in the Chi Square statistic.

As described above, the conceptual framework guiding this study proposes that relationships between the local food environment and the dietary behaviour of mothers with young children can be direct or mediated by psychosocial and perceived environmental variables.[1] This chapter adds to the limited literature, particularly in the UK, by using SEM to examine the relative effects of environmental and individual factors on dietary behaviour. The specific aims of this chapter were to:

i) Determine whether associations between local food environment exposures and mothers' quality of diet are mediated by psychosocial and environmental perception factors (hypothesis four)
ii) Determine differences in these relationships across educational groups

8.2 Structural equation modelling methods

8.2.1 Mothers

Structural equation modelling requires a complete dataset with no missing values. Of the 921 mothers who took part in the Southampton Initiative for Health follow-up survey 82% (n=753) had complete individual data and lived and shopped for food within the study area. Compared to those with complete data, mothers who were excluded (n=168) had higher educational attainment but showed no difference in dietary quality score, age, number of children, or level of neighbourhood deprivation.

8.2.2 Conceptual model

The conceptual model of the local food environment and dietary quality that underpins this study forms the theoretical foundation for the structural equation modelling analyses. In the model (Figure 8-1), the community, consumer and organisational nutrition environments have direct effects on maternal dietary quality, while psychosocial factors and perceptions of the local food environment mediate these relationships between environment exposures and dietary quality. The model also suggests that individual socioeconomic factors, in this case level of educational attainment, can moderate these relationships.

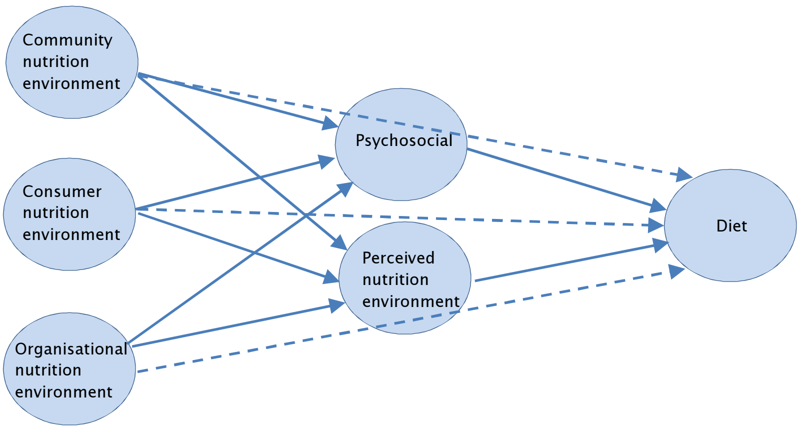


Figure 8-1 Conceptual model of the local food environment and dietary quality adapted from the model of nutrition environments[1]

8.2.3 Measures

8.2.3.1 Dietary outcome

Four dietary outcomes were selected to describe the latent diet construct: dietary quality score, fast food intake, takeaway intake and fruit intake. Creation of mothers' dietary quality scores is described in section 4.2.2.1 and, fast food and takeaway intake measures are indicated in 4.2.2.2. Positive dietary quality scores described higher consumption of vegetables and wholemeal bread and negative scores described higher intakes of processed meats, white bread and sugar. Higher scores on fast food and takeaway measures indicate more frequent consumption of these foods. Fruit intake was assessed by a question that asked mothers to indicate how often in the previous month they consumed fresh fruit (seven point scale from never to more than once a day). Exploratory factor analysis showed that these four variables loaded onto a single factor using the criteria eigenvalue greater than 1.0[350] and factor loadings greater than 0.32[352]. The total variance explained by the factor was 23%.

8.2.3.2 Local food environment variables

Five variables of mothers' activity spaces were chosen to describe the

community nutrition environment latent construct because activity space measures provide more realistic measures of food outlet accessibility than residential exposure measures.[241 242] The five variables included: time to main supermarket (section 5.2.5.3), healthy food environment score and less healthy food environment score (section 5.2.5.1), variety of supermarkets (5.2.5.2) and square kilometre of individual activity space (5.2.4.2). Exploratory factor analysis showed that time to main supermarket had a small factor loading (<0.32) and was therefore omitted. The four remaining variables loaded adequately onto a single factor (eigenvalue >1.0). The total variance explained by the factor was 46%.

The **consumer nutrition environment** latent construct was described by the composite score of healthfulness of mothers' main food stores. Creation of this composite score is described in section 6.2.6. The single composite score was used because principal components analysis and factor analysis showed no interpretable patterns and conceptually each of the nine components were considered to be important indicators of the in-store environment. A higher composite score represented more healthful supermarket environments. Internal consistency of the composite score of healthfulness was high (α=0.86).

The four variables that described the **organisational nutrition environment** of mothers' Sure Start Children's Centres were: food policy content, centre healthy eating ethos, availability of healthy eating information and barriers to promoting healthy eating. A detailed description of these measures is provided in section 7.2.4. In exploratory factor analysis, the four organisational nutrition environment variables represented a single factor (eigenvalue >1.0). The total variance explained by the factor was 46%.

8.2.3.3 Psychosocial and perception variables

Five psychosocial variables (section 4.2.4) and six environmental perception variables (section 4.2.5) were selected to describe the individual latent constructs based on conceptual models, and empirical evidence of their importance as predictors of dietary behaviour. In exploratory factor analysis, social support for purchasing fruit and vegetables and accessibility to healthy takeaway options locally showed small factor loadings (<0.32). The low factor loadings suggested that these two variables represent different underlying processes to the other variables and they were therefore omitted. Three factors were obtained during exploratory factor analysis using the criteria of eigenvalues greater than 1.0. Four **psychological** variables (perceived control, self-efficacy for healthy eating, outcome expectancies for healthy eating and food involvement) characterised one factor. The second factor included the two **perceived food affordability** variables (could not afford food in the past year and could not afford balanced meals in the past year). The third factor was represented by three **perceived food accessibility** variables (can food shop locally, limited variety of produce locally, good quality of produce locally). The total variance explained by three factors was 45%.

8.2.3.4 Covariates

Mothers' demographic information was collected during the Southampton Initiative for Health follow-up survey including age, number of children, highest educational attainment (categorised as low-≤GCSE, mid-A level/diploma or high-degree), and home LSOA deprivation quintile.

8.2.4 Statistical analyses

SEM was used to examine the direct and indirect effects of latent local food environment constructs, and the direct and mediating effects of latent psychosocial and perception constructs on dietary behaviour. Initially, the model was tested for the full sample of mothers. In the process of fitting a multi-group structural model, inadmissible solutions were identified for low and high education groups so models were fitted separately for each education group. Stata statistical software package version 13.0[255] was used for descriptive analyses, IBM SPSS Statistics 21.0[353] for exploratory factor analysis and IBM SPSS AMOS 21.0 to perform model testing.

8.2.4.1 Data preparation

The distribution of all measured variables were screened prior to modelling. Two variables, healthy and less healthy food environment scores, were positively skewed and subsequently log transformed. To set an equal scale for the analyses, all variables were standardised to have a mean of zero and standard deviation of one.

8.2.4.2 Measurement model

Confirmatory factor analysis was used to validate the relationships between latent constructs and their indicator variables in three measurement models: *i)* dietary behaviours, psychological, perceived affordability and perceived accessibility constructs all correlated, *ii)* community nutrition environment and *iii)* organisational nutrition environment. The measurement model was tested initially in the full sample of mothers and then for the three educational groups. The null hypothesis of multi-group confirmatory analysis states that the factor structure is the same for each group.[350] Nested model analysis was used to test that factor loadings did not vary across groups by applying between-group constraints that set factor loadings to be equal across groups.[347] If full invariance is not met, single constraints may be released in an attempt to achieve partial factor loading invariance. However, partial invariance requires that at least two variables remained constrained on each construct. Differences in factor loadings across educational groups were also examined.

8.2.4.3 Structural model

The structural model was tested to estimate the relative strength of relationships between latent constructs, with particular focus on the indirect effects of local food environment constructs on diet. Given that the three nutrition environments are likely to be related, the covariance between these constructs was modelled. Consistent with the individual factor measurement model, a covariance between the error terms for the three individual constructs was also modelled. The consumer nutrition environment construct was defined by only one indicator variable, the composite score of supermarket healthfulness. For single indicator constructs, the factor loading of the construct on the indicator variable can be set to one and error variance set to zero.[111] Alternatively, the error variance for the indicator variable can be set to the variance multiplied by one minus the variable's reliability coefficient (i.e. $[s.d^2 \times (1-\alpha)]$).[354] The latter option was used in these analyses using the composite score of supermarket healthfulness Cronbach's alpha statistic.

The structural model was initially fitted to the full sample. Mediation effects were assessed by Sobel's test,[69] comparing the total, direct, indirect associations, and examining model fit between a model containing only indirect associations and another containing both direct and indirect associations.[347] Mothers' age, number of children, neighbourhood quintile of deprivation and level of educational attainment were controlled for in the analyses of the full sample. Paths were added from each covariate to the diet latent construct because these covariates are known to be associated with dietary behaviours.

To test for moderation a nested group model is used. However, in the process of fitting a multi-group structural model, inadmissible solutions were identified for low and high education groups. Consequently, separate analyses for each group were attempted following slight modifications (i.e. addition of a covariance between less healthy food environment score and area for low education group). No solution was identified for the high education group. Structural models for low and mid education groups are presented in the results (section 8.3.3). However, true group differences may not be represented because moderation could not be tested.

8.2.4.4 Evaluating goodness of fit

Several goodness of fit indices were used to evaluate fit of the measurement and structural models. CFI, GFI and AGFI all indicate that the model provides a sensible explanation of the data when values are ≥0.90.[347] RMSEA and sRMR are measures of badness of fit in which high values indicate poor model fit. RMSEA is suitable for sample sizes greater than 500 participants and values less than 0.08 indicate good fit and less than 0.05 better fit.[347,355] One advantage of RMSEA is that confidence intervals can be reported. For sRMR, values less than 0.08 indicate good model fit.[351] The Chi Squared statistic was not used because this measure is not reliable with larger sample sizes.[347]

8.3 Structural equation model results

The mean dietary quality score for the 753 mothers with complete data was zero (SD: 1). Most mothers (70%) reported consuming fruit once a day or more, while 38% and 21% reported never eating fast food or takeaway in the past month respectively. Mothers' mean age was 32 (SD: 6) and most mothers (80%) had one or two children. Approximately two thirds of mothers had low or mid educational attainment (37% each) and one quarter (26%) had a high educational attainment. A little over one fifth of mothers (22%) lived in the most deprived neighbourhoods and 14% lived in the most affluent neighbourhoods.

8.3.1 Measurement model

Figure 8-2 shows the factor loadings for the latent variables in the measurement model. Most factor loadings are above 0.50, and all are above 0.32.

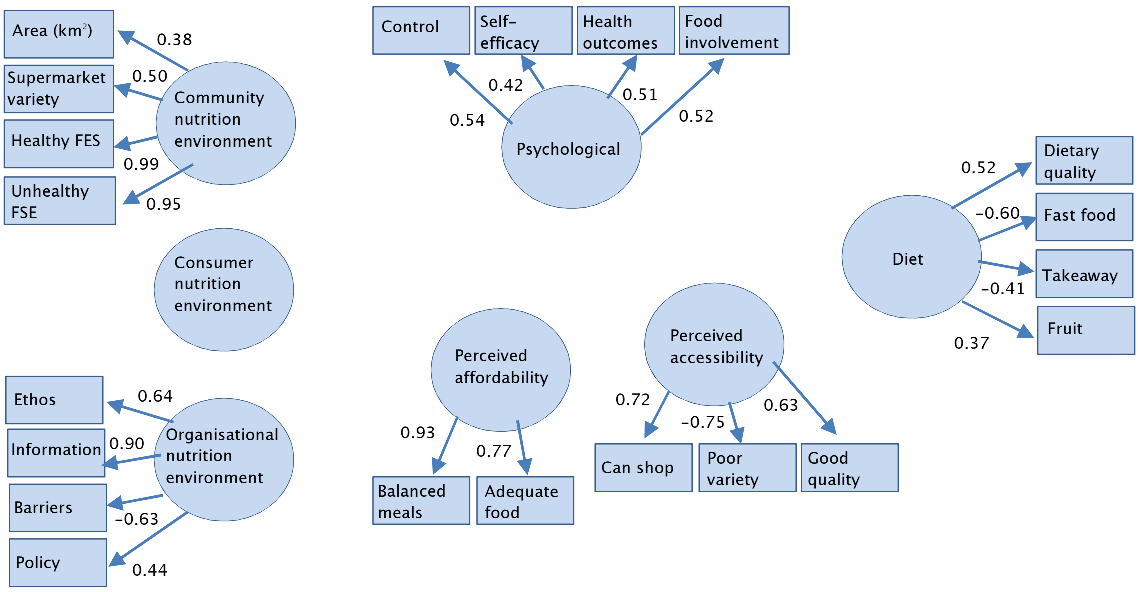


Figure 8-2 Measurement models showing standardised factor loadings for multiple indicator latent constructs

The measurement model for **diet, psychological and two environmental perception** constructs indicated good fit (CFI=0.94, GFI=0.97, AGFI=0.95, sRMR=0.04, RMSEA=0.05 [0.04, 0.06]). The measurement model for the **community nutrition environment** showed adequate model fit (CFI=0.99, GFI=0.99, AGFI=0.96, sRMR=0.01, RMSEA=0.08 [0.04, 0.13]). The measurement model for the **organisational nutrition environment** revealed good fit for CFI, GFI, AGFI and sRMR indices, but poorer fit for RMSEA (CFI=0.97, GFI=0.98, AGFI=0.92, sRMR=0.04, RMSEA=0.12 [0.08, 0.17]). Post hoc modifications showed that co-varying the error terms for ‘healthy eating ethos’ and ‘food policy’ would improve model fit. Organisational policies have been shown to have an effect on organisational ethos including the behaviour and attitudes of management and staff.[76 159] This covariance was therefore added and superior fit was revealed (CFI=1.00, GFI=1.00, AGFI=0.98, sRMR=0.01, RMSEA=0.06 [0.00, 0.13]).

8.3.2 Structural model

Overall model fit for the structural model was good (CFI=0.91, GFI=0.93, AGFI=0.91, sRMR=0.05, RMSEA=0.05 [0.05, 0.06]). Indicator variables generally loaded well on the latent constructs with most (16 of 22) having values greater than 0.50. Six measured variables had poorer factor loadings, all were above 0.32 except takeaway intake (-0.30). However all measured variables showed significant relationships with their corresponding construct ($p<0.01$) and the total variance in diet explained by the individual and environmental factors was 37%

8.3.1 Direct associations

Figure 8-3 shows the standardised regression weights between constructs in the structural model. None of the environmental constructs were associated with diet ($p>0.1$), nor was the community nutrition environment associated with the individual constructs ($p>0.1$). The consumer nutrition environment was significantly associated with the psychological construct, as well as the perceived affordability construct. Healthier in-store environments were associated with positive psychological attitudes towards healthy eating and fewer perceived affordability concerns. The organisational nutrition environment was associated with perceived food accessibility however in the unexpected direction: better organisational nutrition environments in mothers' Sure Start Children's Centres were associated with poorer perceived accessibility to food locally.

Similar to the results in section 4.3.3, the psychological and perceived affordability constructs were associated with the diet construct, while the perceived food accessibility construct was not associated with dietary behaviour.

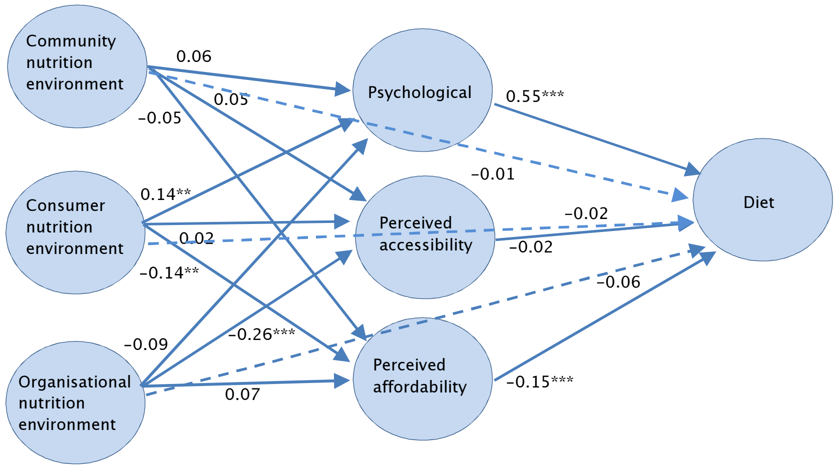


Figure 8-3 Structural model showing standardised regression weights *<0.1, **<0.05, ***<0.01

8.3.2 Indirect associations

The consumer nutrition environment of mothers' main food stores were indirectly related to dietary behaviour through the psychological and perceived affordability constructs. Healthier in-store environments of mothers' main stores were associated with positive psychological attitudes to healthy eating (b=0.08, SE: 0.04) which related to better dietary behaviours (b=0.64, SE: 0.09). Healthier in-store environments were associated with fewer food affordability concerns (b=-0.11, SE: 0.04) which related to better dietary behaviours (b=-0.13, SE: 0.05). Although true mediation could not be tested because of the insignificant relationship between the consumer nutrition environmental construct and diet (total effect p=0.3), the Sobel test confirmed the indirect effects of the consumer nutrition environment through the psychological construct (z=2.04, p<0.05), but not the perceived affordability construct (z=1.87, p>0.05). Comparison of the standardised total, direct and indirect effects and model fit between two models, one containing direct and indirect consumer nutrition environment relationships and a second containing only the indirect relationships, revealed little difference.

Adjustment for covariates weakened the model's goodness of fit indices (CFI=0.88, GFI=0.92, AGFI=0.89). However the badness of fit indices remained acceptable (sRMR=0.06, RMSEA=0.06 [0.05, 0.06]). There was little change in the strength and significance of relationships between constructs following addition of the covariates. Only the relationship between perceived food affordability and diet attenuated ($p=0.16$). Each of the four individual covariates were significantly associated with dietary behaviour ($p<0.05$). The indirect effects of the consumer nutrition environment, through the psychological construct remained after adjustment ($z=1.99$, $p<0.05$).

8.3.3 Multi-group model

Nested model analysis of the **diet, psychological and perception** measurement model achieved partial invariance ($p=0.59$) of factor loadings across the three education groups after constraints on three variables (perceived control, food involvement and dietary quality) were released from the fully constrained model. Full invariance of the **community nutrition environment** measurement model was observed, where factor loadings did not varying significantly across groups ($p=0.08$). Partial invariance was achieved after releasing one constraint ($p=0.27$) in the **organisational nutrition environment** measurement model. Table 8-1 shows the variable factor loadings onto the latent constructs for each educational group and illustrates some differences across the education groups particularly for the diet, psychological and affordability constructs.

As the nested multi-group structural model returned inadmissible solutions for the low and high education groups separate analyses for each group were attempted following slight modifications.

For the **low education group** model modification indices revealed that co-varying the measurement error terms in the community nutrition environment construct for *less healthy food environment scores* and *activity space area (km^2)* would improve fit. Food environment scores corresponded to the geographical size of mothers' activity spaces; greater prevalence of less healthy food stores than healthy stores was observed in more deprived neighbourhoods. It was therefore conceptually sound to add this post hoc covariance which showed adequate model fit (CFI=0.92, GFI=0.90, AGFI=0.87, sRMR=0.07, RMSEA=0.05 [0.04, 0.06]). The structural model for mothers in the **mid education group** showed an adequate model fit (CFI=0.93, GFI=0.91, AGFI=0.87, sRMR=0.06, RMSEA=0.05 [0.04, 0.06]). No admissible solution was identified for the **high education group** model due to persistent negative error related to the diet and perceived affordability constructs.

Table 8-1 Standardised factor loadings (β) for measurement model by educational attainment group

	Educational attainment		
Construct variable	**Low** (≤GCSE) (n=282) **β**	**Mid** (A-level/HND) (n=267) **β**	**High** (Degree) (n=195) **β**
Diet			
Dietary quality	0.46	0.57	0.90
Fast food intake	-0.43	-0.57	-0.33
Takeaway intake	-0.44	-0.30	-0.27
Fruit intake	0.39	0.48	0.19
Psychological			
Perceived control	0.23	0.51	0.69
Self-efficacy for healthy eating	0.58	0.39	0.39
Outcome expectancies for healthy eating	0.70	0.51	0.44
Food involvement	0.25	0.53	0.55
Accessibility perceptions			
Can shop locally	0.67	0.78	0.71
Good quality locally	0.64	0.63	0.65
Poor variety locally	-0.73	-0.78	-0.70
Affordability perceptions			
Ran out of food	0.72	0.72	0.94
Can't afford balanced meals	0.99	0.99	0.70
Community nutrition environment			
Healthy food environment score	0.99	0.98	0.97
Less healthy food environment score	0.95	0.96	0.99
Activity space area (km^2)	0.47	0.30	0.42
Variety of supermarkets	0.58	0.49	0.51
Organisational nutrition environment			
Food policies	0.40	0.50	0.40
Healthy eating ethos	0.61	0.59	0.65
Healthy eating information	0.99	0.97	0.98
Barrier to promoting healthy eating	-0.67	-0.53	-0.65

Figure 8-4 presents the path coefficients for both low and mid education groups (normal text and bold text respectively). Although truly differing structural relationships may not be represented because the nested group model was inadmissible, differences in the relationships between constructs were observed in the low and mid education group models. Specifically, better community nutrition environments were associated with better perceived food accessibility among mothers with a low educational attainment but not those with mid educational attainment. No relationship between the consumer nutrition environment and the psychological construct was observed for either group. However, healthier consumer nutrition environments were associated with better dietary quality among mothers with a level of low education. Healthier in-store environments of mothers main supermarket were also associated with fewer concerns about affordability among mothers with low education but not those in the mid education group. Conversely, only among mothers in the mid education group were greater affordability concerns associated with poorer quality diet. This relationship was not observed among mothers with the lowest level of educational attainment.

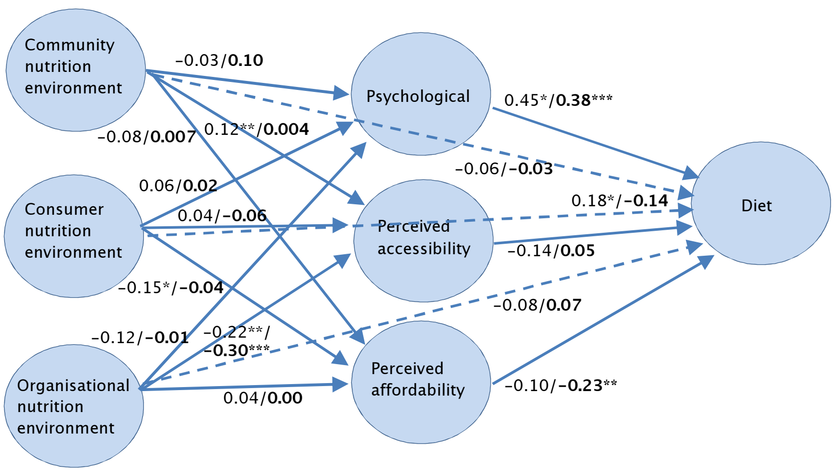


Figure 8-4 Structural models for low and mid education groups with standardised path coefficients are indicated separately (low=normal text, mid= bold text)

*<0.1, **<0.05, ***<0.01

8.4 Discussion

8.4.1 Summary of findings

This chapter tested the potential of an ecological model to explain dietary behaviour in a sample of mothers with young children. The results support the premise that dietary behaviour is associated with factors at both the environmental and individual level. The consumer nutrition environment of mothers' main food stores were indirectly associated with dietary behaviour through mothers' psychological attitudes towards healthy eating. Healthier in-store environments were associated with positive psychological attitudes towards healthy eating and better dietary behaviours. Healthier in-store environments were also associated with fewer food affordability concerns which related to better dietary behaviours (although the latter relationship attenuated after adjustment for covariates). Results also revealed that psychological attitude towards healthy eating had the strongest association with diet. However, the associations between the consumer nutrition environment and psychological attitude, and affordability perceptions were not insubstantial and were similar to previous SEM food environment research.[111]

Although true moderation by educational attainment could not be tested because the nested multi-group model was inadmissible, the differences identified in the structural models of mothers in the low and mid education groups may provide some indication of true socioeconomic variation. In particular, more healthful consumer nutrition environments were directly associated with better dietary behaviour among mothers with low education but not those in the mid education group. This finding is consistent with the results of Chapter 6 and suggests that mothers with lower education may be more susceptible to the supermarket environment than other mothers. Additionally, associations between healthier community nutrition environments and positive perceptions of food accessibility, and better consumer nutrition environment and fewer perceived food affordability concerns, were observed only among mothers with low educational attainment. However, accessibility and affordability perceptions were not associated with dietary behaviour among these mothers. These findings suggest that environmental determinants may be more important to more disadvantaged groups although the path of influence may be more complex than indicated by the model tested in this study. Consistent with the results in Chapter 4, positive psychological attitudes to healthy eating were associated with better dietary behaviours in both low and mid education groups, and showed the strongest relationship relative to all those examined.

8.4.2 Comparison with previous research

This study is unique in its examination of relationships between objective food environment measures and psychological attitude to healthy eating, and the indirect relationship between the local food environment and diet through psychological characteristics. The finding that the consumer nutrition environment was associated with mothers' dietary behaviours indirectly through their psychological characteristics makes an important addition to current empirical evidence. Consistent with this finding, previous multivariate regression and SEM analyses have shown that psychological characteristics towards healthy eating are positively associated with dietary quality.[111 114 354] Previous work has examined the indirect relationship between characteristics of the consumer nutrition environment and dietary behaviours through perceived food affordability. Similar to the findings in this chapter, research in Canada showed that mean price of a healthy food basket and shelf space of fruit and vegetables near home were associated with perceived affordability of food locally.[134] However, perceived affordability was not then associated with dietary quality. Work with African Americans also showed that while shopping at a supermarket related to fewer affordability concerns, perceived affordability was not associated with fruit and vegetable intake.[356] Research in Australia did not find a relationship between objective measures of fruit and vegetable cost and women's perceptions of the cost of these foods in their neighbourhood.[207] But that study did show that perceived cost of fruit was associated with fruit intake among women living in more deprived neighbourhoods.[56] These studies also assessed objective measures of the community nutrition environment and perceived accessibility of food locally and, unlike the current study, all found significant relationships between objective and perceived measures. These differences in study findings may relate to the variations in the objective measures used. For example, the research from Canada found significant results for four out of seven different measures used to characterise the community nutrition environment. Additionally, all three studies used residentially focused measures of objective accessibility as opposed to the current study which used mothers' activity spaces that included other frequented locations, such as workplace and children's centre. Consistent with prior SEM work,[111 357] none of the local food environment constructs in the current study were directly associated with diet.

An unexpected finding in this chapter showed that the organisational nutrition environment of Sure Start Children's Centres was inversely associated with perceived accessibility of foods within mothers' local neighbourhoods. However, one could speculate that good nutrition policies and food related activities in Sure Start Children's Centres might serve to increase mothers' awareness of the importance of healthy eating and may subsequently lead them to recognise the high accessibility of less healthy foods in their local neighbourhoods. The results from Chapter 5 somewhat support this claim which revealed greater prevalence of less healthy food outlets than healthy outlets across the study area, particularly in poorer neighbourhoods. Additionally, Sure Start Children's Centres target, and were traditionally established in, more deprived areas to better service disadvantaged younger families.[179] This may explain the association between Sure Start Children Centres nutrition environment and perceived food accessibility, and provides some evidence to support continuation of nutrition-related activities in these centres.

The multi-group results of this chapter, although not a true test of moderation, revealed differences by level of educational attainment that are consistent with the findings of the previous chapters and prior empirical research. Greater healthfulness of mothers' main food stores related to better dietary behaviours only among mothers with low educational attainment. This finding replicates the results of Chapter 6 and is consistent with results from the US, where disadvantaged women participating in the Supplemental Nutrition Assistance Program (SNAP) with higher availability of healthy food close to home had greater intakes of vegetables.[112] However, these findings differ from those of a study with low-income women which showed no association between healthy food availability of main store and fruit and vegetable intake.[138] The different findings may correspond to variations in individual characteristics. Participants in the latter study were middle-aged and overweight or obese whereas the current and SNAP studies targeted women of childbearing age and represented a wider body weight spectrum. Age and weight status are associated with dietary behaviours,[26 189 221] and may affect total and disposable income. Mothers of young children from disadvantaged backgrounds may be more susceptible to the environment of their food stores due to financial and other lifestyle constraints. The finding that better consumer nutrition environments relate to fewer food affordability concerns somewhat supports this claim, particularly as this association was only identified among mothers in the low education group.

Healthier consumer nutrition environments represent stores where the relative availability, price, promotion and placement of food products are more favourable to healthy food products than less healthy food products (section 6.1). Mothers shopping at stores whose relative availability, price, promotion and placement favour less healthy foods may, particularly if more susceptible to environmental exposures due to financial or other constraints, have an increased perception of not being able to afford a balanced diet. A recent survey by the British Heart Foundation highlighted that nearly three quarters of people earning less than £10,000 per year reported struggling to eat healthily as a result of rapidly rising food prices.[312] Surprisingly, however, the relationship between perceived affordability and dietary behaviour was not significant among mothers with low education in this study, but was among mothers with mid educational attainment. This finding is similar to that of research with women of lower educational attainment in Australia[56] and with African Americans in the US.[356] The differences between education groups may reflect inconsistencies in the concept of 'balanced meals' or may indicate high optimistic bias, where the true prices of healthy foods are under reported because they are infrequently purchased.[59] Consistent with findings in Chapter 4, associations between positive psychological attitudes towards healthy eating and better dietary behaviours were replicated in both low and mid education groups.

8.4.3 Strengths and limitations

Another novelty of this study is the use of SEM to assess the relative strength of associations between multiple environmental and individual factors, and dietary behaviour. SEM is a cutting-edge statistical technique that enables more accurate estimation of the relative strength of direct and indirect relationships simultaneously thus facilitating identification of areas with the greatest potential for intervention. One prior study has used SEM to assess objective environmental and individual influences on diet; however, it focused on a different population group (rural adults in the US) and tested a different conceptual model.[111] Using latent constructs, SEM enables relationships to be measured free of error. Simultaneous assessment of associations between constructs enables the strength of relationships to be compared relative to each other in addition to providing measures of statistical significance. The conceptual model of the local food environment that has guided this study asserts the need for several measured variables to characterise each of the environmental and individual components that may determine dietary behaviour. As such, latent variables and SEM offer a valuable method for summarising measured variables and testing pathways of influence. However, the use of cross-sectional data in this study precludes conclusions of cause and effect and can be used only to describe associations between environmental and individual factors and dietary behaviours.

Limitations of these analyses include the inability to generalise the findings beyond the sample population. Validation of the model and hence broader applicability could be achieved by cross-validation of the model with another sample,[350] however such activity was beyond the scope of this study. Alternative models may be available that could also fit the data equally well. Good model fit does not necessarily conclude that all necessary constructs have been included in the model.[349] For example, governmental and food corporation policy were hypothesised as potential influences on the local food environment in the Glanz model of nutrition environments.[1] Additionally, the home nutrition environment and social support for healthy eating have been shown to play a significant role in path analyses of previous nutrition or obesity related SEM work.[111 354] Social support was discarded in the current analyses because it had a low factor loading when combined with the psychological variables. While that single indicator could have been used to represent a social support construct, it would be more appropriate for future research to use multiple indicators as in previous research.[111 354] Additional pathways could also have been added to the model. For example, research has shown that perceptions about food availability are associated with self-efficacy for healthy eating and perceived affordability.[358 359] While covariance paths between these constructs where included, directional pathways could have been alternatively added. However, more complexity necessitates larger sample sizes and can cause more ambiguity particularly when interpreting model fit, which involves several researcher-lead choices.

Strict cut-offs for normalised estimate of multivariate kurtosis[360] were violated in this sample of mothers. However, normality tests are known to be quite sensitive in large samples[347] and maximum likelihood bootstrapping of 1000 iterations (90% CI) showed no difference in model fit and very minor changes in standardised regression estimates (<0.05) with the standard model.

A considerable limitation was the return of inadmissible solutions for two of the groups in the nested multi-group model. This result was surprising because the partially constrained measurement model suggests only slight variance between the groups on each of the constructs. The factor loadings for each group, however, did indicate differences between mothers with high education and the other two groups on perceived affordability and dietary behaviour. These two constructs returned the inadmissible solutions (negative error). Dietary quality loaded very strongly onto the dietary behaviour construct among mothers with high educational attainment which could be indicative of little variation among these mothers for fast food, takeaway and fruit intake. Similarly, there was little variation in responses to the two affordability questions among mothers with high educational attainment. Future research may include additional affordability questions that included a wider response categorisation than the three-point scale used in this study. It is generally recommended that categorical items include four or more response categories for modelling analyses.[360] The small sample size of mothers with high educational attainment may have had some impact in causing the inadmissible solution as the tested model was quite complex.

8.4.4 Policy and research implications

A recent letter to the current government from the UK Faculty of Public Health warned of the serious effect current food price rises are having on the dietary behaviours of the UK population, and urged for governmental action.[311] A recent survey identified that more than a third of British adults sacrificed health for cost when doing their grocery shopping, with many choosing cheaper ready meals knowing they were a less healthy option.[312] The results in this chapter provide some additional evidence of food affordability issues, with choice of supermarket being linked to food price concerns and greater affordability concerns relating to poorer dietary behaviours. A 12% rise in food prices in real terms since 2007, combined with a 7% fall in real wages translates to consumption of cheap processed foods high in sugar, salt and fat in place of fresh produce.[311] The percentage of household income spent on food is greatest for low-income families[222] thus food price rises place these families under further pressure. Governmental and non-governmental action is crucial to promoting equitable public health. Future avenues for advancement include: monitoring nutrition and hunger status[311] and food environments[361], reviewing the health effects of agricultural and corporation subsidies[362] and introducing regulations, such as taxing high-sugar foods, if voluntary approaches, such as the Responsibility Deal, fail to be effective.[235]

Future research could test the local food environment model used in this study with a different sample to provide cross-validation of the model and greater generalisability of this study's findings. A larger study would provide an adequate sample size for nested multi-group analyses to validate the separate group results identified in this study. Future research could also enhance the stability of the perceived affordability construct by including additional questions that enquire about perceived cost of specific food items, use of 'specials/discounts' or changes in shopping habits over the past year due to food affordability concerns. Such questions have been used in previous studies.[54 363] Considering the resource requirements for a large study with individualised measures for the community, consumer and organisational nutrition environments, it may be more cost effective to complete future model testing as part of an intervention study.

The results of the modelling presented in this chapter identified that the in-store environment of mothers' main food stores were indirectly associated with diet through psychological and perceived affordability factors. Likewise, the diets of mothers with low educational attainment are directly associated with the in-store environment. The results of Chapter 6 showed that this direct association was particularly strong among women who shop at the least healthful discount supermarkets which had poorer availability, pricing and promotion of healthy products than other supermarkets. Intervention research in Australia and the Netherlands has shown that price, and to a lesser extent, behaviour change strategies are effective at improving dietary habits.[364 365] Additionally, results from a pilot intervention that aimed to improve perceptions of healthy food affordability among disadvantaged mothers showed promising results.[363] Evidence from the UK in these areas is limited. Future research could test the feasibility of designing an in-store intervention with a supermarket retailer, combined with individually targeted activities to enhance perceived affordability and psychological attitude towards healthy eating that are acceptable to disadvantaged groups.

8.5 Conclusion

This chapter tested whether the relationships between the local food environment and the dietary behaviour of mothers with young children are directly or indirectly associated through individual psychosocial and perceived environmental factors. Differences in the strength and significance of these relationships were also assessed according to three levels of educational attainment. Structural equation modelling (SEM) was used to test the entire set of relationships represented in the conceptual model that guides this study (Figure 3-1). SEM has advantages over other multivariate analysis techniques because it enables simultaneous assessment of multiple interdependent relationships and uses latent constructs to estimate relationships free of measurement error. The nutrition environments and individual factors examined in this study are characterised by several measured variables and latent constructs offer a valuable method of summarising such variables. Results showed that each of the seven constructs were significantly and adequately associated with their measured variables. Additionally, there was support for the ecological hypothesis that dietary behaviour is associated with factors at environmental and individual levels.

Assessment of the relative relationship between environmental and individual factors and dietary behaviour indicated that the in-store environment of mothers' main food stores were indirectly associated with diet through psychological and perceived food affordability factors. Furthermore, a direct association between more healthful in-store environments and better dietary behaviours was observed among mothers with low educational attainment. Future interventions that aim to *i)* improve the consumer nutrition environment of less healthful supermarkets, and *ii)* enhance psychological and cost-related attitudes towards healthy eating, are likely to be effective at improving the dietary behaviours of mothers and their families, particularly those most disadvantaged.

Chapter 9 Discussion and Implications

The conceptual model (Figure 9-1) which guided this study purports that the local food environment is associated with the dietary behaviours of mothers with young children both directly, and indirectly through psychosocial and environmental perception factors. The local food environment conceptually consists of three components:

i) *Community nutrition environment* – geographical accessibility of food outlets
ii) *Consumer nutrition environment* – factors that affect food choices within stores
iii) *Organisational nutrition environment* – organisational settings where defined groups of people can learn about healthy eating

It was theorised that differences in socio-demographic factors (i.e. level of neighbourhood deprivation and educational attainment) alter or moderate the relationships between environmental factors and dietary behaviours.

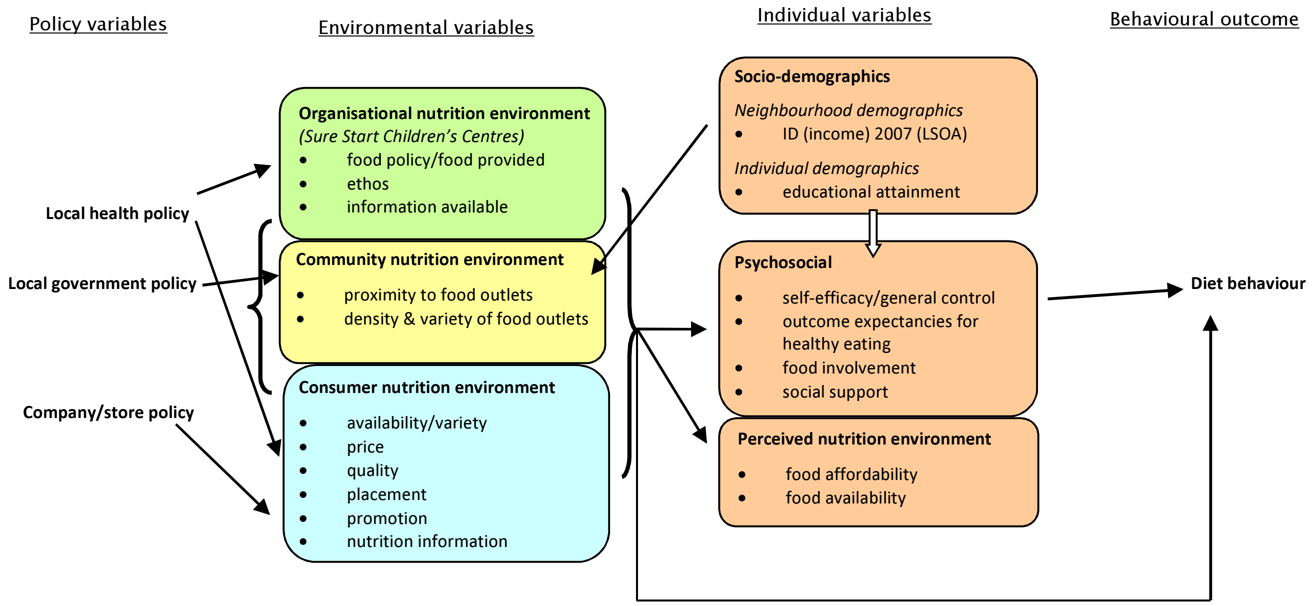


Figure 9-1 Conceptual model of the local food environment and mothers' dietary behaviours

This chapter summarises the findings of this study against the four hypotheses that were derived from the conceptual model. Possible research and policy initiatives for the future to improve the dietary behaviours of mothers from disadvantaged backgrounds are also discussed.

9.1 Summary of the study findings

9.1.1 Hypothesis 1

1. **Disadvantaged neighbourhoods have significantly poorer local food environments than more affluent neighbourhoods.**

Results from this study provide some support for hypothesis one. Disadvantaged neighbourhoods had poorer community nutrition environments than more affluent neighbourhoods; consumer and organisational nutrition environments were more equitable across neighbourhoods.

This study used English LSOA deprivation quintiles (section 3.3.5.1) to assess neighbourhood disparities in the local food environment rather than other administrative boundaries, such as electoral wards. LSOAs are advantageous over other measures because they characterise small areas where residents (~1000) are socially homogeneous and provide the best quality data for socioeconomic neighbourhood comparison.

The measures used in this study to assess socioeconomic neighbourhood differences in the community and consumer nutrition environments make an advance on those used in other studies (Chapter 2). The community nutrition environment density assessment included measures of all retail food and takeaway outlets in the study area, rather than commonly used proxy measures, such as fast food outlets or supermarkets. Moreover, using food environment scores (FES) provided a more nuanced assessment than count density because it discriminates between different store types. FES are novel density measures which weight food outlets according to their potential contribution to healthy or less healthy dietary behaviours (section 5.2.5.1). Assessment of the consumer nutrition environment in this study covered 99% of supermarkets and convenience stores in the study and used a new audit tool that is the first to measure nine different in-store factors that can influence food choices (section 6.2.4). Previous consumer nutrition environment area-based investigations have commonly measured only two in-store factors: availability and price. However, those assessments may have missed important socioeconomic differences in other in-store variables, as was revealed in this study. This is the first study to assess socioeconomic neighbourhood differences in the nutrition environment of Sure Start Children's Centres.

Comprehensive assessment of the three nutrition environments, that may affect the dietary behaviours of mothers with young children, identified some neighbourhood disparities:

Community nutrition environment – Less healthy food outlets were more prevalent than healthy food outlets across the study area. Overall food outlet density (healthy minus less healthy food outlets (H-U)) measures showed that more affluent LSOAs were more likely to have neutral environments or better access to healthier food outlets than more deprived LSOAs. There was greater density of healthier food outlets in more deprived neighbourhoods, but also greater density of less healthy outlets in these areas than in more affluent areas. This result meant that the overall food outlet density was poorer in the more deprived neighbourhoods (Chapter 5).

Consumer nutrition environment – The overall healthfulness of supermarkets and convenience stores across the study area did not vary according to LSOA deprivation quintiles. There was a trend towards more affluent LSOAs having in-store environments more supportive of healthful food choices. In particular, more affluent areas had better quality and placement of healthy products, and more nutrition information and healthier alternatives for less healthy products. Price promotion practices were healthier in the most deprived neighbourhoods. There were no neighbourhood disparities for product variety, price or single fruit sale (Chapter 6).

Organisational nutrition environment – The overall nutrition environment of Sure Start Children's Centres did not differ by level of neighbourhood deprivation. This finding reflects a lack of variation in food policy content, healthy eating ethos or availability of nutrition information across centres. Staff working in centres located in more affluent LSOAs reported fewer barriers to supporting healthy eating than those in more deprived LSOAs (Chapter 7).

The findings from this study suggest that socioeconomic neighbourhood disparities in the local food environment were apparent and may be contributing to dietary inequalities. Individuals living in more deprived neighbourhoods had greater access to less healthy food outlets, greater exposure to in-stores environments that promote less healthy food purchases, and Sure Start Children's Centres where staff found healthy eating more challenging to promote. However, not all environmental exposures were poorer in more deprived areas.

9.1.2 Hypothesis 2

2. Local food environment exposures are associated with mothers' dietary behaviours.

Results from this study provide some support for hypothesis two. Local food environment exposures were weakly associated with mothers' dietary quality. However, healthier environmental exposures were not consistently related to better dietary quality.

Much of the food environment literature is based on the assumptions that people are primarily influenced by food outlets geographically proximate to their homes and that exposures can be determined by proxy measures, such as the density of fast food outlets, or availability of fruit and vegetables (Chapter 2). This study addressed these methodological limitations by using comprehensive measures that incorporated a wide range of exposures for each of the three nutrition environments. This study also made an advance on previous research by relating mothers' dietary behaviours to the actual environments they used, including their activity spaces (area around locations frequently visited by an individual), main food stores and Sure Start Children's Centres.

Mothers did not have better dietary quality if their overall community, consumer and Sure Start Children's Centre nutrition environments were healthier. Some individual exposures of the three nutrition environments were shown to be associated with mothers' dietary quality:

Community nutrition environment – Greater density of less healthy food outlets and greater variety of takeaways were weakly associated with better dietary quality. Greater density of healthier food outlets had a stronger association with better dietary quality. For example, having access to two additional small supermarkets related to eating green salad vegetables up to four times more per week.

Consumer nutrition environment – Shopping at stores where mean prices favoured healthy foods by ten pence per portion was associated with consuming crisps up to four times less and vegetable dishes up to four times more each week. None of the other eight consumer nutrition environment variables were associated with dietary quality after adjustment for mothers' demographic characteristics, such as age and educational attainment.

Organisational nutrition environment –Healthier overall nutrition environments in Sure Start Children's Centre were associated with poorer dietary quality. Healthier food policies also related to poorer quality diets, though the effect size was small.

Taken together, these findings suggest that the local food environment has a complex interaction with dietary behaviours and that some exposures may be more important than others.

The association between better dietary quality and increased density of both healthier and less healthy food outlets are likely to reflect areas of high commercial investment,[256] where businesses and community services cluster. The high overall density of food outlets illustrates the difficulty in untangling the influence of healthier and less healthy food outlets on dietary behaviours. However, greater improvements in dietary quality were observed for higher density of healthier food outlets than for higher density of less healthy food outlets; thus, improving the ratio of healthy food outlets relative to less healthy food outlets could be an important way of supporting better dietary behaviours (discussed in section 5.4.4).

The results from this study indicated that shopping at stores where healthy foods were priced more cheaply than less healthy products was associated with better dietary quality. This finding suggests that improving the relative price difference between healthy and less healthy foods within stores could be an important strategy to encourage healthier dietary behaviours. Particularly with rising food prices prompting more British adults to sacrifice health for cost when shopping for food (discussed in section 6.4.4).[312]

This is one of few studies to assess the relationship between parental dietary quality and the nutrition environment of early childhood facilities. Most centres had good nutrition policies and practices. However, mothers' exposure to these centres may not have been adequate to improve their dietary quality, or nutrition activities may focus predominantly on children's dietary behaviours. Encouraging parental involvement in activities, such as deciding what foods to have available at parental workshops, could further promote healthy eating to parents (discussed in section 7.4.4).

The findings from this study suggest that greater exposure to healthy food outlets and cheaper pricing of healthy foods are the local food environment factors most strongly associated with better dietary quality.

9.1.3 Hypothesis 3

> **3. Mothers' levels of education have a moderating effect on associations between local food environment exposures and their dietary behaviours.**

Results from this study support hypothesis three. Mothers' levels of educational attainment moderated the relationships between their dietary quality and local food environment exposures.

Level of educational attainment is a strong predictor of dietary quality among women of childbearing age,[26] and is considered the precursor to other socio-demographic markers including employment status, job role and income level.[188] A greater understanding of the differing effects of the local food environment exposures on the dietary outcomes of individuals with lower and higher socioeconomic position is necessary to identify effective intervention points to reduce dietary inequalities (Chapter 2). This study tested the moderating effect of level of educational attainment (low: ≤GCSE, mid: A-level/HND, high: degree) on all environmental exposure and dietary outcome associations to identify local food environment exposures that may be contributing to dietary inequalities.

Differences in the direction of relationships between environmental exposures and dietary quality were observed by level of educational attainment for each of the three nutrition environments:

Community nutrition environment – Better overall food environment scores for mothers' activity spaces were associated with poorer dietary quality among mothers with high education, but tended toward better quality diet among mothers with low education. Among mothers with low educational attainment, closer proximity to fast food outlets from home tended towards poorer dietary quality and closer proximity to supermarkets tended towards better dietary quality. Among mothers with high educational attainment these associations were in the opposite direction. Not all associations were significant or all effects strong. However, the community nutrition environment may affect mothers differently according to their level of educational attainment, with residential exposures showing greater potential effect on the dietary quality of mothers with low educational attainment.

Consumer nutrition environment – Level of educational attainment moderated the association between dietary quality and overall healthfulness of main food store. Among mothers with low educational attainment, those who shopped at more healthful stores had better dietary quality, equivalent to consuming crisps up to four times less and vegetable dishes up to four times more each week, than those who shopped at the least healthful supermarkets. Among mothers with high educational attainment, the relationship was inverse: decreasing store healthfulness was associated with better dietary quality. Similar differences were found for the individual in-store variables quality of fresh produce and single fruit sale.

Organisational nutrition environment – Among mothers with low educational attainment, fewer barriers and healthier overall nutrition environments were linked to better dietary quality. Among mothers with high educational attainment these relationships were inverse: fewer barriers and healthier overall scores were associated with poorer dietary quality. Not all associations were statistically significant. However, the nutrition environment of Sure Start Children's Centre may affect mothers differently according to their level of educational attainment.

This study is one of the first to show that mothers with low educational attainment had greater vulnerability to their local food environment than mothers with higher educational attainment. Healthier environments repeatedly related to better dietary quality among mothers with low educational attainment. Conversely, among mothers with the highest educational attainment, poorer environments were consistently associated with better dietary quality. This vulnerability of mothers with low educational attainment may be explained by them having fewer economic and psychosocial resources that are protective against poorer environmental exposures. Mothers with low educational attainment showed the poorest scores for psychosocial variables that facilitate better dietary behaviours, and reported the greatest concerns affording food and balanced meals (Chapter 4). Improvements to the local food environment are therefore likely to be of most benefit to those with low educational attainment and who have the poorest quality diets.

9.1.4 Hypothesis 4

4. Psychosocial and environmental perception factors mediate associations between local food environment exposures and mothers' dietary behaviours.

Results from this study provide some support for hypothesis four. The consumer nutrition environment of mothers' main food stores acted indirectly on their dietary quality through psychological and perceived affordability factors.

Evidence of the relative effects of the three components of the local food environment, and perception and psychosocial factors on diet, is limited (Chapter 2). Improved understanding of the relative relationship between environmental, individual and dietary factors will help inform the development of multi-component interventions. Such interventions are most likely to be effective at improving the dietary choices of individuals from disadvantaged backgrounds.[177 366]

This study is the first in the UK to use Structural Equation Modelling (SEM) to test the set of relationships represented in the Glanz model of nutrition environments (adapted model shown in Figure 9-1). SEM is a statistical technique that enables simultaneous assessment of multiple and inter-related relationships and uses latent constructs to estimate relationships free of measurement error (Chapter 8). The nutrition environments and individual factors examined in this study were characterised by several measured variables, and latent constructs offered a valuable method of summarising these variables.

As presented in the conceptual model, dietary behaviour was predicted by factors at both the environmental and individual levels. The consumer nutrition environment of mothers' main food stores acted indirectly on dietary behaviour through their psychological attitudes towards healthy eating. Healthier in-store environments were associated with positive psychological attitudes towards healthy eating and better dietary behaviours. Healthier in-store environments were also associated with fewer food affordability concerns which related to better dietary behaviours, although, not surprisingly, this relationship was affected by demographic characteristics including level of educational attainment. Psychological attitude towards healthy eating was the strongest predictor of dietary behaviour. However, the effects of the consumer nutrition environment on psychological attitude and affordability perceptions were similar to a food environment study in the US that used SEM.[111]

Differences in the predictive effects of environmental and individual constructs on diet were observed between mothers with low and mid educational attainment. More healthful consumer nutrition environments were directly associated with better dietary behaviour among mothers with low education but not those in the mid education group. This finding is consistent with the evidence for hypothesis three (Chapter 6) and indicates that the dietary behaviours of mothers with low educational attainment are more susceptible to the in-store environment than other mothers. Additionally, associations between *i)* healthier community nutrition environments and positive perceptions of food accessibility, and *ii)* better consumer nutrition environment and fewer perceived food affordability concerns, were observed only among mothers with low educational attainment. Consistent with the results in Chapter 4, positive psychological attitudes to healthy eating were associated with better dietary behaviours in both low and mid education groups, and showed the strongest relationship with diet relative to all exposures examined. These results provide further indication that environmental exposures have stronger predictive effects on the individual factors and dietary behaviours of mothers with low educational attainment than those with higher educational attainment. However, further evidence with larger group samples is needed to confirm the moderation effects of level of educational attainment, particularly because the model for mothers with high educational attainment was inadmissible.

This study is one of few studies to show that the in-store environments of main food stores has an indirect relationship with dietary behaviour through psychological and perceived affordability factors. Furthermore, the findings of this study revealed the important potential effect the in-store environment of main food store can have on the dietary behaviours of individuals with low educational attainment. Mothers with low educational attainment were more likely to shop at the least healthful discount supermarkets which showed poorer availability, pricing and promotion of healthy products than other supermarkets (Chapter 6).

The findings from this study may have important implications for future research and policy initiatives to reduce dietary inequalities (discussed in sections 9.3 and 9.4).

9.2 Strengths and limitations of this study

This study contributes to the food environment literature through the development of more nuanced measures to assess three components of the local food environment. These measures provided robust scores for each of the three nutrition environments that enabled quantitative assessment of socioeconomic differences in the local food environment, and associations between the local food environment and dietary behaviours.

This study is the first in the UK to complete a comprehensive assessment of the relationships between the local food environment, psychosocial and environmental perception factors and diet, and to examine whether differences in these relationships contribute to dietary inequalities. The use of actual exposures, including main food store and activity spaces, and temporal connection between data collection of all variables is an improvement on previous work and increases the confidence in the findings of this study. Additionally, the standardised dietary quality score provides a robust outcome measure for analyses and is an advancement on brief dietary measures frequently used in food environment research.

Despite these strengths, the study is not without limitations. The use of self-report measures to collect the dietary outcome, psychosocial, perceived environment and Sure Start Children's Centre nutrition environment data increases the likelihood of response bias. Although interviewer-administered questionnaires and validated measures were used in this study, self-report error may have underestimated or overestimated associations. Moreover, measures were not re-validated among the samples of mothers or Sure Start Children's Centres in this study, and biomarker validation of the dietary assessment tool did not cover the full range of dietary components. The use of convenience samples is another limitation of this study. Although all mothers attending Sure Start Children's Centres in Southampton, Gosport and Havant were eligible to participate, the selection was not random. The participating mothers may have differed from those who declined to participate. The organisational nutrition environment survey also relied on a convenience sample. Staff were identified through Sure Start Children's Centre managers, who may have introduced selection bias by choosing staff that would answer the questionnaire in a manner that positively reflected the centre. These convenience samples may therefore not represent the broader population of women of childbearing age or Sure Start Children's Centres in the UK, which limits the generalizability of the study results.

This study is unlikely to have accounted for the full range of factors that could be associated with variations in local food environment exposures or dietary quality. Additional confounding variables, such as governmental and food corporation policy, crime rate, traffic safety, taste preferences or cooking skills may affect exposures or outcomes. Clustering of mothers by LSOA, council area, main food store or Sure Start Children's Centre was also not accounted for. Furthermore, larger sample size may have provided greater statistical power to show stronger evidence of associations, particularly for analyses stratified by level of educational attainment.

A major limitation is the cross-sectional design of this study. The use of cross-sectional data precludes conclusions of cause and effect and can be used only to describe associations between environmental or individual determinants and dietary behaviour. The collection of longitudinal data to measure changes in dietary patterns and the local food environment has not been achieved in the UK and future research could overcome this limitation.

9.3 Implications for further research

The findings of this study indicate that the in-store environment of main food store, psychosocial factors and perceived food affordability are important determinants of the dietary quality of mothers with young children, particularly those with low educational attainment. The dietary quality of mothers with higher educational attainment consistently showed less susceptibility to poorer local food environment exposures. In contrast, the dietary behaviours of mothers with low educational attainment tended to vary in accordance with the quality of the environments they were exposed to. These results suggest that future interventions aimed at reducing dietary inequalities could be most effective if they specifically target environments used by mothers with low educational attainment.

Enhancements to the in-store environment of the least healthful supermarkets in the UK are likely to offer the greatest improvement to the dietary quality of mothers with low educational attainment. Compared to more healthful supermarkets the least healthful supermarkets had greater promotion of less healthy products, lower variety of healthy products, poorer availability of healthier alternatives to less healthy products and priced less healthy products cheaper than healthy products. Improving these aspects of the in-store environment would make healthier food choices easier for mothers. Reviews of previous in-store interventions suggest that interventions designed to improve both supply and demand are most likely to increase healthy food purchases.[367 368] Supply strategies include price reduction or increased availability of healthier food. Demand initiatives include point-of-purchase activities, such as taste tests or labelling, and advertising strategies, such as marketing pamphlets or supermarket tours. The quality of the current evidence is limited mostly to small studies in smaller grocery stores and further research using randomised controlled trials and including evaluation of the intervention effects on diet and health outcomes has been recommended. More recently, randomised controlled trials in supermarkets in the Netherlands and Australia have shown that price discounts on fruit and vegetables, when coupled with behaviour change strategies, can increase intake of these foods.[364 365] Simulation modelling has shown that subsidies to make healthy foods cheaper than less healthy foods, combined with individually targeted behaviour change strategies to shift low-income individuals' preferences to healthy foods would provide the conditions required to reduce dietary inequalities.[366]

The results of this study showed that positive psychological attitudes to healthy eating were associated with better dietary quality and that mothers with low educational attainment had poorer psychological attitudes to healthy eating. In particular, having stronger belief in the benefits of healthy eating was a more important predictor of dietary quality among mothers with low educational attainment than among those with higher educational attainment. A systematic review of the effectiveness of interventions to improve health behaviours among low-income groups identified that interventions which focused on a small set of techniques were more effective than those which were more comprehensive.[369] The specific techniques most effective at changing health behaviours among low-income groups included providing information about the health benefits of behaviour change, goal-setting and prompting identification of barriers.

A synthesis of the evidence from systematic reviews of behaviour change interventions also showed that providing information on the health risks and benefits of particular behaviours is most likely to be effective, particularly if support is continued after the initial intervention.[370] Furthermore, recent guidance from the National Institute for Health and Care Excellence (NICE) on individual behaviour change approaches recommends that future interventions include strategies that support individuals to set goals, make action plans and coping plans, and identify family and friends to provide support.[371] This guidance also recommends that behaviour change interventions take a person-centred approach to support individuals to manage their own behaviour. This empowerment approach is aligned with the widespread notion that supporting individuals to feel more control over their lives is fundamental to improving health behaviours and addressing health inequalities.[4 7] The current study showed that mothers with low educational attainment perceived less control over their lives than other mothers. This finding provides further evidence for the use of an empowerment approach in future interventions aimed at improving the dietary quality of mothers with young children.

Concerns about the affordability of food were greater among mothers with lower educational attainment than among those with degrees, and greater food affordability concerns were associated with poorer dietary quality. This finding is consistent with previous research,[54 56] but the evidence for effective strategies to promote positive perceptions of healthy food affordability among disadvantaged groups is limited.[363] Results from a recent pilot intervention that aimed to improve perceptions of the affordability of healthy snacks among disadvantaged mothers in Australia showed promising results, with the intervention group perceiving healthy food to be more affordable than the control group post intervention.[363] Further evidence of the effectiveness of food affordability interventions on dietary behaviours and their ability to compliment in-store environmental interventions is needed.

Intervention research in supermarkets in the UK is limited.[368] Evidence from natural experiments in England and Scotland has shown that opening a new supermarket in a deprived neighbourhood alone has little benefit on the dietary behaviours of residents in close proximity to the supermarket.[143 144] Additionally, government supported initiatives to improve the availability and labelling of fresh fruit and vegetables in convenience stores within deprived areas have shown little evidence of effectiveness.[372] These studies suggest that food retailers are willing to engage in nutrition-related activities but indicate that environment strategies alone are not sufficient to change dietary behaviours. As described above, the findings of this thesis and of research in other countries suggest that a multi-component intervention incorporating *i)* in-store environmental changes and *ii)* empowering behaviour change and healthy food affordability strategies would be most effective at improving the dietary quality of mothers from disadvantaged backgrounds. The design of a potential future intervention is described briefly below and represented in a logic model for a possible intervention (Figure 9-2). It is hypothesised that the intervention will improve the environments of the least healthful supermarkets, and use empowering individual behaviour change strategies to improve sense of control and belief in the benefits and affordability of healthy eating. This will enable mothers from disadvantaged backgrounds to make healthier food choices for their families and subsequently reduce dietary and health inequalities.

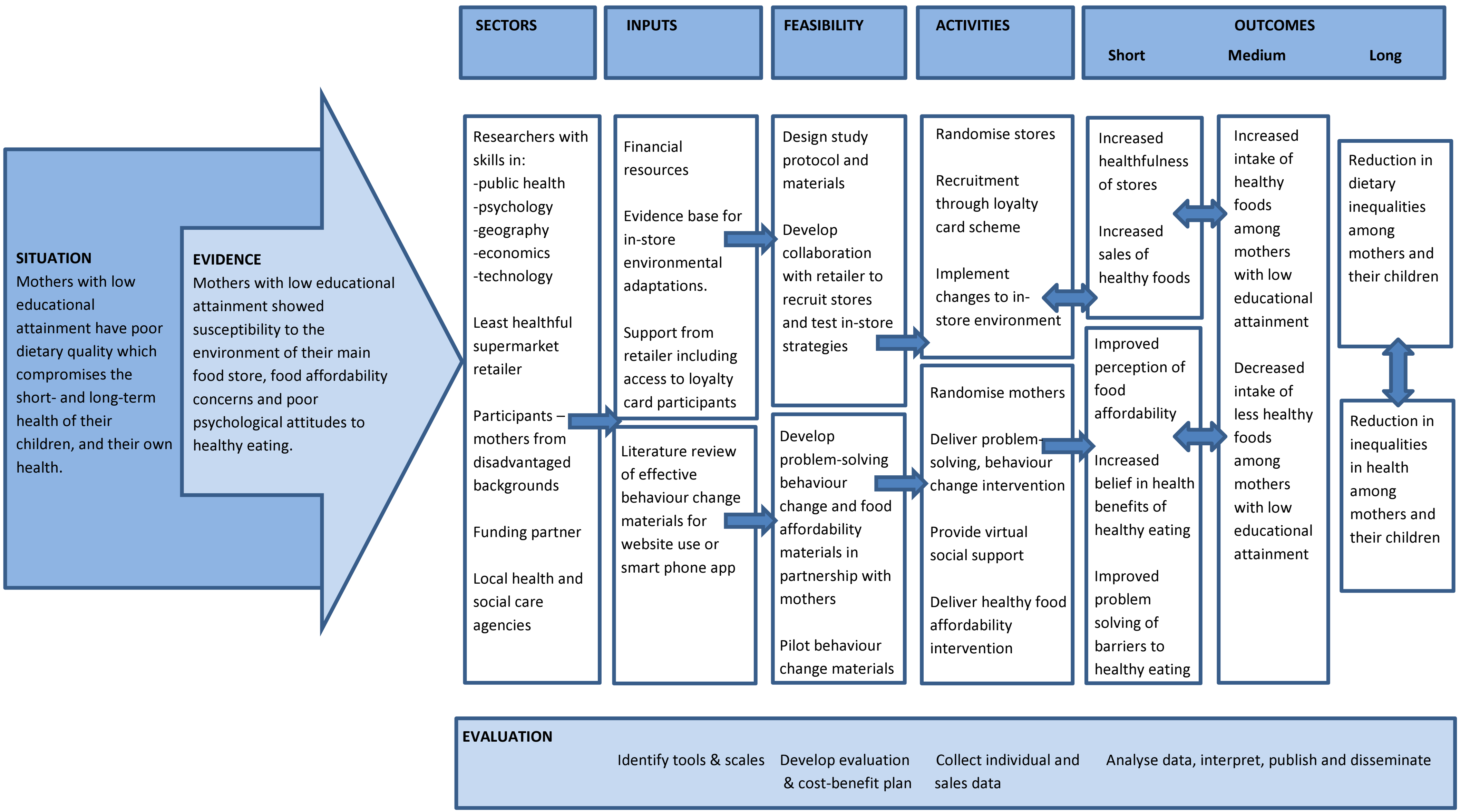


Figure 9-2 Modifying the environmental and psychological factors to improve dietary inequalities: a multi-component intervention – logic model

The first component of the intervention involves building upon the University of Southampton's previous collaborations with supermarket retailers to design an in-store intervention with one of the least healthful supermarket chains. In accordance with the MRC guidance on complex interventions, an initial feasibility stage will be conducted to test acceptability of the intervention strategies and estimate the likely rates of participant recruitment.[373] Sampling through the retailers loyalty card scheme will be explored as this method has been successful in previous supermarket interventions.[374] Feasibility testing may highlight the need for 'shop floor' recruitment to ensure adequate sampling of individuals from more disadvantaged backgrounds.[375] The in-store intervention strategies, informed by the findings of this thesis and previous in-store interventions, will aim to modify the relative pricing, promotion and variety of healthy and less healthy products to create an in-store environment that promotes more healthful food choices to customers. The acceptability of these strategies will be assessed in the feasibility phase of the intervention before rolling out to all intervention stores in the full trial.

The trial design will be a cluster randomised controlled trial containing two components and a 2^2 factorial design. The sample size calculations will enable the effect of either intervention component to be detected, but do not provide adequate power to detect the interaction effects. Using data from this thesis, the clustering of dietary quality score by main food store was examined for mothers shopping in one supermarket chain. The intra-class coefficient (rho) for six stores and a total of 381 mothers was 0.0086. A conservative rho of 0.01 was used. Applying the 'clustersampsi' command in Stata determined that a statistical significance of 5%, with 30 mothers in each cluster, and 12 clusters in each arm would provide 80% power to detect a difference in dietary quality score between the intervention and control clusters of 0.25 SD. Recruiting more participants from each store would increase the power, or detect a smaller effect size. Key outcomes will include changes in sales of targeted food products and dietary quality of participants. Changes in mediating psychological and perception factors will also be assessed including sense of control, belief in diet-disease relationship and perceived affordability of healthy foods.

The second component of the intervention targets these mediating psychological and environmental perception factors and aim to empower mothers to improve their dietary attitudes and behaviour. Building upon previous work in Southampton, the materials for the behaviour change component of the intervention will involve an adaptation of Healthy Conversation Skills[179] and use the free software LifeGuide to create digital materials.[376] Healthy Conversation Skills is a capacity building behaviour change technique that trains health and social care professionals in skills to help clients reflect on their health behaviours, identify barriers and solutions, and set achievable goals to improve these behaviours.[180] The skills of reflection, problem-solving and goal-setting are recognised behaviour change techniques that empower individuals to manage their health behaviours and increase their sense of control.[371] Healthy Conversation Skills could be adapted for mothers with young children to use through a digital interface. Digital interventions enable behavioural support to be provided to participants remotely using technological mediums, such as webpages, mobile applications and text messages.[376] With the intervention trial requiring involvement of 24 stores, remote delivery of the behaviour change component of the intervention is necessary. The virtual Healthy Conversation Skills would also include provision of information about the health benefits of healthy eating (when these information needs are identified by participants), virtual social support and a culturally appropriate adaptation of an Australian pilot intervention to improve perceptions of healthy food affordability.[363] The acceptability of the behavioural change component will be assessed with a sub-set of participants of the current study during the feasibility phase, which will inform the trial behaviour change materials.

This proposed intervention includes targeted strategies to address key environmental and individual determinants of dietary inequalities identified in this thesis. Additional action at the policy level could also be taken to provide a more comprehensive approach to tackling dietary inequalities.

9.4 Implications for public policy

Comprehensive action plans including both universal and targeted intervention initiatives across policy, environmental and individual determinants are most likely to be effective at reducing inequalities in health and health behaviours.[377] Figure 9-3 presents a comprehensive action plan that could be applied to reduce dietary inequalities among mothers with young children. This action plan is based on the: *i)* findings of this thesis, *ii)* model of nutrition environments,[1] *iii)* Norwegian intervention map to reduce social inequalities in health,[377] and *iv)* framework to categorise obesity determinants and solutions.[378]

There is evidence to indicate that universal policy initiatives are more likely to reduce socioeconomic inequalities in health than universal educational interventions.[379] For example, tobacco price increases have been shown to reduce inequalities in smoking behaviour, while media campaigns have been shown to increase inequalities. The results of this thesis indicate that reducing the price differential between healthy and less healthy products in the major supermarket chains could improve dietary quality. This finding is supported by evidence from a systematic review and meta-analysis which found that healthier diets cost $1.48 US more per day than less healthy diets,[44] and that price increases on less healthy foods reduce purchases of these foods.[315 316] However, the political difficulty with implementing policy initiatives, such as less healthy food price increases, are typically much higher than for education-based strategies.[378]

Policy initiatives are likely to have the greatest effect on the health of the whole population and be cost-effective. But, the UK government has shown reluctance to act, opting for voluntary rather than regulatory initiatives for food retailers to create environments that promote more healthful food choices. Expanding initiatives, such as the UK Public Health Responsibility Deal, to include strategies that improve the imbalance of pricing or promotional activities of healthy and less healthy foods fits comfortably within the current policy framework. Yet, the UK Chief Medical Officer recently stated that if voluntary efforts fail to deliver health benefits then regulatory approaches should be considered,[235] and governments in other countries have shown willingness to enact taxes on less healthy food products to improve population health.[316 317] Additional evidence about the differential price and promotion of foods indicative of better and poorer dietary patterns could be used to support advocacy efforts for governmental policy action on food prices.[322] The in-store audit tool developed in this study could be used to monitor change in price and promotion difference overtime or evaluate interventions and their effects on dietary quality and inequalities.

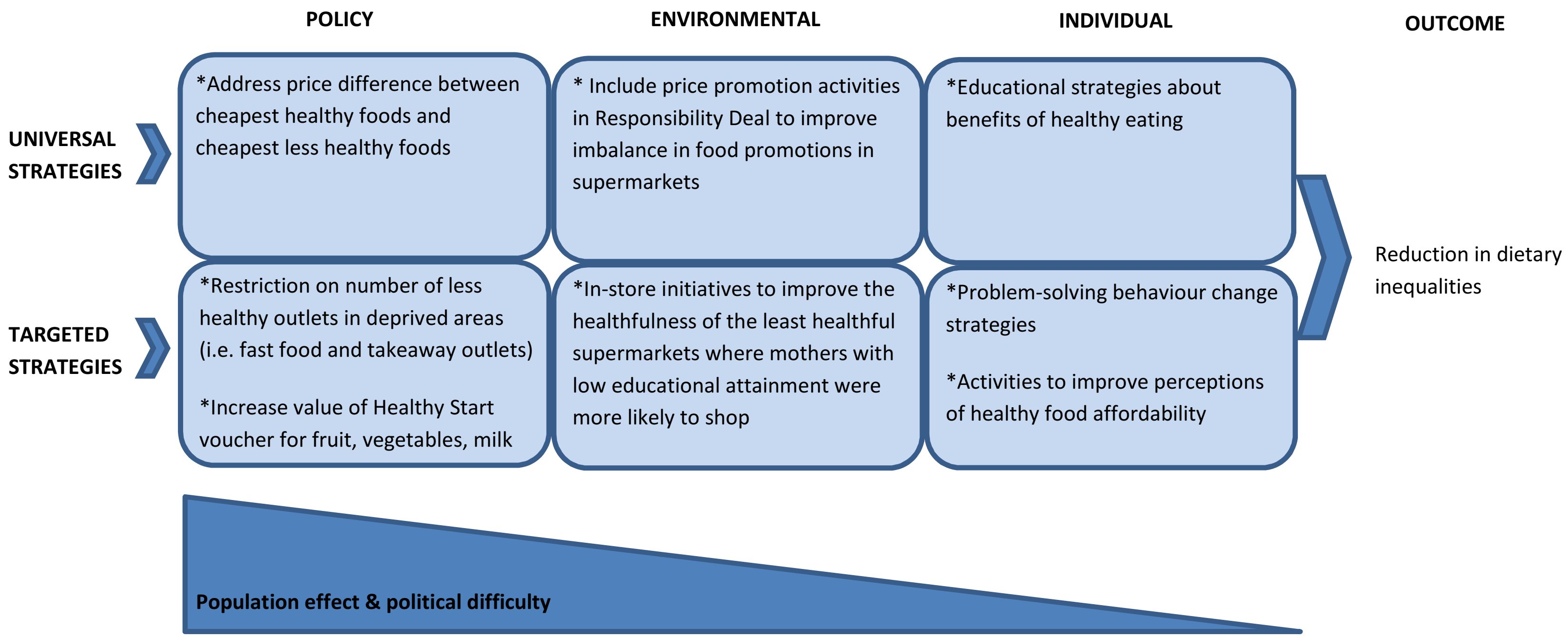


Figure 9-3 Comprehensive action plan to reduce dietary inequalities among mothers with young children[a]

[a] Diagram is informed by the findings of this thesis, model of nutrition environments,[1] Norwegian intervention map,[377] framework to categorise obesity determinants and solutions.[378]

Implementation of policy initiatives that target disadvantaged groups, in addition to universal policy initiatives, are required to address inequalities in health behaviours.[377] The results of this thesis showed that less healthy food outlets were more prevalent across the study area than healthy food outlets. This imbalance was particularly apparent in more deprived neighbourhoods. Additionally, mothers with low educational attainment were more likely to reside in the most deprived neighbourhoods and were more reliant on food outlets proximal to home. Local authorities could enact policy initiatives to improve the imbalance of healthy and less healthy food outlets, particularly through planning restrictions. Some local authorities have already taken action in this area and opportunities exist for other local councils to align public health priorities with other internal sectors, such as economic development and urban planning.[252] Financial constraints on local authorities may prevent the introduction of such policies or laws. However, researchers can assist policy makers by building the evidence-base from natural experiments[272] or longitudinal research using analyses, such as overall food environment scores.

There was also evidence from this study that mothers with lower educational attainment perceived more concerns about food affordability than mothers with higher educational attainment. The Healthy Start scheme currently offers low-income families with young children vouchers of £3.10 to spend on fruit, vegetables and milk.[319] The scheme has been well received by food retailers and shows promising results regarding fruit and vegetable intake,[320] however, uptake of the program has been poorer than desired.[321] There is evidence to suggest that a 10% subsidy on healthy food is required to induce meaningful increases in consumption and higher subsidies have shown greater increases in intake.[318] Larger improvements in dietary behaviour could potentially be achieved if the Healthy Start subsidy was increased. Intervention research trialling the effectiveness of increased subsidies on disadvantaged families alone, and in combination with interventions targeting environmental and individual determinants (e.g. the intervention described in Figure 9-2), would provide additional evidence of the effectiveness of targeted initiatives at reducing inequalities. To be most useful to policy makers, future intervention evaluations should include cost-benefit and modelling analyses to identify the expected size and time scales of impact on dietary and health inequalities and health budgets.

9.5 Conclusion

This thesis began by describing that the greatest burden of chronic illnesses, such as obesity and diabetes, falls upon those most disadvantaged and that their poorer dietary patterns are an important determinant of this burden. This thesis also highlighted that the dietary quality of mothers from disadvantaged backgrounds is of particular concern not only because of the likely impact on their own health, but also for the short and long term health of their children. The results of this thesis showed that compared to mothers with degrees, mothers who left school at 16 years of age have significantly poorer dietary quality, equivalent to eating salad vegetables up to six times less each week and crisps up to six times more each week. While much is known about psychosocial determinants of dietary inequalities, knowledge of local environmental determinants and their interaction with psychosocial determinants is more limited, particularly in the UK. This study addressed a gap in the literature by comprehensively exploring how the local food environment and individual factors are associated with dietary behaviours, and whether these associations varied according to level of educational attainment.

Three novel measures were developed during the study to assess each of the three components of the local food environment. These measures make a contribution to the food environment literature as they provide more nuanced exposure measures than previous work and provide robust scores for statistical analyses. The use of actual exposures, including main food store and activity spaces, and temporal connection between data collection of all variables are also improvements on previous work and increase confidence in the study findings.

The results of this study showed that the in-store environment of mothers' main food stores act indirectly on dietary behaviour through psychological and perceived food affordability factors, with the latter a more important predictor among mothers with lower educational attainment. The dietary quality of mothers with higher educational attainment consistently showed little susceptibility to poorer local food environment exposures. In contrast, the dietary quality of mothers with low educational attainment tended to vary in accordance with the quality of the environments they were exposed to. In particular, those who shopped at more healthful supermarkets had better dietary quality, equivalent to consuming crisps up to four times less and vegetable dishes up to four times more each week, than those who shopped at the least healthful supermarkets. These findings suggest that a future intervention which aims to *i)* improve the in-store environment of the least healthful supermarkets, and *ii)* enhance psychological and cost-related attitudes towards healthy eating, is likely to improve the dietary behaviours of mothers and their families, particularly if the most disadvantaged families are targeted. However, action at the policy level could also be taken to provide a more comprehensive approach to tackling dietary inequalities.

In particular, local authorities could enact planning restrictions to improve the imbalance of healthy and less healthy food outlets, particularly in more deprived neighbourhoods, which showed greater access to less healthy food outlets than more affluent neighbourhoods. In addition, increasing the value of Healthy Start subsidies could enable disadvantaged families to afford to make more fruit, vegetables and milk purchases. A more universal approach to supporting healthy food choices could be to expand the UK Public Health Responsibility Deal to address the cheaper pricing and more frequent promotion of less healthy foods in supermarkets that was observed in this study. These initiatives fit within current government policy frameworks. But they need to be evaluated to ascertain their effectiveness on dietary and health inequalities, and health budgets. Ongoing partnerships between academics, policy makers, supermarket retailers and community members are necessary to create healthier food environments for the whole population. These partnerships can also provide additional support to mothers from disadvantaged backgrounds to enable them to make healthy food choices for their families that will reduce inequalities in diet and health.

Appendices

Appendix A Peer-reviewed paper about the literature review

Health & Place 27 (2014) 229–242

Contents lists available at ScienceDirect

Health & Place

journal homepage: www.elsevier.com/locate/healthplace

Dietary inequalities: What is the evidence for the effect of the neighbourhood food environment? ☆

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ARTICLE INFO

Available online 17 October 2013

Keywords:
Food environment
Dietary inequalities
Review

ABSTRACT

This review summarises the evidence for inequalities in community and consumer nutrition environments from ten previous review articles, and also assesses the evidence for the effect of the community and consumer nutrition environments on dietary intake. There is evidence for inequalities in food access in the US but trends are less apparent in other developed countries. There is a trend for greater access and availability to healthy and less healthy foods relating to better and poorer dietary outcomes respectively. Trends for price show that higher prices of healthy foods are associated with better dietary outcomes. More nuanced measures of the food environment, including multidimensional and individualised approaches, would enhance the state of the evidence and help inform future interventions.

Contents

☆ This Keynote Review introduces the Health and Place Virtual Special Issue on Diet and Nutrition Environments available online at http://www.journals.elsevier.com/health-and-place/

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1353-8292/$ - see front matter
http://dx.doi.org/10.1016/j.healthplace.2013.09.015

1. Background

Socioeconomic disparities in dietary quality exist in developed countries across the globe (Ball et al., 2004; Ecob and Macintyre, 2000; Robinson et al., 2004) and are contributing to the inequitable distribution of conditions such as obesity and cardiovascular disease (Fox and Smith, 2011; McLaren, 2007; Mente et al., 2009). Dietary intake is recognised as a complex behaviour of multifactorial origin, whereby individual and environmental factors interact to influence what people eat (Foresight, 2007; Story et al., 2008). Areas with little or no provision of healthy foods are believed to contribute to disparities in diet-related conditions such as obesity and diabetes, particularly in the United States (US) (Larson et al., 2009; Walker et al., 2010).

There is growing evidence that the neighbourhood food environment is an important determinant of dietary behaviour and obesity (Giskes et al., 2011; Holsten, 2009; Lovasi et al., 2009) and an increasing consensus over the need to adapt the environment to make healthy choices easier, particularly for individuals from disadvantaged backgrounds (Department of Health UK, 2010). Recent recommendations from the United Nations stressed the need for member states to provide equitable access and availability to foods that contribute to a healthy diet and discourage the production and promotion of foods that contribute to an unhealthy diet (United Nations General Assembly, 2012).

The literature examining associations between neighbourhood environmental factors and socio-economic indicators or diet has grown in recent years (Caspi et al., 2012b). The neighbourhood food environment literature has tried to address many different research questions using a variety of different outcome and exposure measures and very few valid or reliable measures (Charreire et al., 2010; Gustafson et al., 2012; McKinnon et al., 2009b). This diversity in methodologies combined with the ecological design of the vast majority of studies has made interpreting this body of literature challenging within the standard systematic review paradigm. As a result, previous reviews of the evidence have made recommendations for further research rather than concise conclusions about the strength or range of effect sizes of the current evidence base (Caspi et al., 2012b; Giskes et al., 2011; Gustafson et al., 2012; Larson et al., 2009; Walker et al., 2010). This paper offers the first synthesis of previous review articles to determine the evidence for socioeconomic disparities in the neighbourhood food environment and explores the potential for quantifying the relationship between the food environment and dietary inequalities.

2. Organising the evidence

Leading academics in the food environment field have called for research to use conceptual models that theorise and test the mechanisms by which specific environmental exposures interact with individual factors to influence health behaviours such as diet (Cummins, 2007; McKinnon et al., 2009a; Oakes et al., 2009). A widely used model of the food environment is that of Glanz et al. in 2005 (Fig. 1). It considers the policy, environmental, social and individual determinants of diet. The model links dietary behaviour directly to a collection of three settings: *community nutrition environment, consumer nutrition environment and organisational nutrition environment*. The model also suggests that the effect of these settings plus a fourth setting, the *information environment* (media and advertising), may be moderated or mediated by demographic, psychosocial or perceived environmental factors.

Most of the food environment research to date has focused on the *community nutrition environment* (Caspi et al., 2012b; Thornton and Kavanagh, 2010b) which measures the accessibility of food sources in the context of residential neighbourhoods. These studies use Geographic Information Systems (GIS) or other methods to determine the geospatial location of food sources to measure accessibility in terms of outlet proximity, density and to lesser extent diversity (Charreire et al., 2010; McKinnon et al., 2009b). Proximity assesses the minimum distance between food outlet and residence or proxy location, using road network, Euclidean distance or travel time. Density quantifies the availability of different types of food outlets within a specific area such as census tracts or buffer zones around centroid, home or food outlet. Density calculations may include total count, count per population, per square area or kernel density estimation (density calculation weighted by distance from origin). Diversity measures the different types of outlets for example the number of different fast food outlets.

The *consumer nutrition environment* reflects factors that consumers encounter within a retail food outlet such as the types of food available, price, promotions, placement, range of choice, freshness or quality and nutrition information. Assessment of the in-store environment typically requires internal audits by observation using a checklist or market basket tool (McKinnon et al., 2009b). A range of such tools have been developed where the majority measure product availability and price. A smaller number of tools consider additional factors such as product quality or variety (Gustafson et al., 2012). Fewer studies have explored consumer nutrition environment factors probably due to the time

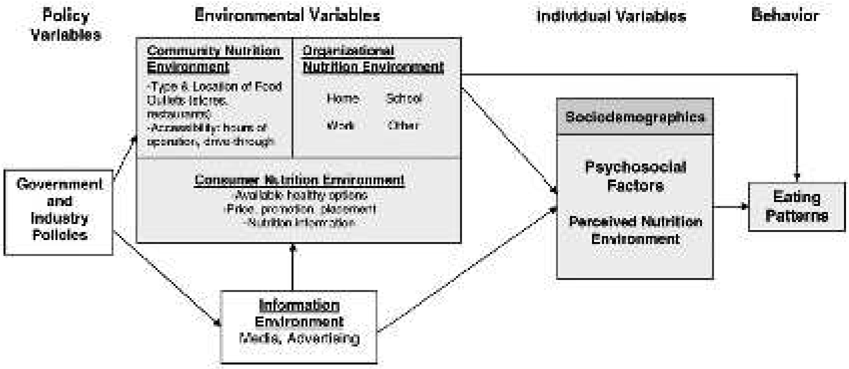

Fig. 1. Model of nutrition environments (Glanz et al., 2005).

and financial costs associated with collecting and analysing such data (Thornton and Kavanagh, 2010b).

The *organisational nutrition environment* refers to specific institutional settings where defined groups of people consume food such as workplace cafeterias or children's centres, churches and healthcare facilities. The nutrition environment of these institutions has long been identified as an important determinant of health whereby the ethos, policies and practices of the setting can heavily influence an individual's beliefs and behaviours including food choices (McLeroy et al., 1988). To date the role of organisational nutrition environments have rarely been considered in reviews of the food environment literature. However, these settings can play an important part of an individual's day-to-day life and form part of their food environment exposure.

This paper uses the model by Glanz and colleagues to structure a review of the literature with a key focus on identifying the evidence for the role of the food environment on dietary inequalities. This review is restricted to research conducted in developed nations, on adults aged 18–60 years and does not cover literature on the organisational nutrition environment. More specifically, the review (i) summarises the evidence for neighbourhood disparities in community and consumer nutrition environments from previous review articles, and (ii) assesses the evidence for the effect on dietary intake.

3. Methods

In order to summarise the evidence for neighbourhood disparities in community and consumer nutrition environments previous semi-systematic and systematic review articles assessing this literature were identified and synthesised. A literature search for reviews was completed in January 2013 using Medline and Web of Science databases using the search terms 'review' and 'food environment'. A total of 123 articles were reviewed. After screening and analysis a total of ten papers were found to have reviewed the findings of studies investigating neighbourhood disparities in the community and consumer nutrition environments. Review papers that described methods for assessing the food environment were excluded. Collectively these 10 review articles considered research on the community and consumer nutrition environment to early 2011. Additional original research papers recently published were also considered to present examples of more recent evidence.

To answer the second aim of the paper, and assess the evidence for an effect of the community and consumer nutrition environments on dietary intake, a literature search was performed in November 2012 and again in September 2013 using Medline, Embase, AMED and PsycArticles, and Web of Science databases. Both MeSH and free terms were applied including 'environmental medicine' (MeSH), 'food stores', 'food outlet', 'food price', 'food availability', 'food promotions', 'food habits' (MeSH), 'diet', 'consumption' and 'intake'. A total of 3943 articles were returned in November 2012. After screening abstracts and removing duplicates 59 original research articles and two review articles were identified. A further 33 articles were excluded because they did not assess the direct relationship between objective measures of permanent food outlets and dietary outcomes in adults aged 18–60 years. An additional 21 articles were identified from the bibliographies of relevant papers and through contact with experts in the field of food environment research. In September 2013 nine new studies that met the inclusion criteria were identified. Due to the heterogeneity of the exposure and outcome variables used in these original research papers a meta-analysis could not be performed. As an alternative, exposure measurements were tallied according to the direction of their relationship with three common dietary outcomes: dietary quality, fruit and vegetable intake or fast food intake. Several exposure measures from a single article may have been included in the count. Exposure measures were grouped by store type and key environmental variables (density, proximity, availability, price, quality and variety). The final results were presented in tables or graphs. Similar methods were used to summarise studies which investigated relationships between environmental variables and diet in disadvantaged populations.

4. Results

4.1. *Question 1: disparities in the neighbourhood food environment*

A total of ten published reviews have assessed studies investigating differences in neighbourhood deprivation or ethnicity of the community nutrition environment and/or the consumer nutrition environment (Beaulac et al., 2009; Black and Macinko, 2008; Fleischhacker et al., 2011; Ford and Dzewaltowski, 2008; Fraser et al., 2010; Gustafson et al., 2012; Hilmers et al., 2012; Larson et al., 2009; Lovasi et al., 2009; Walker et al., 2010). Three articles were described as systematic reviews (Beaulac et al., 2009; Fleischhacker et al., 2011; Gustafson et al., 2012) however, only one review by Beaulac et al. indicated that two independent authors had reviewed the search results. Collectively, these reviews consider 102 original research papers from five developed countries, which were published from 1966 to 2011. Four of the ten review articles assessed literature solely from the US where the bulk of the research in this field has been conducted (Ford and Dzewaltowski, 2008; Larson et al., 2009; Lovasi et al., 2009; Walker et al., 2010). The remaining six reviews took an international perspective but were limited to research from developed nations and papers published in English. Of the 102 papers reviewed, 70 were from the US, 12 from the UK, 11 from Canada, seven from Australia and two from New Zealand. Approximately half (47%) of the studies focused on assessing neighbourhood disparities in the community nutrition environment, 34% on the consumer nutrition environment and 19% included measures of both these nutrition environments. There was much overlap in original research papers reviewed, with 41% of studies featuring in more than one review article.

The reviews considered heterogeneity in measurements of the community and consumer nutrition environments to be a major challenge in interpreting the literature. A variety of definitions of neighbourhood and food outlets had been used and a range of analyses applied for measures of food outlet density or proximity and the availability and price of food within stores. As a result of this heterogeneity none of the review articles were able to perform a meta-analysis. A summary of the ten review articles is provided in Table 1 and a summary of their main findings are described below.

4.1.1. *Community nutrition environment*

There is consensus across the nine articles reviewing the community nutrition environment of sufficient evidence that residents of low income or ethnic minority neighbourhoods in the US have disproportionally poorer access to healthy foods (Beaulac et al., 2009; Black and Macinko, 2008; Larson et al., 2009; Walker et al., 2010) and greater access to food outlets selling less healthy foods (Black and Macinko, 2008; Fleischhacker et al., 2011; Fraser et al., 2010; Hilmers et al., 2012; Larson et al., 2009) than residents of more affluent neighbourhoods. One review concluded that the strongest evidence for environmental influences for socioeconomic and ethnic disparities in obesity is the unequal access to food stores (along with access to exercise facilities and neighbourhood safety (Lovasi et al., 2009). The evidence for differences in access to healthy food by level of area deprivation from other developed nations including Canada, Australia and the UK was equivocal (Beaulac et al., 2009; Black and Macinko, 2008). However, there was more consistent evidence for disparities in access to fast food outlets in these countries, with greater access in more deprived neighbourhoods (Black and Macinko, 2008; Fleischhacker et al., 2011; Fraser et al., 2010; Hilmers et al., 2012).

The five review articles that assessed the evidence for neighbourhood differences in fast food access found that internationally, the vast majority of studies showed greater access to fast food outlets in neighbourhoods with higher levels of deprivation and minority populations (Black and Macinko, 2008; Fleischhacker et al., 2011; Fraser et al., 2010; Hilmers et al., 2012; Larson et al., 2009).

4.1.1.1. The United States. The four review articles which assessed the evidence for spatial disparities in grocery store access found consistent trends for low-income and ethnic communities in the United States having fewer supermarkets per capita and farther distances to travel to the closest store than more affluent communities (Beaulac et al., 2009;Black and Macinko, 2008; Larson et al., 2009; Walker et al., 2010). For example, research assessing the national distribution of supermarkets by zip codes showed that residents in low income neighbourhoods had only 75% as many chain supermarkets as middle income neighbourhoods (Powell et al., 2007b). There were also differences in access according to ethnicity, with the availability of chain supermarkets in neighbourhoods with higher proportions of black residents roughly half that in predominantly white neighbourhoods. Similarly research from Detroit, which investigated distance to closest supermarket from census tracts centroid, showed the nearest supermarket was at a significantly greater distance from people's homes in the most impoverished areas (> 17% in poverty) compared with the least impoverished areas (< 5% in poverty) (Zenk et al., 2005). Furthermore, the most impoverished black areas were 1.1 miles further from the closest supermarket than the most impoverished white areas. A more recent study in a Texan county however, found that percent Latino in the neighbourhood was not associated with access to supermarkets, grocery stores or specialty stores but there was an association with exposure to convenience stores (Lisabeth et al., 2010). This brief summary suggests, as noted in the review by Black and Macinko (2008), that there is evidence in the US that neighbourhood environmental factors may be inhibiting residents of more disadvantaged communities from making health dietary choices.

In the United States a national study that examined the distribution of food service outlets in more than 28,000 zip codes, found lower income neighbourhoods had 1.2 and 1.3 times the number of full service and fast food outlets of higher income neighbourhoods respectively (Powell et al., 2007a). These disparities were observed after adjustment for population density, urbanisation and region. Research from New York City highlights how black communities are disproportionally affected by fast food access with results showing that the prevalence of fast food outlets was positively associated with percentage of black residents (Kwate et al., 2009). This association was stronger than the association with median household income such that high income black neighbourhoods had similar exposure to fast food outlets as low income black neighbourhoods. A more recent study, included in one review article (Hilmers et al., 2012), applied a novel approach to assessing food outlet accessibility by creating an index that considered density of supermarkets, convenience stores selling healthy foods and fast food outlets in census blocks (Gordon et al., 2011). Results showed that predominantly black neighbourhoods had poorer food access scores while predominantly Latino and white neighbourhoods had better food access scores. Additionally, neighbourhoods with the highest median income had better food access scores compared with the lowest income neighbourhoods.

4.1.1.2. Other developed nations. Grocery store access studies from other developed nations including Australia, Canada and the UK have not consistently identified disparities in access to supermarkets and grocery stores among neighbourhoods of varied socioeconomic status (Beaulac et al., 2009;Black and Macinko, 2008) and very few studies have reported differences by the ethnic composition. For example, research from Melbourne, Australia, has shown that geographical access to supermarkets and fruit and vegetable stores was better for those living in more advantaged neighbourhoods (Ball et al., 2009). This finding was consistent across three measures of access: count within a two kilometre buffer of home, density per 10, 000 residents and closest proximity via road network. Another study from Melbourne, however, found that although more advantaged areas had closer access to supermarkets, most residents (> 80%) lived within an 8–10 min car journey of a major supermarket suggesting most people had good access to healthy food (Burns and Inglis, 2007). Similarly, research in Brisbane, Australia, demonstrated no differences in shopping infrastructure according to the socioeconomic status of census districts (Winkler et al., 2006b). In Canada, research conducted in Edmonton revealed few differences in supermarket access across neighbourhoods of differing socioeconomic status or proportion of Aboriginal residents (Smoyer-Tomic et al., 2008). Furthermore, research in British Columbia and Quebec has shown that supermarkets predominated low income neighbourhoods (Apparicio et al., 2007; Black et al., 2011), while in Ontario, lower income neighbourhoods were predominated by convenience stores (Latham and Moffat, 2007). The evidence from the UK is also mixed. Assessment of the community nutrition environment in Wales and Northern England has shown poorer access to supermarkets in poorer areas (Clarke et al., 2002). Research in Glasgow, however, has shown little difference by neighbourhood deprivation (Macdonald et al., 2009) or better access to supermarkets in more deprived neighbourhoods (Cummins and Macintyre, 2002). Nation-wide research in Sweden, that was not included in the review articles, revealed that neighbourhoods of high deprivation have a greater prevalence of supermarkets and grocery stores than less deprived neighbourhoods (Kawakami et al., 2011). These results provide further indication that food access issues, which appear to be important predictors of inequalities in the US, may be less apparent in other developed countries.

Socioeconomic trends in fast food access in other developed countries have been reasonably consistent with trends observed in the US (Black and Macinko, 2008). Only three studies, from Canada and the UK, have shown no association between level of neighbourhood deprivation and fast food access (Fleischhacker et al., 2011; Fraser et al., 2010). In Australia for example, research in Melbourne has shown, that residents of the poorest neighbourhoods lived closer, and had up to 2.5 times more exposure to fast food outlets, than people living in wealthier neighbourhoods (Burns and Inglis, 2007; Reidpath et al., 2002). In Edmonton, Canada, poorer neighbourhoods, as well as those with higher percentages of Aboriginal residents, had greater access to fast food outlets than more affluent neighbourhoods (Smoyer-Tomic et al., 2008). This association remained after adjusting for supermarket proximity to residents' homes. Research from the UK has shown a positive linear relationship between the density per 1000

Table 1
Summary of review articles and key findings relevant to neighbourhood inequalities in the community nutrition environment and consumer nutrition environment.

Author, year	Review aim and methods	Number of papers reviewed	Geographical coverage	Key findings—community nutrition environment	Key findings—consumer nutrition environment
Hilmers et al. (2012) Am. J. Public Health	Examine socio-economic/ethnic disparities in neighbourhood access to fast food outlets and convenience stores. Reviewed literature from 2000 to 2011.	24 in total, all relevant to this review. 14 ecological design.	Australia Canada New Zealand UK US	14 of 18 studies identified fast food access favoured more deprived areas. 5 of 9 studies found fast food access was greater in predominantly ethnic areas. All 8 studies found higher density of convenience stores in areas of higher deprivation/ethnicity.	
Gustafson et al. (2012) J. Community Health	Review literature on food availability in stores and neighbourhood characteristics, diet, weight and food prices. Reviewed literature between 2000 and 2011. Described as systematic review.	56 in total. 30 relevant to this review, all cross-sectional design.	Australia UK US		Inconsistent evidence for less availability of healthy food (6 of 10) and F&V (7 of 11) in poorer/ ethnic areas. Prices of healthy foods (2 of 8) rarely differed by area deprivation. All 8 studies showed quality of healthy foods was poorer in more deprived areas.
Fleischhacker et al. (2011) Obes. Rev.	Systematic review to examine the evidence on fast food access and its associations with socioeconomic status, ethnicity, obesity, other health behaviours/outcomes. Reviewed literature between 1998 and 2008. Described as systematic review.	40 in total. 17 relevant to this review. 3 cross-sectional design and 14 ecological design.	Australia Canada New Zealand UK US	Only 3 of 15 studies did not find fast food outlets were more prevalent in low income areas (all non-US). 7 of 9 studies found fast food outlets were more prevalent in high ethnic minority areas.	
Fraser et al. (2010) Int. J. Environ. Res. Public Health	Summarise the literature regarding fast food outlet location by area deprivation, dietary intake and weight. Reviewed literature between 1990 and 2008.	33 in total. 12 relevant to this review, all ecological design.	Australia Canada New Zealand UK US	10 out of 11 studies showed associations between increasing area deprivation and access to fast food outlets.The 2 studies identified showed a positive association between area ethnicity and access to fast food outlets.	
Walker et al. (2010) Health Place	To review the literature on healthy food access in the US. Reviewed literature up to January 2010.	31 in total. 20 relevant to this review. 8 cross-sectional design and 12 ecological design.	US	Evidence to suggest that disparities in supermarket access exist with ethnic minority and low-income neighbourhoods being disproportionately affected. Non-chain smaller grocery stores are more likely to be located in poor areas. Supermarkets are more prevalent in more affluent areas.	Chain supermarkets have lower prices and better availability and quality of healthy food than smaller non-chain stores. Residents of neighbourhoods with no supermarket pay more for food and have poorer quality food.
Beaulac et al. (2009) Prev. Chronic Dis.	To determine whether access to healthy, affordable food in retails stores varies by area, specifically disadvantaged areas. Reviewed literature up to 2007. Systematic review—two independent authors reviewed the search results.	52 in total, all relevant to this review. 32 cross-sectional design and 20 ecological design.	Australia Canada New Zealand UK US	18 out of 19 US studies showed low-income/black American areas were underserved by grocery stores compared with more advantaged areas. In other developed countries, 1 out of 6 studies found that low-income areas had poorer access to grocery stores while 2 studies showed low income areas had better access.	5 of 9 US studies found poorer availability and quality of foods in disadvantaged areas. 6 of 9 nine studies in other developed countries found no difference in availability, variety or quality of healthy foods by area deprivation. In all countries findings for price were mixed and complex. From a total of 23 studies, 3 found higher prices in poorer areas, 4 found lower prices in poorer areas and 16 found mixed or no association.

Table 1 (*continued*)

Author, year	Review aim and methods	Number of papers reviewed	Geographical coverage	Key findings—community nutrition environment	Key findings—consumer nutrition environment
Larson et al. (2009) Am. J. Prev. Med.	To comprehensively review disparities across the US according to neighbourhood access to more and less healthy foods and obesity and dietary outcomes. Reviewed literature between 1985 and 2008.	54 in total. 26 relevant to this review. 14 cross-sectional design and 12 ecological design.	US	14 of 17 studies showed low income and ethnic neighbourhoods were more often affected by poor access to supermarkets than more affluent areas. 4 of 6 studies showed access to fast food outlets was greater in low income and minority areas.	8 of 10 studies showed the availability of healthy food was poorer in more disadvantaged areas. 2 of 2 studies showed restaurants in more affluent areas off more health menu options than low income areas.
Lovasi et al. (2009) Epidemiol. Rev.	To evaluate whether built environments might explain ethnic and socioeconomic disparities in obesity. Reviewed literature between 1995 and 2009.	45 in total. 15 relevant to this review. 8 cross-sectional design and 7 ecological design.	US	10 of 15 studies found disadvantaged areas had fewer supermarkets than more affluent areas. 5 of 8 studies found higher proportions of fast food outlets in more disadvantaged areas.	
Ford and Dzewaltowski (2008) Nutr. Rev.	To provide preliminary evidence to assess: (a) geographical disparities in the retail food environment, (b) disadvantaged areas have poor-quality retail food environment and (c) individuals exposed to poor-quality retail food environments have poorer quality diets and higher obesity rates. Reviewed literature from 1992 to 2007.	13 in total, all relevant to this review. 7 cross-sectional design and 6 ecological design.	US	8 of 9 studies found lower access to supermarkets in more deprived and ethnic areas compared to more affluent and white neighbourhoods.	5 of 5 studies found poorer availability or quality of healthy foods in more disadvantaged areas. 2 of 2 studies found no difference in price of products by area deprivation or ethnicity.
Black and Macinko (2008) Nutr. Rev.	Comprehensively assess the neighbourhood determinants of obesity in high-income countries. Reviewed literature from 2005 to 2007.	90 in total. 18 relevant to this review. 5 cross-sectional and 13 ecological.	Australia Canada UK US	9 US studies showed access to stores selling healthy food is worse for low income neighbourhoods. 3 studies from Canada, Australia and UK did not identify differences in grocery store access by area deprivation. 2 studies found more food retailers in low income areas. 4 studies from the US, UK and Australia showed low income and ethnic neighbourhoods had greater exposure to fast food outlets.	2 studies showed low income and ethnic areas had fewer healthy choices in local restaurants.

population of McDonald's and other chain fast food outlets and neighbourhood deprivation such that fast food outlets were more prevalent in poorer areas (Cummins et al., 2005b; Macdonald et al., 2007). However, investigations including all out-of-home eating outlets in Glasgow showed the density was highest in neighbourhoods of the second most affluent quintile (Macintyre et al., 2005). A more recent study assessing facilities across Sweden revealed results consistent with the international trend showing higher prevalence of fast food outlets in more deprived neighbourhoods (Kawakami et al., 2011).

4.1.2. *Consumer nutrition environment*

Six review articles appraised neighbourhood disparities in the consumer nutrition environment literature, three with an international perspective (Beaulac et al., 2009; Black and Macinko, 2008; Gustafson et al., 2012) and three focused on literature from the US (Ford and Dzewaltowski, 2008; Larson et al., 2009; Walker et al., 2010). Ford and Dzewaltowski (2008) concluded that consumer nutrition environment studies revealed weaker associations between in-store variables and area deprivation than community nutrition environment studies that used store type as a proxy for healthy food (larger stores having greater availability and cheaper prices). However, the authors also stated that consumer nutrition environment studies are important because they allow for critical differences in availability, price and quality to be observed (Ford and Dzewaltowski, 2008).

4.1.2.1. *The United States.* There is some evidence for neighbourhood disparities in the availability of healthier foods in the United States but the evidence for price is less robust (Beaulac et al., 2009; Ford and Dzewaltowski, 2008; Larson et al., 2009; Walker et al., 2010). For example, results from in-store surveys in two socioeconomic and ethnically contrasting cities in Alabama revealed that the more disadvantaged city had a dominance of convenience stores which stocked few healthy foods. The more affluent city had no convenience stores and several chain supermarkets which offered a large variety of healthy food options and lower price ranges for some fruit and vegetables (Bovell-Benjamin et al., 2009). In contrast, survey results from grocery stores in two socio-economically and ethnically contrasting cities in Chicago showed that store prices were cheaper in the poorer community (Block and Kouba, 2006).

4.1.2.2. *Other developed countries.* In other developed countries the evidence is equivocal (Beaulac et al., 2009; Gustafson et al., 2012). In Australia, research in Brisbane showed no differences in fruit and vegetable price or availability by level of neighbourhood deprivation (Winkler et al., 2006a). In-store surveys in Melbourne however, revealed that fruit and vegetable availability slightly favoured more affluent neighbourhoods but food prices were cheaper in more deprived neighbourhoods (Ball et al., 2009). Cheaper food prices in poorer areas have also been observed in Canada (Latham and Moffat, 2007) and the UK (Cummins and Macintyre, 2002; Cummins et al., 2010).

Although limited and reviewed in only one article, evidence has consistently shown poorer quality produce in more deprived neighbourhoods (Gustafson et al., 2012). A recent study from the UK revealed that residents of the most deprived neighbourhoods had 69–76% greater risk of poor quality fruit and vegetables than residents of more affluent neighbourhoods (Black et al., 2012). The small body of evidence assessing the consumer nutrition environment in food service outlets, reviewed in only one article, revealed that restaurants in more affluent areas offer more healthy menu options than low income areas (Larson et al., 2009). The current evidence for socioeconomic neighbourhood differences in the consumer nutrition environment suggests that the relationship between the availability and price of healthy food and area deprivation is complex and context dependent (Ford and Dzewaltowski, 2008). Variations in the foods assessed in stores and exclusion of in-store factors such as marketing and product placement limits the ability of the current body of evidence to determine whether neighbourhood differences in the consumer nutrition environment contribute to dietary inequalities (Gustafson et al., 2012).

4.2. *Question 2: the neighbourhood food environment and dietary quality*

In the search for evidence of a relationship between the community and consumer nutrition environments and dietary outcomes two systematic reviews were identified. Caspi et al. (2012b) completed a systematic review of articles published prior to March 2011 which investigated a relationship between neighbourhood food environment exposures and diet. A total of 38 empirical studies were identified, 26 of which measured the relationship between objective community or consumer nutrition environment exposures and dietary outcomes in adults aged 18–60 years. More than two-thirds of the articles ($n=26$) used geographical exposure data to measure community nutrition environment against dietary outcomes. Gustafson et al. (2012) systematically reviewed literature investigating the consumer nutrition environment of food stores from 2000 to 2011. A total of six articles that assessed the relationship between objective consumer nutrition environment exposures and diet in adults aged 18–60 years were identified. One article (Hermstad et al., 2010) was additional those identified by Caspi et al., however, has not been included in our review because multiple community and consumer nutrition environment variables were combined in a model, making direct comparison with other original research papers not possible.

The literature search for the present paper identified a further 27 articles (Ball et al., 2006; Boone-Heinonen et al., 2011; Burgoine et al., 2009; Burgoine et al., 2011; Casagrande et al., 2011; Caspi et al., 2012a; Duffey et al., 2010; Dunn et al., 2012; Fuller et al., 2013; Gordon-Larsen et al., 2011; Gustafson et al., 2013a; Gustafson et al., 2013b; Hickson et al., 2011; Jack et al., 2013; Layte et al., 2011; Macdonald et al., 2011; Minaker et al., 2013; Monsivais et al., 2012; Murakami et al., 2010; Ollberding et al., 2012; Rehm et al., 2011; Richardson et al., 2011; Robinson et al., 2013; Sadler et al., 2013; Sharkey et al., 2011; Thornton et al., 2012; White et al., 2004) in addition to those identified by Caspi et al., and Gustafson et al., Grey literature identified from the bibliographies of relevant papers were included in this review however the grey literature was not systematically reviewed. All identified literature was reviewed by only one reviewer. The findings from the two systematic reviews and a summary of the original research papers investigating the neighbourhood food environment and dietary outcomes is provided below for the community and consumer nutrition environments respectively.

4.2.1. *Community nutrition environment and dietary quality*

A total of 31 articles, involving adults aged 18–60 years, measured access to food stores using measures of density. These studies tested whether (a) increased access to food stores selling healthy foods such as supermarkets/ green grocers is associated with better dietary outcomes and/or (b) increased access to outlets selling less healthy foods like fast food outlets is associated with poorer dietary outcomes. The majority of these studies ($n=20$) identified at least one significant association between geographical density and their diet in the expected direction. Two studies assessed the ratio of number of healthy food outlets to less healthy food outlets (Retail Food Environment Index) within a specified boundary but found no association between overall retail exposure and diet (Gustafson et al., 2013a; Minaker et al., 2013). A total of 24 articles, involving adults aged 18–60 years, examined distance to nearest food outlet from participant's home or proxy location. Thirteen of these papers revealed no association between proximity and diet. One study investigated fast food chain diversity and showed that increased numbers of different fast food outlets were linked with higher fast food intake (Thornton et al., 2009).

Summaries of the findings from the 42 original research papers investigating a relationship between community nutrition environment exposures and diet are presented in Figs. 2–5. Around a quarter of the density findings provide evidence for expected associations: food stores selling healthy foods (supermarkets, grocery stores and green grocers) related to better dietary outcomes (27%) and less healthy food stores related to poorer dietary outcomes (22%). Approximately one fifth of the proximity findings provide evidence for an association between healthier food stores and better dietary outcomes (20%) and even fewer indicate an association between less healthy food outlets and poorer dietary outcomes (13%). Very similar trends were observed in the few studies ($n=9$) that focused analyses on disadvantaged populations. More than a quarter of the density findings showed an association between density of healthier food stores and better dietary outcomes while, nearly a fifth showed evidence of an association between closer proximity to healthier food stores and better dietary outcomes. No relationships were observed between proximity of convenience stores and diet in disadvantaged populations however, proximity to fast food outlets was associated with higher fast food intake in the one study identified (Dunn et al., 2012). The evidence for the community nutrition environment shows a trend toward expected associations however the majority of findings reported no association. There is some variation by global regions which is discussed further below.

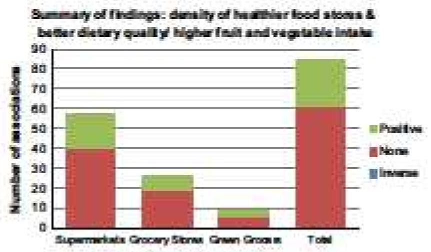

Fig. 2. Summary of findings relating density of healthier food stores to better dietary quality or higher fruit and vegetable intake. (Across 42 different exposure measures, 17 studies and 21 papers).

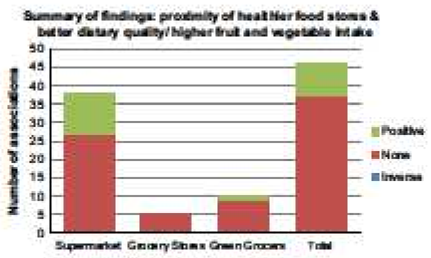

Fig. 3. Summary of findings relating proximity of healthier food stores to better dietary quality/fruit and vegetable intake. (Across 11 different exposure measures, 16 studies and 18 papers.)

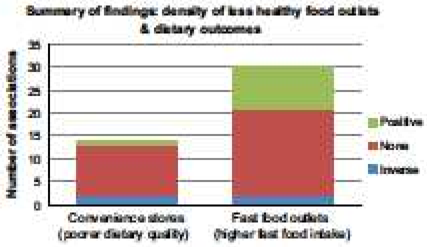

Fig. 4. Summary of findings relating density of less healthy food stores to poorer dietary outcome. (Across 10 different exposure measures for convenience stores, 7 studies and 7 papers; across 12 different exposure measures for fast food outlets, 8 studies and 9 papers; 2 studies were not included in the convenience store calculation because different outcome measures were used; and 5 studies were not included in the fast food outlet calculation because different outcome measures were used.)

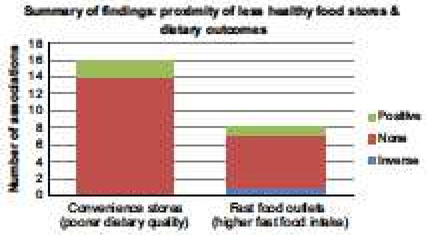

Fig. 5. Summary of findings relating density of less healthy stores to poorer dietary outcomes. (Across 5 different exposure measures for convenience stores, 7 studies and 7 papers; across 1 different exposure measures for fast food outlets, 4 studies and 5 papers; 1 study was not included in the convenience store calculation because different outcome measures were used; 1 study was not included in the fast food outlet calculation because different outcome measures were used.)

4.2.1.1. The United States. The majority of studies have been conducted in United States ($n=24$). This literature provides the strongest evidence of all regions for a relationship between community nutrition environment exposures and dietary outcomes with almost two-thirds showing significant associations ($p<0.05$) in the expected direction. Better access to supermarkets and green grocers was associated with healthier dietary behaviours in ten studies. However, a further eleven studies revealed no significant associations. Two studies revealed negative associations between fruit and vegetable intake and the density of small grocery stores and convenience stores which are known to offer poorer availability of healthy foods (Gustafson et al., 2011; Powell et al., 2009). For example, Powell et al. (2009) showed that each additional grocery store per 10,000 capita was associated with an approximate 3% decrease in weekly fruit and vegetable consumption ($p=0.05$). This study by Powell et al., also showed that each additional fast food outlet per 10,000 capita was associated with an approximate 5% decrease in fruit and vegetable consumption. However, the evidence for a relationship between fast food access and fast food intake in the US is mixed with four of the nine studies showing mixed results and three returning null or unexpected findings. Results from a longitudinal study stratifying the sample by gender found no association between fast food outlet density and fast food consumption in women. For males however, 1% increase in access to fast food outlets within a 1 km and 1–3 km radius from home corresponded with modest increases in monthly fast food intake of 0.13% and 0.34% respectively (Boone-Heinonen et al., 2011). The evidence suggests that while some inconsistency exists in the literature there is weak evidence for a relationship between community nutrition environment exposures and dietary outcomes in the US.

4.2.1.2. Canada. One comprehensive study in Ontario, Canada, has assessed the relationship between food access and diet (Minaker et al., 2013). This study measured multiple aspects of the community nutrition environment including road network distance to nearest grocery store, convenience store and fast food outlet, total store and restaurant density within one kilometre of home, and the ratio of healthy to unhealthy stores and restaurants. Analyses were stratified by gender and results revealed not one significant relationship. These lack of findings suggest that in Canada, diet quality is not influenced by access to food stores and restaurants however, clear conclusions cannot be drawn from a single study.

4.2.1.3. Australasia. A total of eight articles were identified from the Australasia region: four from Australia, two from New Zealand and two from Japan. The outcomes from these papers are largely equivocal, with several studies revealing mixed results. For example, the SESAW study from Australia found that density of supermarkets per 10,000 residents (Ball et al., 2006) and within 2 km radius of low-income women's homes (Williams et al., 2010) was not associated with fruit and vegetable consumption. Higher supermarket density within 3 km radius of residence, however, was associated with increased vegetable consumption of the full sample of women (Thornton et al., 2010a). In New Zealand, research by Pearce et al. (2008, 2009) found no association between supermarket access and fruit and vegetable consumption. However, this study did show that residents with the worst access to fast food outlets were up to 17% *more* likely to consume the recommended intake of vegetables and those with the best access to convenience stores were up to 25% *less* likely to.

4.2.1.4. Europe. Across Europe, a total of nine articles written in English were identified: eight from the UK (five in England and three in Scotland), and one from Ireland. This literature revealed many inconsistencies with several studies reporting conflicting findings. In the UK, Burgoine et al. (2011) showed no association between fruit and vegetable consumption and density of supermarkets or convenience stores. They also found an unexpected association between elevated vegetable consumption and higher density of food service outlets. These outlets included restaurants as well as take-away outlets and the authors postulate that residents may not always be making unhealthy choices if they are eating-out within their neighbourhood. Two natural experiments exploring the effects of opening a new supermarket have been conducted in the UK. In northern England, consumers who switched supermarkets or lived within 500 m of the new store had increased fruit and vegetable consumption after the new supermarket had opened (Wrigley et al., 2003). In Glasgow, however, no positive effect on the fruit and vegetable intake of neighbourhood residents was identified even though 30% of the sample reported switching to the new supermarket (Cummins et al., 2005a). The single non-UK study revealed a weak effect for supermarket access on dietary quality in the republic of Ireland: each additional supermarket within a two kilometre radius from home was associated with a 2.5% increase in diet score which represented a healthier dietary pattern (Layte et al., 2011). The findings from studies in Europe demonstrate inconsistencies in the relationships between the community nutrition environment and diet and the effect sizes observed have been relatively small. However, the body of literature is limited, particularly outside the UK, and there is a need to improve methodological techniques to enhance the quality of this body of evidence (Caspi et al., 2012b; Charreire et al., 2010).

4.2.2. *Consumer nutrition environment and dietary quality*

A total of 20 studies used in-store audit tools to measure consumer nutrition environment exposures and dietary outcomes in adults aged 18–60 years. These studies tested whether (a) better availability, variety and quality of healthy foods is associated with healthier dietary intakes and/or (b) lower costs of healthy food and higher costs of less healthy food are associated with healthier dietary outcomes.

Different in-store audit tools were used across most studies and few studies reported the tool's reliability. Ten assessed product availability, six of which identified at least one positive association with diet. The eight studies that assessed price found either null associations or unexpected associations where better dietary patterns were associated with higher prices. The two longitudinal studies (Duffey et al., 2010; Gordon-Larsen et al., 2011), however, showed that price increases on less healthy foods were associated with lower energy or fast food intake. Few studies measured the variety or quality of products ($n=4$) and results were mixed.

Summaries of the findings from the 20 original research papers investigating a relationship between consumer nutrition environment exposures and diet are presented in Table 2. Almost a quarter (24%) of findings regarding the availability of healthy products revealed that better availability was associated with better dietary outcomes. Findings for price showed, in a fifth of studies, that lower prices of healthy and less healthy products increased consumption of these foods. However, almost half of the findings regarding price showed that higher prices of healthy foods were associated with better dietary outcomes. Few studies ($n=5$) investigated the effect of produce variety or quality on dietary outcomes and the evidence is currently equivocal.

4.2.2.1. The United States. A total of 16 studies from the United States have investigated links between factors within food stores and dietary outcomes. This region has the largest body of research on this topic and provides moderate evidence to support the hypothesis that the consumer nutrition environment influences diet. Of the ten studies investigating the relationship between product availability and dietary outcomes, six showed at least one significant association in the expected direction, healthy food availability and healthier dietary intakes. One study found that, after adjusting for individual characteristics, lower availability of healthy foods in residential neighbourhood was associated with higher scores on the poorer dietary pattern but not the better dietary pattern (Franco et al., 2009). Four studies using the NEMS-S market basket tool showed mixed results: lower availability of healthier foods was associated with poorer quality of diet patterns (Franco et al., 2009) and better availability of healthier foods was associated with higher odds of eating at least one serve of vegetables a day (Gustafson et al., 2013b), but associations

Table 2
Summary of findings relating consumer nutrition environment exposures to better dietary quality/higher fruit and vegetable intake.

Direction of relationship	*Number of findings*			
	Availability	**Price**	**Variety**	**Quality**
Inverse (unexpected)	2	11	0	0
None	27	12	3	4
Positive	9	5	1	1
Number of exposure measures	20	13	3	4
Number of papers	11	10	3	4
Number of studies	11	10	3	4

between higher dietary quality and lower availability of healthier foods have also been found (Casagrande et al., 2011).

Five of the nine studies investigating the effect of price on dietary outcomes found at least one significant association in the expected direction, higher prices and lower intake of less healthy items or lower prices and increased intakes of healthy items. A longitudinal price study showed a strong relationship between weekly fast food consumption and prices of soda and weaker associations for take-away burger prices (Gordon-Larsen et al., 2011). This relationship was differentiated by ethnicity and income. The strongest association, in black males, showed a 20% increase in the price of soda was associated with a 0.25 reduction in number of days eating fast food per week. Two recent cross-sectional studies using published price data revealed negative associations between total diet cost and dietary quality such that better quality diets were more costly (Rehm et al., 2011) and diet cost mediated the relationship between socioeconomic position and diet quality (Monsivais et al., 2012).

4.2.2.2. *Other developed nations*. Four studies have investigated product availability or price and diet outside of the US: two from the UK and one each from Canada and Australia. This small body of literature revealed inconsistent findings that can largely be considered inconclusive.

5. Discussion

This review has summarised the evidence for neighbourhood disparities in community and consumer nutrition environments from ten previous review articles, and also assessed the evidence for the effect of community and consumer nutrition environments on dietary intake. There is evidence that disadvantaged neighbourhoods in the US have poorer access to healthy foods than more affluent areas. Globally there is also a trend for greater access to less healthy foods in neighbourhoods of higher deprivation. More than a quarter of density investigations and a fifth of proximity investigations provide evidence for an association between increased access to stores selling healthy foods and better dietary outcomes. There is some evidence for neighbourhood disparities in the availability of healthier foods but the evidence on price is less robust. A quarter of the food availability investigations showed that greater availability of healthy foods was related to better dietary outcomes however, half of the price investigations revealed that higher prices for healthy products related to better dietary outcomes. The literature for other consumer nutrition environment factors such as variety, quality, placement and promotions is limited.

5.1. *Community nutrition environment*

There is consensus across review articles of evidence in the community nutrition environment literature for area-based inequalities in healthy food access in the US: residents of low income and ethnic minority neighbourhoods in the US have disproportionately poorer access to healthy food than residents of more affluent neighbourhoods. The evidence for differences in access to healthy food is equivocal for Australia, Canada and the UK. However, there is compelling international evidence for inequalities in access to less healthy foods: neighbourhoods with higher levels of deprivation and ethnic populations have greater access to fast food outlets than more affluent, predominantly white neighbourhoods. This evidence confirms that, particularly in the US, there is variation in terms of neighbourhood factors that influence diet and health. The stronger evidence from the US may be in-part due to the higher levels of urban residential segregation in the US than in other developed countries. Globally, low income areas offer low rent, low competition and cheap labour opportunities, however black areas in the US are also stigmatised and seen as undesirable to many retailers including supermarket chains (Kwate, 2008). In these circumstances, policy makers may be reliant on retailers willing to trade in these communities such as fast food chains, to create jobs and employment opportunities for local residents.

Fraser et al. (2010) have suggested that the disparities identified above are an illustration of the 'deprivation amplification' effect. Deprivation amplification describes how individual or household deprivation, for example low income or educational attainment, is amplified by area level deprivation and the conditions within deprived neighbourhoods such as the increased availability of less healthy foods or decreased availability of affordable healthy food (Macintyre et al., 1993). However, as has been suggested in the literature (Macintyre, 2007) and confirmed by the evidence in our review, it may not always be true that poorer neighbourhoods provide a less healthful environment for residents. Two recent intervention studies, focused on mobile food stores, aimed to improve access to fruit and vegetables in low income communities. The interventions, which involved a mobile food store in the UK and farmers market in the US, found that self-reported intakes of fruit and vegetables had increased over the time period of the interventions (Evans et al., 2012; Jennings et al., 2012). Neither of these studies, however, used a control group or indicated adjustment for individual or societal factors that may have also influenced dietary intake. Other initiatives such as public-private partnerships to introduce supermarkets to underserved areas, improved transportation in low income neighbourhoods or restrictions and incentives for food retailers such as zoning regulations or tax rebates have been proposed as strategies to enable a more equitable distribution of food sources (Hilmers et al., 2012).

5.2. *Consumer nutrition environment*

There have been fewer studies of the consumer nutrition environment than the community nutrition environment and the findings of these studies are mixed. There is some evidence in the US for poorer availability of healthy products in low income and ethnic neighbourhoods than more affluent neighbourhoods. The evidence from other developed countries is weaker and less consistent. The evidence for neighbourhood disparities in price is varied across all countries with findings showing both cheaper and dearer prices in disadvantaged neighbourhoods. While few studies have assessed neighbourhood differences in quality of food, the evidence consistently showed poorer quality produce in more deprived than more affluent neighbourhoods. Moving to consider how consumer nutrition environment factors relate to diet, the literature shows some evidence for associations between price and availability and dietary intake in the US. The literature and evidence from other developed countries is limited and weaker. Changes in the price of less healthy foods, particularly sweet carbonated drinks, have shown that as price increased intake of these foods decreased. This relationship was differentiated by ethnicity and income with the strongest associations observed in blacks and low-income earners. Local availability of healthy foods was also shown to relate to poorer dietary patterns but not better dietary patterns. This finding suggests that individuals with poorer diets may be disproportionately affected by their neighbourhood food environment than individuals with better quality diets. This disparity may result from being less likely to have access to a private car to travel to other shopping opportunities or more likely to keep daily activities to a more localised space (Coveney and O'Dwyer, 2009).

5.3. Limitations of the food environment literature

Methodological limitations of the neighbourhood food environment literature have been repeatedly cited in review articles (Beaulac et al., 2009; Black and Macinko, 2008; Fleischhacker et al., 2011; Ford and Dzewaltowski, 2008; Fraser et al., 2010; Larson et al., 2009; Walker et al., 2010). Heterogeneity in the categorisation of outlets, definition of neighbourhood and measurement of exposure variables, as well as the ecological study design of many studies have been reported as potential contributors to the inconsistent findings observed in review papers. A great assortment of neighbourhood boundaries have been applied including various predefined boundaries from census blocks to county boundaries and wide range of buffer zone radii measured by road network or Euclidean distance. A variety of food outlet categorisation systems have been applied across studies and the majority of studies have focused on one or two outlet types with very few assessing the neighbourhood differences or dietary affects of a full range of food retailers.

Much of the research to date is ecological in design, comparing neighbourhood or dietary data from national or cohort surveys with secondary food outlet information and may not accurately represent true associations. Few studies ground-truthed their food outlet data and may misrepresent food outlet access by including outlets that have ceased to trade and having missed those which have recently opened. Field validation studies of secondary data have shown only fair to moderate agreement between observation and existence of food outlets from commercial and government lists or remote sensing technology such as Google street view (Lake et al., 2010; Powell et al., 2011). Levels of agreement, however, were poorer when categorisation of outlets was included in the comparison (Clarke et al., 2010; Rossen et al., 2012). The findings from secondary data may therefore need to be viewed with caution and more longitudinal studies are needed, particularly using individualised data.

Another methodological limitation of this body of literature is the premise that people shop and are primarily influenced by food outlets geographically proximate to their homes (Zenk et al., 2011). The assessment of individualised living spaces for community nutrition environment research has been piloted in two studies: one used seven day global positioning system tracking data to create a total individualised area by buffering all locations visited by 0.5 mile radius (Zenk et al., 2011) and the other used one day travel surveys and locations visited as anchor points to calculate an individualised area (Kestens et al., 2010). Time-geographic accessibility measures may also provide opportunities for more complete and realistic representations of the food environment by considering exposures along routes people regularly travel in conjunction with practical time restrictions on food shopping (Widener et al., 2013). Applying these individualised food environment exposure measures to individualised dietary measures will help eliminate the ambiguity found in the current evidence.

There is also a need for consumer nutrition environment studies to link dietary data to the in-store environment of where people shop to overcome previous methodological assumptions (Caspi et al., 2012b). Consumer nutrition environment studies could be further enhanced by the use of reliable tools that assess the range of environmental stimuli consumers face when shopping in additional to product availability and price, including product placement, prominence, promotion and labelling (Kelly et al., 2011). These tools may also be useful for assessing organisational nutrition environments such as workplace canteens (Kelly et al., 2011).

It has been suggested that the single most important strategy for future food environment research is combining multiple environment assessment techniques. An intelligent mix of in-store audit measures and GIS based methods would provide a more accurate characterisation of the neighbourhood food environment (Rose et al., 2010). A good example of such multi-dimensional assessment is work by Hermstad et al. (2010) which used structural equation modelling to investigate the relative influence of environmental, social and individual level factors on dietary fat intake. The reliable in-store audit tool NEMS-S was used to assess the availability, cost and quality of lower fat items and scores were summed for all grocery and convenience stores within a five mile radius of participants home. Proximity measures of fast food outlets were also calculated. Modelling calculations measured the combined effect of these exposures as well as the home nutrition environment, perceived nutrition environment and psychosocial factors. Further research applying a multi-dimensional approach to investigating the neighbourhood food environment and incorporating potential mediating factors such as transport method and psychosocial factors is needed. Recent qualitative research has also shown that residents of deprived neighbourhoods do not respond in a uniform manner to similar in-store supermarket environments suggesting a mediating role for psychosocial factors (Thompson et al., 2013). Therefore, socio-ecological conceptual approaches and sophisticated modelling techniques are required alongside qualitative research to enhance the current state of the evidence and identify the relative influence of multiple dimensions of the neighbourhood food environment and psychosocial factors on dietary inequalities. Findings of such research are likely to help inform the allocation of resources and development of complex interventions to improve disparities in dietary intake.

6. Conclusion

This review summarised the evidence for neighbourhood disparities in community and consumer nutrition environments from 10 previous review articles, and also assessed the evidence for an effect of the community and consumer nutrition environments on dietary intake. There is evidence for inequalities in food access in the US; trends are less evident in other developed countries. The evidence also shows a trend for greater access and availability, to either healthy or less healthy foods, relating to diet as expected. However unexpectedly, the evidence for price shows a trend for higher prices of healthy foods being associated with better dietary outcomes. The neighbourhood food environment literature suffers from considerable heterogeneity in methodology and generalised environmental exposures. These methodological limitations hinder the development of clear policy recommendations and interventions to improve nutrition environments. Further research applying a multi-dimensional approach and individualised environmental exposures is needed to enhance the current state of the evidence and help inform future interventions.

Acknowledgements

This review is independent research arising from a Doctoral Research Fellowship supported by the UK National Institute for Health Research. The views expressed in this publication are those of the author(s) and not necessarily those of the NHS, the National Institute for Health Research or the Department of Health UK.

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Appendix B Southampton Initiative for Health follow-up questionnaire

Location:	ID: DoB: Initials:

Interviewer:	Date:

NUTRITION, EXERCISE & WELL-BEING STUDY

We are interested in diet, exercise and well-being of women in Hampshire.

This questionnaire is designed to find out about what you eat, when you eat it, how often you exercise and how you're feeling in general. It also asks for some background details about you.

It is **not** a test and we are interested in you as you really are, rather than how you would like to be.

Your answers are strictly **confidential** and your name will not be put on the questionnaire. I will take the questionnaire away when you have finished.

You will generally be asked to indicate the answer that describes you best.

Thank you very much for your help

This questionnaire has been compiled by the Food Choice Group
Medical Research Council Epidemiology Resource Centre
University of Southampton
July 2010

Version number: 07/2010

2

About you

In this section, we want to know a little bit more about you.

1(a) How many children (under 18 years) live with you? ☐

1(b) How old are they? ☐☐ ☐☐ ☐☐ ☐☐ ☐☐
[Specify months or year]

1(c) Are your children registered with Sure Start?
[Show Sure Start registration form if required]

Yes ☐ No ☐ Don't know ☐

2. Have you passed any exams or do you have any formal qualifications? ☐
[Enter number in the box to show highest level reached]

1. None
2. CSE / School cert / GCSE (grade D or lower) / NVQ1 / Foundation GNVQ
3. O levels / Matric / GCSE (grade A,B,C) / RSA secretarial / NVQ2 / Intermediate GNVQ
4. A levels / City & Guilds / EN(G) / ONC / NNEB / BTech (day release) / NVQ3 / Advanced GNVQ / OND / HNC
5. HND / RGN / Teaching Cert / NVQ4
6. Degree / NVQ5
7. Other (specify)

3. Are you (or your husband/partner) on any of the following benefits?
Income support, jobseekers allowance, working families tax credit and/or housing benefit

Yes ☐ No ☐

4. To which of the following ethnic groups do you feel you belong?
[Show participant ethnic group prompt card]

White	☐	Bangladeshi	☐
Black Caribbean	☐	Chinese	☐
Black African	☐	Other Asian group	☐
Black other	☐	Mixed	☐
Indian	☐	Arabic	☐
Pakistani	☐	Other American	☐

Other, *please specify*: ______________________

5. How often have you attended Sure Start children's Centres sessions in the last 18 months?

Never	☐
Once a Month or less	☐
Once every two weeks	☐
1-2 Times per week	☐
3-6 Times per week	☐
Once a day	☐
More than once a day	☐

Your eating habits

In this section we would like to know about some of the foods you eat and how often you eat them.

[TICK one box on each line for every item – show response prompt sheet table [i] & refer to FFQ prompt sheet if necessary]

OVER THE PAST MONTH HOW OFTEN HAVE YOU EATEN THESE FOODS?								
	Over the past month	**Never**	**Once a Month**	**Once every two weeks**	**1-2 Times per Week**	**3-6 Times per Week**	**Once a day**	**More than once a day**
6	Roast Potatoes or chips							
7	Peppers or watercress							
8	Tomatoes							
9	Meat pies							
10	Vegetable dishes							
11	Courgettes, marrow or leeks							
12	Sausages or sausage rolls							
13	Gravy							
14	Green salad							
15	Wholemeal bread							

4

	Over the past month	Never	Once a Month	Once every two weeks	1-2 Times per Week	3-6 Times per Week	Once a day	More than once a day
16	White bread							
17	Onion							
18	Vegetarian food							
19	Pasta							
20	Yorkshire pudding or savoury pancakes							
21	Crisps or savoury snacks							
22	Beef							
23	Spinach							
24	Fresh fruit							
25	Approximately how many teaspoons of **sugar** do you add each day to breakfast cereals, tea and coffee, etc?				teaspoons			
26	How much **full-fat milk** on average do you use per day in your drinks, added to breakfast cereals, etc?				pints			

OVER THE PAST MONTH HOW OFTEN HAVE YOU EATEN FOODS FROM THESE OUTLETS?

	Over the past month	Never	Once a Month	Once every two weeks	1-2 Times per Week	3-6 Times per Week	Once a day	More than once a day
27	Fast Food outlet (No waiting, chains: McDonalds, KFC, Burger King)							
28	Take-away shops (fish & chips, Chinese, pizza, Indian) *NOT sandwich shops*							

Food, money & shopping

People do different things when they are running out of money for food, to make their food or their food money go further. *[TICK one box for each question]*

29. In the last 12 months 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 ☐ No *(go to Q31)* ☐

30. How often did this happen?

In only 1 or 2 months ☐ Some months, but not every month ☐ Almost every month ☐

31. In the last 12 months did you ever eat less than you felt you should because there wasn't enough money to buy food?

Yes ☐ No ☐

32. In the last 12 months were you ever hungry but didn't eat because you couldn't afford enough food?

Yes ☐ No ☐

Here are 2 statements that people have made about their food situation. For these statements, please tell me whether the statement was **'never true', 'sometimes true'**, or **'often true'**, for you (or other members of your household) in the last 12 months.

33. 'The food that I / we bought just didn't last and I / we didn't have money to get more'.

Never true ☐ Sometimes true ☐ Often true ☐

34. 'I / we couldn't afford to eat balanced meals'.

Never true ☐ Sometimes true ☐ Often true ☐

35. Please specify the name and location of the shop where you do your main food shopping. ______________________

[If more than one answer is provided please ask participant to rank them in order of frequency, number 1,2,3 etc.]

36. What is your home postcode? ______________________

(Let the participant know that we only ask this so we can find out how far they travel to their food shop)

37. What mode of transport do you usually use to do most of your food shopping?
[If more than one answer is provided please ask participant to rank them in order of frequency, number 1,2,3 etc. If a different mode of transport if used dependant on which shop is being visited please specify which mode of transport relates to which shop]

- Walk ☐
- Cycle ☐
- Public transport ☐
- Taxi ☐
- Car – I rely on lift from family/ friend ☐
- Car – I drive myself ☐
- Other – I don't do food shopping/ I do internet shopping etc ☐

	In my local neighbourhood…… (10-15 minute walk or a 5 minute drive)	**Strongly Disagree**	**Disagree**	**Agree**	**Strongly Agree**
38	I can do most of my food shopping				
39	The variety of fresh fruits and vegetables is limited				
40	The fresh produce is usually of a high quality				
41	There are lots of healthy take-away and fast food options				

7

Healthy Eating

We would like to find out how your family feels about healthy eating.

	Think about your family. **HOW OFTEN DO MEMBERS OF YOUR FAMILY…**					
		Never	**Rarely**	**Sometimes**	**Often**	**Very often**
42	Approve when you buy fruit, fruit juice or vegetables					
43	Ask you to buy fruit, fruit juice or vegetables					
44	Remind you to buy fruit, fruit juice or vegetables					
45	Buy fruit, fruit juice or vegetables					
46	Talked to you about buying fruit, fruit juice or vegetables					

Now we would like to find out how you feel about healthy eating and food in general.

Please say how much you agree or disagree with each of these statements about eating healthy food.

[TICK one box on each line for every item - show response prompt sheet table [iv]]

	I know that if I eat healthy foods …	**Strongly Disagree**	**Disagree**	**Agree**	**Strongly Agree**
47	I'll feel physically more attractive				
48	I won't have any weight problems				
49	It will be good for my blood pressure				
50	I'll feel happier				
51	It will be good for my cholesterol levels				
52	Other people will admire my willpower				

Please could you say how much you agree or disagree with these statements about healthy eating depending on how true they are for you

	"I could stick to eating healthy foods even if…"	**Strongly Disagree**	**Disagree**	**Agree**	**Strongly Agree**
53	I need a long time to build new habits				
54	I have to try a few times before I succeed				
55	I have to rethink my whole diet				
56	I don't receive much support from others when I start out				
57	I have to make a detailed plan				

A question about your clothes size …

58	What sizes would you normally try on when buying clothes? *[Circle which sizes – more than one if necessary]*			
	6 – 8	8 - 10	10 - 12	12 - 14
	14 - 16	16 - 18	18 - 20	20 -22
	22 - 24	24 - 26	26 - 28	Above

59. How would you describe your health in general?

- Very bad ☐
- Bad ☐
- Fair ☐
- Good ☐
- Very good ☐

We want to know how you think about what you're going to cook and eat, and what you feel about preparing food. Please say how much you agree or disagree with each of these statements.

[TICK one box on each line for every item – show response prompt sheet table [v]]

		Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly Agree
60	I don't think much about food each day					
61	Cooking or barbequing is not much fun					
62	Talking about what I ate or am going to eat is something I like to do					
63	Compared with other daily decisions, my food choices are not very important					
64	When I travel, one of the things I anticipate most is eating the food there					
65	I do most or all of the cleaning up after eating					
66	I enjoy cooking for others & myself					
67	When I eat out, I don't think or talk much about how the food tastes					
68	I do not like to mix or chop food					
69	I do most or all of my own food shopping					
70	I do not wash dishes or clean the table					
71	I care whether or not a table is nicely set					

Physical Activity

During the last week how many hours did you spend doing the following activities?
[Tick one box per activity – show response prompt sheet [vii] if required

		None	Some but less than 1hour	1hour but less than 3hours	More than 3 hours
72	Physical exercise such as swimming, jogging, aerobics, gym				
73	Cycling, including cycling to work and during leisure time				
74	Walking, including walking to work and during leisure time				
75	Housework/childcare				
76	Gardening/DIY				

77. If you use a gym, swimming pool or leisure centre please state its location: ____________________
[Please state street name and/or full postcode]

78. How would you describe your normal walking pace?

Slow pace ☐

Steady average pace ☐

Brisk pace ☐

Fast pace ☐

79(a) Have you done any paid work over the past 7 days, either as an employee or self-employed?

Yes ☐ No *(go to Q81)* ☐

79(b) Please could you give the location of your place of work ____________________
[Ask for street name and/or full postcode]

80. How much physical activity is involved in your work?
[Show response prompt card [vi] – read out examples for each category if required]

Spend most of the time sitting
e.g. in an office ☐

Spend most of the time standing or walking
but it does not require much intense physical effort
e.g. shop assistant, hairdresser. ☐

Work involves definite physical effort including
handling of heavy objects and use of tools
e.g. nurse, gardener, plumber ☐

Work involves vigorous physical activity including
handling of very heavy objects
e.g. refuse collector, construction worker ☐

Please could you say how much you agree or disagree with these statements about exercising depending on how true they are for you

	"I could stick to an exercise routine even…"	**Strongly Disagree**	**Disagree**	**Agree**	**Strongly Agree**
81	When I have worries and problems				
82	If I feel depressed				
83	When I feel tense				
84	When I am tired				
85	When I am busy				

Your feelings

This section is about how you have been feeling. Please say which answer best describes how you have felt over the last 2 weeks.

[TICK one box on each line for every item – show response prompt sheet table [iii]]

	Over the last two weeks …	**At no time**	**Some of the time**	**Less than half of the time**	**More than half of the time**	**Most of the time**	**All of the time**
86	I have felt cheerful and in good spirits						
87	I have felt calm and relaxed						
88	I have felt active and vigorous						
89	I woke up feeling fresh and rested						
90	My daily life has been filled with things that interest me						

Please could you say how much you agree or disagree with these statements depending on how true they are for you

		Strongly Disagree	Disagree	Agree	Strongly Agree
91	I can always manage to solve difficult problems if I try hard enough.				
92	I can find a way to get what I want even if someone is trying to stop me.				
93	It is easy for me to stick to my aims and reach my goals.				
94	I am calm when things are difficult because I know I can cope.				
95	If I am in trouble I can usually find a way out				

		Strongly Disagree	Disagree	Agree	Strongly Agree
96	I feel that what happens in my life is often determined by factors beyond my control				
97	I often have the feeling that I am being treated unfairly				
98	Keeping healthy depends on things that I can do				
99	Over the next 5 – 10 years I expect to have many more good things than bad things happen				
100	There are certain things I can do for myself to reduce the risk of heart disease				
101	In the past 10 years, my life has been full of changes without my knowing what would happen next				
102	There are certain things I can do for myself to reduce the risk of cancer				
103	At home I feel I have control over what happens in most situations				
104	I gave up trying to make big improvements or changes in my life a long time ago.				

That's all the questions.

Thank you very much for your help

Appendix C Justification for consumer nutrition environment audit tool variables

Consumer nutrition environment tool variables

I. **Variety** – *number of different choices within each product range, based on: product flavour, product size, fair trade/organic range or no-name/low-cost range.* Previous studies have defined variety as the number of different products in a category, for example the number of different vegetables available.[1] However, in this study variety was measured within a product range, for example the number of different peppers available. This approach was taken because the literature has shown that the variety of products has expanded rapidly in the past two decades, with great variation in flavours, brands and package size.[2] Variety within a product range may therefore be an important influence on food purchasing patterns. For example, a small store may stock only one variety of a product whereas a larger store may offer five or more varieties which would not be captured by the dichotomous availability measure. Product variety was rated for each product as 1, 2, 3, 4, 5 or more varieties.

II. **Price** – *Price of the cheapest item, pound per kilo, for each product.* Price has been reported as an important factor influencing food purchasing decisions and consumers are more likely to buy foods that are perceived to be a good price relative to others.[2] Previous studies have used a range of methods to measure price. Some have recorded the price which most closely matched a specified size and brand of a product,[3,4] except for fruit and vegetables when the cheapest were selected. Other studies have measured the cost of a basket that would feed a family or age-gender groups for two weeks, measuring either specified brands[5] or the cheapest items.[6,7] While each of these methods of assessing price have their advantages and disadvantages it was decided for this study that the cheapest price for each available item would be recorded to capture the lowest price on offer to the consumer. This method was deemed most appropriate due to the focus on disadvantaged families and food equity. Promotional prices were recorded if that made the product the cheapest. However, prices of multiple purchase offers and discounted products due to near expiry dates or poor product quality were not recorded. For fruits and vegetables, prices of both the cheapest packed and loose items were recorded because of difficulty in determining the cheapest item while conducting the survey. Standardised weights were used for fruit and vegetable items which did not have the weight labelled.[8] Early versions of the tool also included a measure of the most expensive items available for each product to provide a price range for comparison between stores. However, piloting revealed large inter-rater variability, so this element was removed and only the cheapest price for each product was recorded.

III. **Quality** – *level of quality of each fruit and vegetable*. Product quality may affect consumers' purchasing patterns; if an item is bruised, blemished or moulding it may be less likely to be purchased.[8] Information on the quality of two fruit and four vegetables was collected using the quality indicator in the Healthy Eating Indicator Shopping Basket (HEISB) tool.[9] The assessment of quality was made visually based on the quality of 50% or more of the cheapest product, according to a three-point Likert scale: 1=poor, 2=medium, 3= good. In an attempt to reduce known subjective error in the measurement of quality, a description of each level of quality for each fruit and vegetable product was included in the consumer nutrition environment survey protocol, where discriminating adjectives were printed in bold.

IV. **Healthier option available** – *whether or not a healthier option was available for less healthy products*. Previous consumer nutrition environment audit tools, including the NEMS-S tool, have measured the availability of healthier options of less healthy indicator foods.[3] A dichotomous score was used to measure the availability of healthier options for the less healthy items surveyed. A healthier option was defined as a product containing a nutrient claim on the front of the pack claiming that it is lower in total fat, sugar or salt and/or is higher in a nutrient intrinsically part of the product. The survey protocol contained specific details for each of the five less healthy items.

V. **Shelf placement** – *where on the shelf the cheapest item for each product was placed*. Placing food items at eye-level on the shelf has been reported as a retail strategy associated with increased visibility and product purchases.[10] A recent study showed that potato chips placed on the middle shelf were associated with highest percentage of purchases.[11] Audit tools to date have not measured shelf placement. However, some studies have assessed the relative shelf-space assigned to different products.[12,13] A three-point likert scale was used where the shelf placement of the cheapest item for each of the 12 products surveyed was classified as 1=bottom, 2=other or 3= prominent (eye-level). Illustrations of the shelves considered prominent were provided in the survey protocol. Items placed on more than one shelf were allocated the highest possible score.

VI. **Store placement** – *which part of the store the cheapest item for each product was placed*. Supermarket and convenience store operators design their store layouts to promote greater purchasing, placing profitable and high selling items in areas with the greatest flow of traffic including near the entrance and counters, or at the end-of-aisles.[2, 14, 15] Consumer nutrition environment studies to date have not measured store placement of items as part of the audit tool. Hence a three-point likert scale was developed for this study where the store placement of the cheapest item for each of the 12 products surveyed was classified as 1=inconspicuous, 2=noticeable or 3=prominent.

VII. **Promotions** – *whether or not the product category was on price promotion*. Pricing promotions lead to substantial short-term increases in sales volumes, the greater the discount the greater the increase.[2] The dietary implication of these promotions is that consumers will consume more of widely promoted foods. The HEISB assessed dichotomously whether or not each indicator product was on promotion.[4] In this study, promotion of each of the 12 indicator products was measured as yes/no on any item within the product range including price reductions for single item or multiple item purchases. Price reductions for poor quality or near expiry date were not included.

VIII. **Nutrition information** – *the type of nutrition information available on the cheapest item for each product*. Supermarkets and convenience stores provide a useful site for nutrition promotion activities, particularly point-of choice nutrition information to help consumers identify healthier products.[16] Nutrition labelling on food products, in particular, has received much attention in recent years with many major food retailer and manufacturers introducing front-of-pack nutrition labels on their products, following either 'traffic-light' or Guideline Daily Amount (GDA) design. Front-of-pack nutrition labelling provides consumers with a simplified summary of key information as distinct from the complex nutrition table on the back of the product.[17] A review of how food labels effect consumers revealed that self-reported use of food labels is greater for highly processed products.[17] Two major UK retailers have also reported that sales of some healthier products increased after introducing their front-of-pack labelling system and those of less favourable nutrition information went down. However, the evidence that nutrition labels influence diet of people with lower education levels and lower income is less clear.[18] Previous studies assessing the consumer nutrition environment have not, to date, have not measured the presence of point-of-sale nutrition information.[19] A four-point likert scale was therefore developed and applied in this study to assess availability of nutrition information at point-of-sale for on the cheapest item of each of the five less healthy products: 0=no information, 1=other (e.g. recipe card), 2=back-of-pack, 3=front-of-pack (GDA and 'traffic-light') and back-of-pack.

Single fruit option – *whether or not single sale of the two fruit measured was possible*. Dietary habits in the UK are moving away from three staple meals to increased consumption of energy dense, nutrient-poor snack foods between meals.[20] These snack foods are readily available for impulse purchase in convenience stores and assessing whether healthier impulse snack options are available is also important. Using a dichotomous measurement we assessed whether or not apples and bananas were available for single purchase for impulse snacking.

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Appendix D Justification for consumer nutrition environment audit tool food products

Consumer nutrition environment audit tool
JUSTIFICATION FOR PRODUCTS

This document outlines the selection process behind the products included in the Consumer Nutrition Environment survey tool.

Food outlets to be included in the audit

Only the seven types of food outlets that sell all or almost all of the 20 FFQ items were included in the investigation surveying the consumer nutrition environment. These seven outlets include: premium supermarkets; large supermarket; discount supermarket; small supermarket; 'world' store; convenience store; and petrol store.

Products

The audit tool products have been selected to correspond with the 20-item Food Frequency Questionnaire (FFQ) used in the Southampton Initiative for Health survey to characterise better and poorer quality diets for women of childbearing age, which was derived from the 100-item FFQ used in the Southampton Women's Survey. Principal component analysis has shown that the 20-item FFQ produce a diet score highly correlated with the scores obtained using the original 100-item FFQ and that these items(1). The consumer nutrition environment tool contains 12 food products, 10 representing foods from the 20 FFQ items. The products included were selected according to the strength of the coefficient for the item from the principle components analysis, frequency of consumption according to the National Diet and Nutrition Survey 2000 (NDNS)(2) results and practicality of measuring the item in an in-store survey. The reasons for excluding each of the 10 items not included in the consumer nutrition tool are provided in Table 1. The reasons for including 10 items and selection process for the proxy product included in the consumer nutrition environment tool are provided in Table 2. Two items of fresh fruit, apples and bananas were also included in the survey tool. The reasons for selecting these two fruit items are provided at the end Table 2.

Table 1. Food products excluded from the consumer nutrition environment tool

Potential survey product	Corresponding FFQ item	FFQ item correlation	Exclusion justifications
Meat pies	Meat pies	-0.1905	The 'meat pie' item has the second strongest negative coefficient after roast potatoes and chips, however was excluded because sausage rolls (f=189) were the most commonly consumed pastry covered product in the NDNS data and according to the20 FFQ items sausage rolls are classified with sausages. According to the NDNS data pork sausages grilled (f=546), sausage rolls (f=189) and pork sausages fried (f=175) were all consumed more frequently than Cornish pasties (f=139) and pork pies (f=125) the second and third most frequently consumed pastry covered products.

			The complexity of defining which meat pies to measure in food stores also contributed to the exclusion of the product from the consumer nutrition survey. For example pork pies, individual pies and family pies can be eaten on different occasions and for different purposes. For these reasons sausages were selected over meat pies.
Vegetable dishes	Vegetable dishes	0.1898	It was not feasible to include all possible ingredients in vegetable dishes in the survey tool. Convenience vegetable meals could have been included as a proxy for vegetable dishes however it is likely that the item 'vegetable dishes' represent a large proportion of home cooking and therefore convenience meals would not be an appropriate product to measure home cooking.
Courgettes	Courgettes, marrow and leeks	0.1875	Leeks were the most frequently consumed product from the 'courgettes, marrow and leeks' item (more frequent than courgettes and marrow) according to the NDNS data. Leeks (frequency (f)=145) were consumed less frequently than tomatoes (f=3584), lettuce (f=2231), onions (f=612) and red peppers (f=312) according to the NDNS data. These four vegetables have been included in the consumer nutrition survey. Neither leeks, courgettes nor marrow were included in the fruit and vegetable quality scale by Cummins et al.(3)
Gravy	Gravy	-0.1825	Gravy is made up of a number of ingredients and it was not feasible to include all possible ingredients in the survey tool. Gravy granules and/or ready-made gravy could have been included as a proxy for the 'gravy' item however it was considered too great an assumption to conclude that most people eat gravy from granules. While gravy (f=861) was commonly consumed, it was considerably less commonly consumed than sugar (f=14876) according to the NDNS data. This comparison has been made because sugar is the item with the next highest coefficient after gravy. In addition, gravy is eaten in a different manner to sugar and two items gravy can be consumed with sausages and oven chips have been included in the survey tool. Therefore gravy was excluded and sausages, oven chips and sugar were included in the consumer nutrition survey.

Yorkshire pudding	Yorkshire pudding and savoury pancake	-0.1486	Yorkshire puddings are made up of a number of ingredients and it was not feasible to include all possible ingredients in the survey tool. Frozen Yorkshire puddings could have been included as a proxy for Yorkshire puddings however crisps, the item with the next highest coefficient after Yorkshire puddings, was included instead because crisps (f=555) were more commonly consumed than Yorkshire puddings (f=235) according to the NDNS data. In addition, crisps tend to be consumed as a snack rather than as part of a meal and no other unhealthy snack items had been included in the survey tool.

Table 2. Food products included in the consumer nutrition environment tool

Survey product (proxy)	Corresponding FFQ item	FFQ item correlation	Proxy product justifications
Peppers	Peppers or watercress	0.1974	The 'peppers and watercress' item has the strongest positive coefficient. Raw red peppers (f=312), cooked red peppers (f=231) and raw green peppers (f=210) were more commonly consumed than watercress (f=133). Peppers were the fourth most commonly consumed vegetable product, ahead of leeks (f=145) and spinach (f=81) according the NDNS data. Loose red peppers have been included as the proxy product for assessing quality according to the fruit and vegetable quality scale by Cummins et al(3) and is used as the quality proxy for the survey tool. If this product is not available quality is assessed on the loose cheapest and then the cheapest packed product.
Tomatoes	Tomatoes	0.1928	The 'tomatoes' item has the second strongest positive coefficient. According to the NDNS data raw tomatoes were the most commonly consumed fruit and vegetables (f=3584). Loose medium tomatoes have been included as the proxy for assessing quality according to the fruit and vegetable quality scale by Cummins et al(3) and is used as the quality proxy for the survey tool. If this product is not available quality is assessed on the loose cheapest and then the cheapest packed product.

Lettuce	Green salad	0.1673	The item 'green salad' has the fifth strongest positive coefficient after 'courgettes, marrow and leeks'. Lettuce, cucumber, celery and radish are the four products listed on the FFQ prompt card as examples of what is included in the green salad item. Lettuce (f=2231), raw cucumber (f=1917) and iceberg lettuce (f=784) therefore lettuce was included as the proxy product for this item. Loose round lettuce was included as the proxy for assessing quality according to the fruit and vegetable quality scale by Cummins et al.(3) Iceberg was chosen as the specific round lettuce for the survey tool. If this product is not available quality is assessed on the loose cheapest and then the cheapest packed product.
Bread-wholemeal	Wholemeal bread	0.1640	The 'wholemeal bread' item is the sixth strongest positive coefficient and the 'white bread' item is the sixth strongest negative coefficient. Incorporating both bread products in the survey tool provided a balanced comparison of the regular and healthier versions of a product. A proxy product was selected for this item because including the whole range of wholemeal breads was too time consuming, especially for larger stores. Sliced wholemeal bread was selected as the proxy because sliced white bread (f=3982) was the most commonly consumed bread according to the NDNS data and including sliced wholemeal bread provided a equal comparison. Wholemeal bread (f=1504) was more frequently consumed than toasted wholemeal bread (f=646) and brown bread no added bran (f=511) respectively.
Onion	Onion	0.1590	According to the NDNS data raw onion were the sixth most commonly consumed type of vegetable (f=612). Loose brown onions have been included as the proxy for assessing quality according to the fruit and vegetable quality scale by Cummins et al(3) and is used as the quality proxy for the survey tool. If this product is not available quality is assessed on the loose cheapest and then the cheapest packed product.
Oven chips	Roast potatoes or chips	-0.2087	The 'roast potatoes and chips' item has the strongest negative coefficient. According to the NDNS data oven baked chips (f=) were the most commonly consumed type of roasted or fried potatoes and therefore was considered as the

			proxy product for this item. In addition, roast or fired potatoes are made from several ingredients and it was not feasible to include all ingredients in the survey tool.
Sausages	Sausages or sausage rolls	-0.1874	The 'sausages' item has the third strongest negative coefficient. According to the NDNS data grilled pork sausages were the second most commonly consumed meat (f=546). Therefore, uncooked meat sausages were included as the proxy product for the 'sausages' item. Both cold and frozen sausages are considered in the survey.
Sugar	Sugar	-0.1665	According to the NDNS data white sugar (f=14876) was the second most commonly consumed product after weak infused tea. Including sugar in the survey item provided an indication of differences in price, availability and placement of this commonly consumed food product over different areas. Icing sugar was excluded from the survey because this product is not consumed in the same manner as granulated sugars such as white, Demerara, caster etc.
Bread-white	White bread	-0.1611	The 'white bread' item is the sixth strongest positive coefficient and the 'wholemeal bread' item is the sixth strongest negative coefficient. Incorporating both bread products in the survey tool provided a balanced comparison of the regular and healthier versions of a product. A proxy product was selected for this item because including the whole range of white breads was too time consuming, especially for larger stores. Sliced white bread was selected as the proxy because sliced white bread (f=3982) was the most commonly consumed bread according to the NDNS data. Sliced white bread (f=3982) was more frequently consumed than toasted white bread (f=646) and soft white rolls (f=511) respectively.
Crisps	Crisps and savoury snacks	-0.1461	After excluding meat pies, sausages and Yorkshire puddings for the reasons cited above crisps had the fifth strongest negative coefficient. Crisps tend to be consumed as a snack rather than as part of a meal and no other unhealthy snack items had been included in the survey tool. According to the NDNS data potato crisps (f=1558) were the second most commonly consumed product that could be classified as a snack after bananas (f=2275). As such, potato crisps were selected as the proxy product for the 'crisps and savoury snacks' item.
Apples	Fresh fruit	0.1289	According to the NDNS raw apples (f=1244) are the second most frequently consumed fruit.

			Fresh fruit was included in the FFQ because this product had the 12th highest positive coefficient. Bananas and apples were included in the store audit tool to provide additional measures of fruit and vegetable quality and availability. The availability of single items was also measured to assess whether a healthier snack alternative was available. Loose eating apples have been included as the proxy for assessing quality according to the fruit and vegetable quality scale by Cummins et al(3) and is used as the quality proxy for the survey tool. If this product is not available quality is assessed on the loose cheapest and then cheapest packed product.
Bananas	Fresh fruit	0.1223	According to the NDNS raw bananas (2275) are the most frequently consumed fruit. Fresh fruit was included in the FFQ because this product had the 13th highest positive coefficient. Bananas and apples were included in the store audit tool to provide additional measures of fruit and vegetable quality and availability. The availability of single items was also measured to assess whether a healthier alternative to crisps was available as a snack. Loose bananas have been included as the proxy for assessing quality according to the fruit and vegetable quality scale by Cummins et al(3) and is used as the quality proxy for the survey tool. If this product is not available quality is assessed on the loose cheapest and then cheapest packed product.

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Appendix E Consumer nutrition environment audit tool

NUTRITION, EXERCISE & WELL-BEING STUDY

Consumer nutrition environment audit tool

Interviewer:	**Date:** / /

Geographical Area:	**LSOA code:**	**Store ID:** **IMD:**
Opening hours (24 hour time):		**Store type:**
Mon	Fri	**Start time:** :
Tues	Sat	**Finish time:** :
Wed	Sun	**Total time:** minutes
Thurs		
Number of cash registers:		

This questionnaire has been compiled by the Southampton Initiative for Health team

NEW Study Consumer nutrition environment audit tool | VEGETABLES/ FRUIT

2

Product	Varieties (V)	Quality	Standard Price:	Placement –shelf:	Placement –store:	Nutrition Info	Promotion:
	1 2 3 4 5+ 9 (none)	(>50%) 3= Good 2= Medium 1= Poor	-Cheapest loose (L) Per gram (g) -Cheapest packed (P) Per gram (g)	3= Prominent 2= Other 1= Bottom	3= Prominent 2= Noticeable 1= Inconspicuous	3= Front & Back of pack 2= Back of pack 1= Other 0= None	Y / N
Peppers	V	Loose red	Loose £ per *description* Packed £ per *description*	L P	L P	L P	All peppers
Tomatoes	V	Loose medium	Loose £ per *description* Packed £ per *description*	L P	L P	L P	All tomatoes
Lettuce	V	Iceberg	Loose £ per *description* Packed £ per *description*	L P	L P	L P	All lettuce

3

NEW Study Consumer nutrition environment audit tool	VEGETABLES/ FRIUT						
Product	**Varieties (V)** 1 2 3 4 5+ 9 (none)	**Quality** (>50%) 3= Good 2= Medium 1= Poor	**Standard Price:** -Cheapest loose (L) Per gram (g) -Cheapest packed (P) Per gram (g)	**Placement – shelf:** 3= Prominent 2= Other 1= Bottom	**Placement – store:** 3= Prominent 2= Noticeable 1= Inconspicuous	**Nutrition Info** 3= Front & Back of pack 2= Back of pack 1= Other 0= None	**Promotion:** Y / N
Onion	V	Loose medium brown	Loose £ per *description* Packed £ per *description*	L P	L P	L P	All onions
Apples Single available	V Y / N	Loose eating	Loose £ per *description* Packed £ per *description*	L P	L P	L P	All apples
Bananas Single available	V Y / N	Medium loose	Loose £ per *description* Packed £ per *description*	L P	L P	L P	All bananas

NEW Study Consumer nutrition environment audit tool | **SHELF, COLD & FROZEN**

4

Product	Healthier Option (HO) Y/ N Varieties (V) 1 2 3 4 5+ 9 (none)	Standard Price: -Cheapest (C) Per gram (g) - Healthier Option (HO) Per gram (g)	Placement –shelf: 3= Prominent 2= Other 1= Bottom	Placement –store: 3= Prominent 2= Noticeable 1= Inconspicuous	Nutrition Info 3= Front & Back of pack 2= Back of pack 1= Other 0= None	Promotion: Y / N
Oven chips (All frozen oven chips including fries, wedges & smilies. Excludes croquettes & frying chips)	HO V	C £ per *description* HO £ per *description*	C HO	C HO	C HO	All oven chips
Sausages (Uncooked cold & frozen meat sausages. Excludes veggie & cooked sausages, salami)	HO V	C £ per *description* cold/ frozen HO £ per *description* cold/ frozen	C HO	C HO	C HO	All sausages

NEW Study Consumer nutrition environment audit tool | **SHELF, COLD & FROZEN**

5

Product	Healthier Option (HO) Y/ N Varieties (V) 1 2 3 4 5+ 9 (none)	Standard Price: -Cheapest (C) Per gram (g) - Healthier Option (HO) Per gram (g)	Placement –shelf: 3= Prominent 2= Other 1= Bottom	Placement –store: 3= Prominent 2= Noticeable 1= Inconspicuous	Nutrition Info 3= Front & Back of pack 2= Back of pack 1= Other 0= None	Promotion: Y / N
Crisps (potato crisps only)	All crisps HO	Plain salted crisps C £ per *description*	Plain salted crisps C	Plain salted crisps C	Plain salted crisps C	All crisps
	All crisps V	HO £ per *description*	HO	HO	HO	
Sugar (All types of sugar)	HO	C £ per *description*	C	C	C	All sugar
	V	HO granulated £ per *description*	HO	HO	HO	
		HO tablets £ per *description*	HO	HO	HO	

NEW Study Consumer nutrition environment audit tool	SHELF, COLD & FROZEN

6

Product	Healthier Option (HO) Y/ N Varieties (V) 1 2 3 4 5+ 9 (none)	Standard Price: -Cheapest (C) Per gram (g) - Healthier Option (HO) Per gram (g)	Placement –shelf: 3= Prominent 2= Other 1= Bottom	Placement –store: 3= Prominent 2= Noticeable 1= Inconspicuous	Nutrition Info 3= Front & Back of pack 2= Back of pack 1= Other 0= None	Promotion: Y / N
Bread-wholemeal (Sliced wholemeal loaf including rye if placed with sliced breads etc)	HO	C £ per *description*	C	C	C	All brown breads
	V	HO £ per *description*	HO	HO	HO	
Bread-white (Sliced loaf)	HO	C £ per *description*	C	C	C	All white breads
	V	HO £ per *description*	HO	HO	HO	

Appendix F Consumer nutrition environment survey protocol

Consumer nutrition environment audit tool
SURVEY INSTRUCTIONS

This tool has been developed to assess the availability, quality, cost, placement, nutrition information and promotion of selected food products identified from the 20-item Food Frequency Questionnaire (FFQ) in the Southampton Initiative for Health. The tool includes 12 products, six fruit and vegetables, and six shelf/cold products. To ensure consistency of data collection it is essential to follow this protocol closely.

Before you start

Time: All surveys are to be completed between 9am-6pm.
ID badge: Ensure your ID badge is clearly visible, clipped to your front or around your neck.
Ask the manager: Present the Nutrition, Exercise and Well-being Study Food Store Audit Information Sheet to the store manager or supervisor in charge. Briefly explain: *we are conducting research investigating the dietary habits of over 2000 women of childbearing age and part of our research involves measuring how the food stores these women have access to influence their dietary patterns. We are looking at over 600 food stores across Hampshire and would like to know if it is possible to complete a 10-15 minute survey of 12 food products within this store. The store or brand will not be individually identified and the only information taken is that already available to customers.*

Front Page

Complete the front page of the consumer nutrition audit tool:
Interviewer: your initials
Date: DD/ MM/ YY
Geographical area: Southampton (S)/ Eastleigh (E)/ Fareham (F)/ Gosport (G)/ Havant (H)/ Portsmouth (P)
LSOA code: 4digit area code – see data collection schedule
Store ID: allocate chronologically as surveys are completed
Store type: See Table 1.
Opening Hours: Note times the store is open on each day of the week in 24 hour time. (24/7 = 08:00-08:00)
Number of cash registers: Note if there are 1, 2, 3, 4 OR 5+ cash registers that could be manned with a sales assistant. Exclude self-service cash registers, service desk and post office registers.
Start time & Finish time: Record the time (using 24 hour time) you start and the time you finish the survey. Use these measures to calculate the total time taken in minutes to complete the surveys in each store.

Table 1. Store type descriptions

Code	Store type	Description	Examples
0	Premium supermarket	5+ manned cash registers Promoted as offering highest quality goods and service	Waitrose, M&S
1	Large supermarket	5+ manned cash registers All foods & many varieties Majority of supermarket share	Tesco, Sainsburys, Asda, Morrisons
2	Discount supermarket	5+ manned cash registers Heavily promoted as low price stores	Aldi, Lidl, Iceland, Netto, Kwiksave
3	Small supermarket	1-4 manned cash registers Smaller store of known brand name	Tesco Express, Co-Op, Sainsburys Local
4	'World' store	1-4 manned cash registers Products for specific ethnicities	Asian supermarkets, Polish supermarkets, World Foods

1

5	Convenience store	1-4 manned cash registers Limited number of products Independents & 'symbols'[b]	Spar, OneStop, MACE, Independent stores
6	Petrol station store	Sell petrol/diesel Includes small supermarkets that sell petrol	Shell Select, Tesco Petrol Station, BP, M&S

[b] 'Symbol' convenience stores are affiliated with a symbol group brand such as OneStop and Spar.

Survey Variables – ONLY include products that are available for purchase

1) **Number of varieties:** The variety variable encompasses product flavour, product size, 'fair trade'/'organic' product and budget product. The number of varieties however is specific to each product (details below). The number of varieties is categorised using: **1, 2, 3, 4, 5+ OR 9** (none available)

2) Quality: Vegetable and Fruit products ONLY
Quality assessment is based on the condition of the vast majority of the proxy product (details in Table 2). If the produce in brackets is not available please assess the quality of the cheapest variety of the product. The quality is categorised using:

3	High/ Good
2	Medium
1	Low/ Poor

3) Healthy Option: Shelf, Cold and Frozen products ONLY
A healthier option is a product that has a nutrient claim on the front of the pack indicating it is lower in total fat, sugar or salt AND/OR is higher in a nutrient intrinsically part of the product (details below).
Note Y (yes) or N (no) if ≤1 healthier option is available.

4) Product price: Note the price (£0.00) of the cheapest product.
Note the sale price if the product is on special offer but exclude BOGOFs where 2 items must be purchased.

***5)* Product weight:** Note the product weight in grams clearly in the space provided.
If the weight of a vegetable product is not identified apply standardised weights in Table 3.
Note the number of tablets instead of weight for artificial sweetener tablets.

Table 3. Standard product weights

Product	Description	Weight
Peppers	1 medium red/green	160g
Tomatoes	1 small tomato	65g
	1 medium tomato	85g
	1 large/beefsteak tomato	150g
	1 cherry tomato	15g
Lettuce	1 iceberg	250g*
	1 round/ 2x little gem	94g*
	2 medium/ 1 large Romaine flute	180g*
Onions	1 small brown onion	60g*
	1 medium brown/red	90g
	1 large brown	120g*
Apples	1 small apple	75g
	1 medium apple	112g
	1 large apple	170g

2

Bananas	1 small banana without skin 1 medium banana without skin 1 large banana without skin	80g 100g 120g
Bread	Small sliced loaf Large sliced loaf	400g 800g

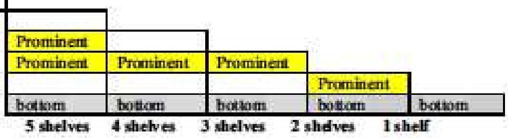
Table 4. Other useful weights

Description	Weight
1 pound	454g
2 pounds	907g
1 kilo	1000g
4 kilos	4000g

6) Product description: Note the brand and name of the product.
Also note the packaging description if the weight of the product is not available or if the product is a multi-pack.
For example write 3 mixed peppers or 6 x 25g for a crisps multi-pack.

7) Placement - shelf: Note the number representing the shelf placement of the cheapest item and cheapest healthier option of the product category.
Shelf placement is categorised using the 3 scales below. Prominent = eye level/ obvious placement. The diagram below provides guidance on using the descriptors.
If the product is placed on more than one shelf (ie 2 & 3) score the product as the highest possibility (3).

3	Prominent
2	Other
1	Bottom



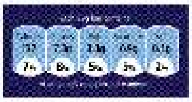
8) Placement - store: Please note the number representing the store placement of the cheapest item and cheapest healthier option of the product. Product placement in the store is categorised using:

3	Prominent	I see the product when I get to/enter the store OR it's at the end of an aisle
2	Noticeable	When I go looking I see the product
1	Inconspicuous	After I have been looking for a while I see the product

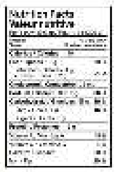
9) Nutrition information: Please note the number representing the nutrition information on the cheapest item and cheapest healthier option. Nutrition information must be easily visible before purchase.

3	Front & back of pack	Front of pack – full GDA or traffic light labelling (below)
2	Back of pack	
1	Other	Please note the type of information ie. recipe card
0	None	

3

GDA labelling  Traffic light labelling  & 

OR

An obvious nutrition table on the front of the product pack 

Note the front of pack for bread includes the sides and ends because of how bread is displayed on the shelf.

10) **Promotion:** Please note <u>Yes or No</u> if there is promotion on <u>any</u> product within the product category. <u>Exclude reduced price items</u> that may have poorer quality or shorter shelf life.

<u>Process to create a composite score of healthfulness for each store</u> – **to be used following data collection, data entry and data cleaning.** Statistical expertise is required.

1
- For each product, £/portion was calculated using standard portion sizes.
- For each store, mean prices for the healthy items and the less healthy items were calculated.
- For stores with no healthy items the 99th centile for healthy price was imputed and for stores with no less healthy items value of zero was imputed. This imputation represented the time, travel and health costs of items not for sale.

2
- For stores with a missing values due to error mean values of variable store type were imputed.

3
- For each store, the values for the healthy items and values for the less healthy items were summed for: *variety, shelf placement, store placement, and promotions.*
- For each store, the values for fruit &vegetable *quality*, *single fruit* option, *nutrition information* on less healthy items, and *healthier option* of less healthy items were summed.

4
- For each store, the less healthy item total was subtracted from the healthy item total for: *variety, shelf placement, store placement and promotions.*
- The healthy item mean was subtracted from the less healthy item mean for *cheapest price.*

5
- Scores for all nine variables were standardised.

6
- For each store, all standardised variables were summed and divide by 9 (all store variables).

7
- The final composite score for each store was standardised to create overall mean=0, S.D=1.

Peppers

Variety

Definition of Variety	**Coding Tips**	
- Different colours - Different size/pointed shape - Organic/fair-trade - Economy Range	Each colour counts as a different variety – except multipacks = 1 variety Size & shape only count if the pepper is a different species (different name) Organic & fair-trade products = 1 variety even if both are available One or more economy products = 1 variety	Exclude multipacks as a variety when colour is repeated Only count organic/fair-trade when an additional choice Only count economy when an additional choice

Quality

Product	**Coding options**		
	High/ Good (3)	**Medium (2)**	**Low/ Poor (1)**
Loose red peppers (Cheapest peppers if loose red pepper are not available)	Good strong intense **bright red** colour, uniform shape and size, **free from cracks**, decay, mould and fungi, clean no blemishes, bruises or marks, firm crisp product, **tight skin**	Good red colour, mixed sizes, **occasional blemish**, no bruises or soft marks, firm product	Soft product, **brown marks**, blemishes, moulds, **wrinkled/ wilted skin**, product drying out

Standard Price - Note price **per Kg or 100g or per piece** for **cheapest loose** and **cheapest packed** items AND the **name/colour** and how the items are packed

Tomatoes

Variety

Definition of Variety	**Coding Tips**	**Exclusions**
- Different species - Different size/shape - Organic/fair-trade - Economy Range	Each species (cherry, beef, plum etc) counts as a different variety Size & shape only count if tomatoes are a completely new species Organic & fair-trade products = 1 variety even if both are available One or more economy products = 1 variety	Vine-ripened tomatoes are not considered a new variety Apply the first name of a product where it is a cross-species ie. cherry plum is classed as in cherry variety Only count organic/fair-trade when an additional choice Only count economy when an additional choice

Quality

Product	**High/ Good (3)**	**Medium (2)**	**Low/ Poor (1)**
Loose medium (cheapest)	**Bright green/red colour**, consistently sized products, **no blemishes**, bruises or abrasions, firm turgid product, **shiny skin**	Shiny red colour (90%) for variety, no bruising, slight size variation, **firm product**, **occasional blemish**, perhaps a few marks, no bruises	**Dull red colour**, marks, blemishes, bruised, product feels soft, skin not turgid but **wrinkled/wilted**

Standard Price - Note price **per Kg or 100g or per piece** for **cheapest loose** and **cheapest packed** items AND the **name** and how the items are packed

Lettuce

Variety

Definition of Variety	Coding Tips	
- Different species	Different sizes of the same species = 1 variety (gem hearts & normal gem)	
- Bagged lettuce	Bagged washed lettuce = 1 variety (no matter how many different types)	
- Organic/fair-trade	Organic & fair-trade products = 1 variety even if both are available	Only count organic/fair-trade when an additional choice
- Economy Range	One or more economy products = 1 variety	Only count economy when an additional choice

Quality

Product	Coding options		
	High/ Good (3)	Medium (2)	Low/ Poor (1)
Iceberg (Cheapest lettuce if iceberg is not available)	Good **bright green colour**, round head, **crisp turgid feel/appearance, clean, no** blemishes, or **browning of leaves**	**Light green colour**, no browning, **occasional blemish** or dirt	Weak colour, **product looks flaccid**, leaves not firm, water loss, **browning on leaves**, soil and mud on product, evidence of slugs, **insect damage**, spotting, brown stain

Standard Price - Note price **per Kg or 100g or per piece** for **cheapest loose** and **cheapest packed** items AND the **name** and <u>how the items are packed</u>. Please note that a singly wrapped iceberg lettuce is considered a loose item.

Onion

Variety

Definition of Variety	Coding Tips	
- Different species	Each species counts as a different variety (red, large mild brown, shallots etc)	Spring onions are <u>not</u> included
- Different sizes/ colour	Size & colour only count if the onion a different species (different name)	Pickled onion are <u>not</u> included
- Organic/fair-trade	Organic & fair-trade products = 1 variety even if both are available	Only count organic/fair-trade when an additional choice
- Economy Range	One or more economy products = 1 variety	Only count economy when an additional choice

Quality

Product	Coding options		
	High/ Good (3)	Medium (2)	Low/ Poor (1)
Loose Medium Brown (Cheapest onion if not available)	Bright, good colour, **no blemishes**, bruises or marks, firm product, **skin intact**	**Occasional blemish**, perhaps a few marks, no bruises, **firm to touch**	Marks, **blemishes/moulds**, bruised, brown/black blotches, defects, greening of fleshy scales, **leathery skin**, soft to touch, product dried out

Standard Price - Note price **per Kg or 100g or per piece** for **cheapest loose** and **cheapest packed** items AND the **name** and <u>how the items are packed</u>

Apples

Variety

Definition of Variety	Coding Tips	
- Different species/ colours	Species identified in name = 1 different variety	
- Bagged sliced apples	Bagged sliced apples = 1 variety (no matter how many different types)	
- Organic/fair-trade	Organic & fair-trade products = 1 variety even if both are available	Only count organic/fair-trade when an additional choice
- Economy Range	One or more economy products = 1 variety	Only count economy when an additional choice

Quality

Product	Coding options		
	High/ Good (3)	**Medium (2)**	**Low/ Poor (1)**
Cheapest loose eating apples (Cheapest packed apples if loose apples are not available)	Good strong intense **bright** red/green **colour, no blemishes**, bruises or marks, firm product, **tight skin**	Good red/green colour for variety, **occasional blemish**, perhaps a few marks, **no bruises, firm product**, looks good	**Weak** red/green **colour**, marks, **blemishes**, bruised, blackened, soft, **wrinkled/wilted skin**, looks like it should be eaten immediately

Standard Price - Note price **per Kg or 100g or per piece** for **cheapest loose** and **cheapest packed** items AND the **name** and <u>how the items are packed</u>

Bananas

Variety

Definition of Variety	Coding Tips	Exclusions
- Different species	Species identified in name = a different variety	Ripen at home is <u>not</u> an additional variety
- Different size	If size is specified in the name = 1 variety (ie kids/ lunchbox bananas)	
- Organic/fair-trade	Organic & fair-trade products = 1 variety even if both are available	Only count organic/fair-trade when an additional choice
- Economy Range	One or more economy products = 1 variety	Only count economy when an additional choice

Quality

Product	High/ Good (3)	Medium (2)	Low/ Poor (1)
Loose medium (cheapest)	**Strong green/yellow colour, no black marks**, blemishes or bruises, **product firm**	Predominately yellow/green stalk, occasional blemish, **perhaps a few marks**, no bruises, **firm product**, looks good	**Brown marks on skin**, blackening, wizened stalk, other blemishes, **product feels soft**, looks like **it should be eaten immediately or use for cooking**

Standard Price - Note price **per Kg or 100g or per piece** for **cheapest loose** and **cheapest packed** items AND the **name** and <u>how the items are packed</u>

Oven chips

Variety

Definition of Variety	Coding Tips	Exclusions
- Different types	Types included – Smilies, Wedges, microwaveable	Frozen frying chips are <u>not</u> included
- Different sizes	Different sizes = different varieties – (eg. jumbo, normal, French fries)	Different cuts (crinkle/straight) are <u>not</u> different varieties
- Healthier options	One or more healthier options = 1 variety	
- Organic/fair-trade	Organic & fair-trade products = 1 variety even if both are available	Only count organic/fair-trade when an additional choice
- Economy Range	One or more economy products = 1 variety	Only count economy when an additional choice

Healthier Option

Nutrient claims included	Example
Lower total fat	*Less 4% total fat*
Lower salt	*20% less salt than regular oven chips*

Standard Price - Note price **per Kg or 100g or per piece** for **cheapest regular** and **cheapest healthier** items AND note item **name, brand** & <u>how the item is packed</u>

Sausages

Variety

Definition of Variety	Coding Tips	Exclusions
- Different flavours	Count different flavours all fresh & frozen sausages first	Cooked sausages are <u>not</u> included
- Different sizes	One or more chipolatas/ smaller sausages = 1 variety	Sausage rolls are <u>not</u> included
- Microwavable	One or more microwavable sausage = 1 variety	Party sausages, salami etc are <u>not</u> included
- Healthier options	One or more healthier options = 1 variety	Vegie sausages are <u>not</u> included
- Organic/fair-trade	Organic & fair-trade products = 1 variety even if both are available	Only count organic/fair-trade when an additional choice
- Economy Range	One or more economy products = 1 variety	Only count economy when an additional choice

Healthier Option

Nutrient claims included	Example
Lower total fat	*30% less fat than regular sausages*
Lower salt	*20% less salt than regular sausages*

Standard Price - Note price **per Kg or 100g or per piece** for **cheapest regular** and **cheapest healthier** items AND note item **name, brand** & <u>how the item is packed</u>.

Note if the cheapest sausages (regular and healthy option) are cold or frozen.

Sugar

Variety

Definition of Variety	Coding Tips	Exclusions
- Different types	Different types are different varieties (eg. white, icing, caster, Demerara)	Exclude icing sugar
- Healthier options	One or more healthier options = 1 variety	
- Organic/fair-trade	Organic & fair-trade products = 1 variety even if both are available	Only count organic/fair-trade when an additional choice
- Economy Range	One or more economy products = 1 variety	Only count economy when an additional choice

Healthier Option

Nutrient claims included	Example
Artificial sweeteners – (virtually no calories)	*Only 0.2 calories per tablet* *Low calorie sweetener*

Standard Price - Note price **per Kg or 100g or per piece** for **cheapest regular** and **cheapest healthier** (granulated & tablets) items AND note item **name, brand** & how the item is packed

Crisps

Variety – all potato crisps

Definition of Variety	Coding Tips	Exclusions
- Different flavours	Count different flavours (cheese & onion, ready salted etc) first	Rice, vegetable, wheat, corn and prawn/oriental crackers are not included
- Different sizes	Each different size other than the main size available = 1 variety	
- Healthier options	One or more healthier options = 1 variety	
- Organic/fair-trade	Organic & fair-trade products = 1 variety even if both are available	Only count organic/fair-trade when an additional choice
- Economy Range	One or more economy products = 1 variety	Only count economy when an additional choice

Healthier Option – only salted potato crisps

Nutrient claims included	Example
Lower total fat Lower salt	*30% less fat than regular salted crisps* *20% less salt than regular salted crisps*

Note the price and availability if a healthier option of crisps is available in a flavour other than plain salted. Please note the flavour.

Standard Price - Note price **per Kg or 100g or per piece** for **cheapest regular** and **cheapest healthier** items AND note item **name, brand** & how the item is packed

Wholemeal bread – sliced bread only

Variety

Definition of Variety	Coding Tips	Exclusions
- Different types	Different types of sliced brown bread (eg. seed & oats, rye, wholemeal etc)	Only count breads that are in the bread section (do not go searching for gluten free breads etc)
- Loaf size	Availability of one or more half loaves = 1 variety	
- Fortification	Omega 3/ calcium fortification = 1 variety	Different cuts (thick/ medium) are not different varieties
- Healthier options	One or more healthier options = 1 variety	
- Organic/fair-trade	Organic & fair-trade products = 1 variety even if both are available	Only count organic/fair-trade when an additional choice
- Economy Range	One or more economy products = 1 variety	Only count economy when an additional choice

Healthier Option

Nutrient claims included	Example & notes
Lower salt Lower sugar	*20% less salt than regular wholemeal bread*

Standard Price - Note price **per Kg or 100g or per piece** for **cheapest regular** and **cheapest healthier** items AND note item **name, brand** & how the item is packed

White bread – sliced bread only

Variety

Definition of Variety	Coding Tips	Exclusions
- Different types	Different types of sliced white bread (eg. farmhouse, white)	Only count breads that are in the bread section (do not go searching for gluten free breads etc)
- Half loaf	Availability of one or more half loaves = 1 variety	
- Fortification	Omega 3/ calcium fortification = 1 variety	Different cuts (thick/ medium) are not different varieties
- Healthier options	One or more healthier options = 1 variety	Crusts off is not a different variety
- Organic/fair-trade	Organic & fair-trade products = 1 variety even if both are available	Only count organic/fair-trade when an additional choice
- Economy Range	One or more economy products = 1 variety	Only count economy when an additional choice

Healthier Option

Nutrient claims included	Example & notes
Lower salt Lower sugar Higher fibre	*20% less salt than regular white bread* *50% more fibre than regular white bread* *Counts as one of your daily serves of wholegrain* Fortification in calcium/ omega 3 etc is NOT a healthier option

Standard Price - Note price **per Kg or 100g or per piece** for **cheapest regular** and **cheapest healthier** items AND note item **name, brand** & how the item is packed

Appendix G Peer-reviewed paper about the consumer nutrition environment pilot study

Health & Place 18 (2012) 1292–1299

Contents lists available at SciVerse ScienceDirect

Health & Place

journal homepage: www.elsevier.com/locate/healthplace

Variety and quality of healthy foods differ according to neighbourhood deprivation

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ARTICLE INFO

Article history:
Received 28 February 2012
Received in revised form
29 August 2012
Accepted 7 September 2012
Available online 18 September 2012

Keywords:
Food environment
Food quality
Food variety
Neighbourhood deprivation

ABSTRACT

This study addresses a gap in the food environment literature by investigating spatial differences in the inter relationship of price, variety and quality of food in southern England. We conducted a survey of all grocery stores (n=195) in the city of Southampton, UK, and ranked neighbourhoods according to national quintiles of deprivation. We found no difference in availability or cheapest price across neighbourhoods. However, the poorest neighbourhoods had less variety of healthy products and poorer quality fruit and vegetables than more affluent neighbourhoods. Dietary inequalities may be exacerbated by differences in the variety and quality of healthy foods sold locally; these factors may influence whether or not consumers purchase healthy foods.

1. Introduction

Quality of diet is associated with level of disadvantage (Ball et al., 2004; McLaren, 2007; Robinson et al., 2004) and this inequality is costly to the individual and society (Foresight, 2007). There is growing evidence that the physical food environment is an important determinant of dietary behaviour and obesity (Holsten, 2009), and governments are recognising the need to adapt the food environment to make healthier choices easier for consumers (Department of Health, 2010; National Institutes of Health, 2011).

Glanz et al. (2005) have developed a conceptual model to guide food environment research. This model has become widely-used and links dietary behaviours to four environmental settings: *community nutrition environments*, *consumer nutrition environments*, *organisational nutrition environments* and *information environments*.

Most of the food environment research to date has focused on *community nutrition environments*, specifically spatial access to supermarkets (Burns and Inglis, 2007; Caspi et al., 2012). Research in the US has shown that the presence of a local supermarket is associated with increased intake of fruit and vegetables (Morland et al., 2002; Zenk et al., 2009). Two recent reviews have illustrated that low-income and minority neighbourhoods in the US have poor access to supermarkets and healthier food choices (Larson et al., 2009; Walker et al., 2010). Evidence from other developed countries is less consistent (Amuzu et al., 2009; Shohaimi et al., 2004; Turrell et al., 2009) and uncertainties about inequalities in the neighbourhood food environment remain. The evidence for area differences in the *consumer nutrition environment* (factors that affect customers whilst inside the food store such as the cost, quality and variety of food products) has been highlighted as an area requiring additional investigation (Thornton et al., 2010b).

A recent review investigating the consumer nutrition environment shows that store size is associated with cost and availability of healthy products, with larger supermarkets having more products available at a cheaper price than smaller grocery and convenience stores (Gustafson et al., 2012). Price and availability trends by level of neighbourhood deprivation however, remain unclear; while studies in the US have tended to find differences between neighbourhoods in the price and availability of healthier food items, studies conducted in other countries have generally reported no association (Gustafson et al., 2012). Several studies from the US have demonstrated low availability (Andreyeva et al., 2008; Franco et al., 2009) and higher prices of healthy foods in

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http://dx.doi.org/10.1016/j.healthplace.2012.09.003

disadvantaged areas (Chung and Myers, 1999; Hendrickson et al., 2006). Outside the US the literature regarding the consumer nutrition environment is limited. In Australia, one study showed no difference in availability and price of fruit and vegetables by neighbourhood deprivation (Winkler et al., 2006) whilst another showed a slight favouring of availability in higher-income areas but cheaper prices in low-income neighbourhoods (Ball et al., 2009).

In the UK, consumer nutrition environment research in Scotland has suggested that the availability and price of fresh fruit and vegetables in lower income areas is not significantly different to higher income areas (Cummins and Macintyre, 2002; Cummins et al., 2010). There is a gap in the literature about the role of other consumer nutrition environment factors including variety and quality, and limited evidence in the UK outside the Scottish context. While there is some evidence in the US and UK to suggest that the quality of fresh produce is poorer in low-income neighbourhoods (Block and Kouba, 2006; Cummins et al., 2009; Sloane et al., 2003) few studies have examined spatial differences in product variety and quality, even though these factors may affect consumers' purchasing patterns (Ball et al., 2009; Cummins et al., 2009; Thornton et al., 2010a). Product variety considers the range of product options available to the consumer and enables consumer choice. The quality of fresh fruit and vegetables can also influence purchasing behaviour; if a product is damaged or looks unappealing it is less likely to be purchased (Cummins et al., 2009).

The aims of this study were to extend the evidence about spatial differences in consumer nutrition environment factors to southern England and contribute to the body of literature that is, unravelling their contribution to dietary inequalities. As a preliminary, we assessed spatial access to supermarkets and grocery stores. We then compared the availability, price and variety of a range of healthy and less healthy foods, and the quality of fruit and vegetables across five levels of neighbourhood deprivation in Southampton, a relatively deprived city in the affluent south of England.

2. Methods

2.1. Neighbourhood deprivation

We measured 'neighbourhood deprivation' using the 2007 income domain of the Index of Deprivation (ID). This measure is provided for Lower Super Output Areas (LSOA), small areas that are focused on social homogeneity and a defined population size (1000–1500 residents) (Noble et al., 2008). LSOAs provide an important tool for identifying the most disadvantaged areas in England and provide the best quality data for comparison across levels of area deprivation. The ID is based on seven distinct domains of deprivation that are recognised and measured separately. In this study we allocated each LSOA in Southampton to a quintile of deprivation by dividing the national rank of the 2007 ID income domain (calculated by the number of individuals seeking financial welfare benefits) (Noble et al., 2008) into fifths (1=most deprived and 5=least deprived). We chose not to use the full ID because it includes an access to services domain (which includes access to grocery stores) and because the income domain is the strongest individual component of the composite ID (22.5% weighting).

2.2. Study sample – grocery stores

A list of all grocery stores and their postcodes within the Southampton City Council boundary was compiled in July 2010. Store postcodes were used to identify the LSOA in which each store was located. Southampton is the 91st most deprived local authority out of a total of 354 in England (Southampton City Council, 2010). Store postcodes were obtained through desktop analysis of the local council food safety register and on-line service directories including yellow-pages and yell.com. The stores were classified into six categories in descending store size: large supermarkets, discount supermarkets, small supermarkets, world stores (selling predominantly international foods), convenience stores and petrol station stores. Field observation by trained workers confirmed the existence and category of stores during in-store data collection conducted over 9 weeks from July to September 2010.

2.3. Consumer nutrition environment data

Data were collected in all grocery stores using a Consumer Nutrition Environment Tool. This tool was developed to measure the availability, price and variety of 12 products, and the quality of two fruits and four vegetables in each store. We defined availability as whether a food product was available for purchase, and recorded the price of the cheapest item, per kilo, in the product range; reduced prices because of expiring sell-by-date were not recorded. Variety was defined as the number of different choices within the product range that were available for purchase, and considered factors such as product flavour, product size, fair trade/ organic range or no-name/ low-cost range. The numbers of varieties were specific to each product and were outlined in our Consumer Nutrition Environment Tool protocol. Information on the quality of fruit and vegetables was collected using the quality indicator in the Health Eating Indicator Shopping Basket (HEISB) tool (Cummins et al., 2009). Quality was assessed visually, based on a three-point Likert scale (1=poor, 2=medium, 3=good).

The 12 food products included in the Consumer Nutrition Environment Tool were selected based on three criteria: ability to predict healthy or less healthy dietary patterns of women of childbearing age (Crozier et al., 2010); high frequency of consumption in England (Food Standards Agency, 2009); and the feasibility of being measured by an in-store survey. The 12 products were a subset of items from a 20-item food frequency questionnaire (FFQ) used to characterise better and poorer dietary patterns in women of childbearing age (Crozier et al., 2010) which was derived from the Southampton Women's Survey 100-item FFQ data (Crozier et al., 2008). For analysis purposes, the 12 products were categorised in three ways: all products, healthy products and less healthy products. Healthy products included: peppers, tomatoes, lettuce, onions, apples, bananas and wholemeal bread. Less healthy products included: oven chips, sausages, crisps, sugar and white bread.

Permission to complete the survey was sought from shop managers prior to administration and fieldwork was carried out by trained staff from July to September 2010. Surveys for a selection of ten grocery stores were repeated by all fieldworkers individually, during the same time period, in order to assess inter-rater reliability.

2.4. Statistical analyses

We used the Chi Square test for trend to investigate differences in product availability (present/absent), variety (1–2 or 3+ varieties) and quality (good/ medium or poor), and Spearman's correlation coefficient to assess cheapest price across the five levels of neighbourhood deprivation and six grocery store types. Poisson regression models were fitted to explore the associations of variety and quality with the five levels of neighbourhood deprivation. The two most affluent neighbourhood fifths were combined in the analysis of quality because of the small number of observations. Adjusted prevalence ratios were estimated fitting Poisson regression analysis with robust variance (Barros et al., 2003). The level of agreement between fieldworkers on measures of variety and quality was assessed by the Kappa statistic. The statistical analysis was performed using Stata version 11.0 (Statacorp, 2009).

3. Results

Nearly all grocery stores in Southampton agreed to take part in the study (195 out of a possible 198; three store managers refused to participate). Of the 146 LSOAs within the Southampton City Council boundary, 90 contained at least one grocery store. There were more LSOAs in Southampton classified as most deprived (19.2%) than least deprived (12.3%). The distribution of LSOAs with at least one grocery store by level of deprivation is summarised in Table 1. Approximately 70% of LSOAs in the most and second most deprived levels had at least one grocery store compared with only 50–52% in the two most affluent levels.

Fig. 1 details the distribution of grocery stores and the levels of LSOA deprivation in Southampton. LSOAs characterised by the three middle layers of deprivation had substantially more supermarkets (large, discount and small) than both the most and least deprived LSOAs. The most deprived LSOAs housed no large or discount supermarkets and one of the least deprived LSOAs had a discount supermarket. Table 2 summarises the distribution of store types across the five levels of neighbourhood deprivation: convenience stores (39.5%) are most prevalent across the city, followed by small supermarkets (22.1%) and world stores (22.1%). Discount supermarkets (3.6%) and large supermarkets (4.1%) were less prevalent.

Table 3 shows the difference in food product availability, price, variety and quality according to level of ID. We found no difference in the availability or median cheapest price of the 12 products between the different levels of neighbourhood deprivation ($p=15$, $p=0.71$, respectively). Nor did we find a difference in the availability or median cheapest price for the seven healthy

Table 1
Distribution of LSOAs and grocery stores by level of neighbourhood deprivation.

	ID=1 Most deprived	ID=2	ID=3	ID=4	ID=5 Least deprived
Number LSOAs ($n=146$)	28	32	41	27	18
Number LSOAs with ≥1 grocery store	19 (67.9%)	23 (71.9%)	25 (61.0%)	14 (51.9%)	9 (50.0%)

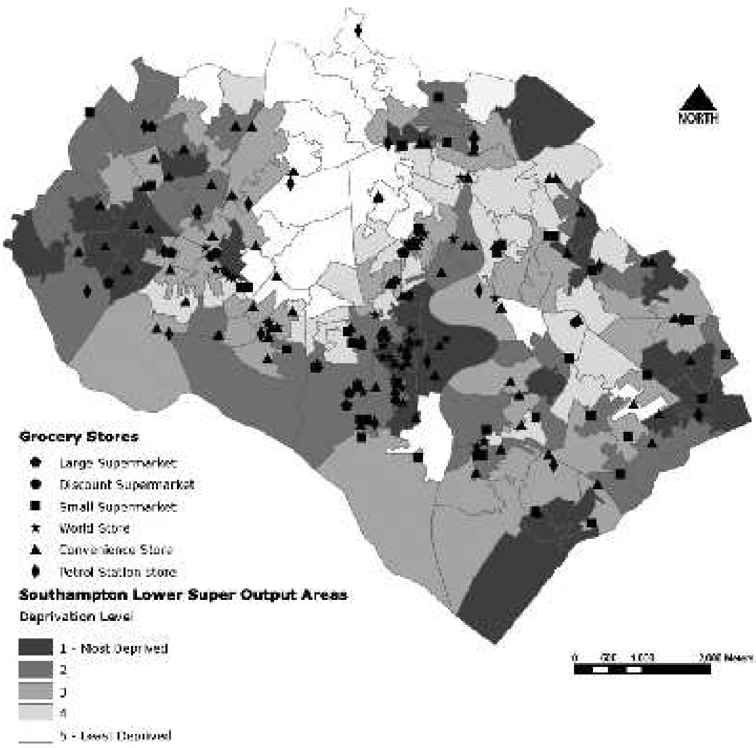

Fig. 1. Map of Southampton showing type of grocery store by level of neighbourhood deprivation.

Table 2
Distribution of grocery stores by store type according to level of neighbourhood deprivation.

	ID=1 Most deprived	ID=2	ID=3	ID=4	ID=5 Least deprived	Total
Large supermarkets	0	4 (50.0%)	2 (25.0%)	2 (25.0%)	0	8 (4.1%)
Discount supermarkets	0	1 (14.3%)	3 (42.9%)	2 (28.6%)	1 (14.3%)	7 (3.6%)
Small supermarkets	7 (16.3%)	17 (39.5%)	11 (25.6%)	5 (11.6%)	3 (7.0%)	43 (22.1%)
World stores	12 (27.9%)	14 (32.6%)	12 (27.9%)	4 (9.3%)	1 (2.3%)	43 (22.1%)
Convenience stores	15 (19.5%)	21 (27.3%)	23 (29.9%)	12 (15.6%)	6 (7.8%)	77 (39.5%)
Petrol station stores	3 (17.7%)	4 (23.5%)	8 (47.1%)	0	2 (11.8%)	17 (8.7)
Total	37 (19.0%)	61 (23.5%)	59 (30.3%)	25 (12.8%)	13 (6.7%)	195

Table 3
The availability, variety and quality, and median price of observed food products according to level of neighbourhood deprivation.

	ID=1 Most deprived	ID=2	ID=3	ID=4	ID=5 Least deprived	p-value
Availability (n (%)) **(7 healthy products)**						
Yes	162 (62.6%)	240 (56.2%)	257 (63.2%)	109 (62.3%)	59 (64.8%)	0.35[a]
No	97 (37.4%)	187 (43.8%)	156 (37.8%)	66 (37.7%)	23 (35.2%)	
Availability (n (%)) **(5 unhealthy products)**						
Yes	152 (82.2%)	257 (84.3%)	254 (86.1%)	104 (83.2%)	59 (90.7%)	0.19[a]
No	33 (17.8%)	48 (15.7%)	41 (13.9%)	21 (16.8%)	6 (9.3%)	
Cheapest price (£/kg) **(7 healthy products)** (median (IQR))	1.99 (1.29, 2.99)	1.89 (1.22, 3.00)	1.96 (1.49, 3.09)	1.96 (1.30, 2.94)	2.06 (1.35, 3.00)	0.44[b]
Cheapest price (£/kg) **(5 unhealthy products)** (median (IQR))	1.54 (1.00, 4.99)	1.55 (0.99, 4.60)	1.53 (0.99, 5.00)	1.38 (0.99, 3.44)	1.81 (1.08, 5.64)	0.71[b]
Variety (n (%)) **(7 healthy products)**						
≥3 varieties	27 (16.7%)	79 (33.2%)	64 (24.9%)	38 (34.9%)	25 (42.4%)	0.001[a]
1 or 2 varieties	135 (83.3%)	159 (66.8%)	193 (75.1%)	71 (65.1%)	34 (57.6%)	
Variety (n (%)) **(5 unhealthy products)**						
≥3 varieties	89 (58.6%)	167 (65.0%)	157 (61.8%)	66 (63.5%)	39 (66.1%)	0.46[a]
1 or 2 varieties	63 (41.4%)	90 (35.0%)	97 (38.2%)	38 (36.5%)	20 (33.9%)	
Quality (n (%)) **(6 fruit & vegetables)**						
Good/ medium	114 (85.1%)	177 (95.7%)	197 (96.1%)	132 (96.4%)		0.003[a,c]
Poor	20 (14.9%)	8 (4.3%)	8 (3.9%)	5 (3.6%)		

The number of observations for each variable shown in the table are not equal because of missing data and because quality was only recorded for the six fruit and vegetables. Price was missing for 26 products and variety was missing for two products out of a total of 1653 products recorded as available. Quality was missing for 26 products out of a total of 687 fruit and vegetables recorded as available.

[a] Chi squared test for trend.
[b] Spearman test for trend.
[c] ID=4 and ID=5 were merged because of the small number of observations.

products ($p=0.35$, $p=0.44$ respectively) or five less healthy products ($p=0.19$, $p=0.71$ respectively) according to level of ID. We did, however, find that the variety of all 12 products and the quality of fruit and vegetables differed significantly by neighbourhood deprivation ($p=0.009$ and $p=0.003$ respectively). Variety and quality improved with increasing levels of neighbourhood affluence. We assessed the variety of healthy and less healthy products by level of LSOA ID separately and found that the significant association observed for all products was explained by differences in the number of choices of healthy products ($p=0.001$) rather than less healthy products ($p=0.46$).

Table 4 shows our examination of these consumer nutrition environment variables by grocery store type. We found that the difference in availability, median price and variety of both healthy and less healthy products varied significantly across the different store types (all $p<0.001$). We also found a significant difference in quality of fruit and vegetables by store type ($p=0.02$). Large supermarkets had 100% of products surveyed, more than three varieties for each product and good quality fruit and vegetables. The poorest availability of both healthy and less healthy items was observed in petrol station stores. Discount supermarkets offered the cheapest median price for healthy products, and equal cheapest with world stores for the less healthy products. Petrol station stores had the dearest median price for less healthy items and convenience stores the dearest for healthy items.

The risk of having low variety and poor quality products was assessed by Poisson regression modelling after adjusting for the possible confounding effect of price, as shown in Table 5. Stores in the poorest neighbourhoods were *more likely* to have *low variety* of healthy products and *more likely* to have *poor quality* fruit and vegetables when compared with stores in less deprived neighbourhoods.

The inter-rater reliability was calculated to assess the variation in reporting amongst the four fieldworkers. We observed good inter-rater reliability for variety of products (kappa=0.83), although the inter-rater reliability for quality of fruit and vegetables was poorer (kappa=0.33).

4. Discussion

The community nutrition environment in Southampton was characterised by higher density of grocery stores in LSOAs in the two highest levels of deprivation, where over two thirds of neighbourhoods contained at least one grocery store. There were fewer neighbourhoods categorised as more affluent with grocery stores which suggests that residents living in the poorer neighbourhoods of Southampton had better access to grocery stores than the more affluent residents. However, when we limited our examination to the presence of supermarkets we found that

Table 4
The availability, variety and quality, and median price of observed food products by type of grocery store.

	Large supermarket	Discount supermarket	Small supermarket	World store	Convenience store	Petrol station store	p-value
Availability (n (%)) (**5 unhealthy products**)							
Yes	40 (100%)	35 (100%)	213 (99.1%)	134 (62.3%)	343 (89.1%)	61 (71.8%)	<0.001[a]
No	0	0	2 (0.9%)	81 (37.7%)	42 (10.9%)	24 (28.2%)	
Availability (n (%)) (**7 healthy products**)							
Yes	56 (100.0%)	45 (91.8%)	290 (96.4%)	136 (45.2%)	251 (46.6%)	49 (41.2%)	<0.001[a]
No	0	4 (8.2%)	11 (3.6%)	165 (54.8%)	288 (53.4%)	70 (58.8%)	
Cheapest price (£/kg) (**5 unhealthy products**) (median (IQR))	0.97 (0.59–1.86)	0.94 (0.59–1.67)	1.55 (1.02–2.75)	1.24 (0.99–6.24)	1.62 (0.99–5.26)	1.81 (1.30-8.23)	<0.001[b]
Cheapest price (£/kg) (**7 healthy products**) (median (IQR))	1.53 (0.84–2.08)	1.49 (1.00–1.96)	1.96 (1.27–3.24)	1.49 (1.11–2.20)	2.50 (1.69–3.13)	2.20 (1.64–3.59)	<0.001[b]
Variety (n (%)) (**5 unhealthy products**)							
≥3 varieties	40 (100.0%)	28 (80.0%)	174 (81.7%)	55 (41.0%)	191 (55.7%)	30 (49.2%)	<0.001[a]
1 or 2 varieties	0	7 (20.0%)	39 (18.3%)	79 (59.0%)	152 (44.3%)	31 (50.8%)	
Variety (n (%)) (**7 healthy products**)							
≥3 varieties	56 (100.0%)	23 (51.1%)	104 (36.0%)	23 (16.9%)	18 (7.2%)	9 (18.4%)	<0.001[a]
1 or 2 varieties	0	22 (48.9%)	185 (64.0%)	113 (83.1%)	232 (92.8%)	40 (81.6%)	
Quality (n (%)) (**6 fruit & vegetables**)							
Good/ medium	45 (100.0%)	37 (100.0%)	224 (94.9%)	103 (91.2%)	177 (90.3%)	34 (100.0%)	0.02[a]
Poor	0	0	12 (5.1%)	10 (8.8%)	19 (6.7%)	0	

[a] Chi squared test for trend.
[b] Spearman test for trend.

Table 5
The relative risk of having low variety of healthy foods and poor quality fruit and vegetable according to level of neighbourhood deprivation.

	Low variety[a] (healthy foods)		**Poor quality**[b] (fruit and vegetables)	
	Relative risk[c] *(95% confidence interval)*	*p-value*[e]	*Relative risk*[c] *(95% confidence interval)*	*p-value*[f]
Level of ID				
1 = most deprived	Baseline		Baseline	
2	0.81 (0.72, 0.91)	<0.001	0.31 (0.14, 0.69)	0.004
3	0.89 (0.80, 0.98)	0.019	0.27 (0.12, 0.60)	0.001
4	0.79 (0.68, 0.91)	0.002	0.26 (0.10, 0.67)	0.006[d]
5 = least deprived	0.66 (0.53, 0.83)	<0.001		

[a] After adjusting for price.
[b] After adjusting for price and variety.
[c] Relative risks were estimated from Poisson regression models.
[d] ID = 4 and ID = 5 were merged because of the small number of observations.
[e] Test for trend p < 0.001.
[f] Test for trend p = 0.007.

access was highest for LSOAs in the three middle levels of deprivation, with over a third of the LSOAs in these classifications having access to a local supermarket. It may therefore be that residents in the poorest areas of Southampton have good access to stores, but primarily convenience stores which tend to sell fewer products at higher prices (Cummins and Macintyre, 2002).

Our findings about supermarket density being poorer in the most and least deprived areas differ from previous UK research which showed no difference in the numbers of supermarkets across LSOA fifths, or better access to supermarkets in poorer areas of Glasgow (Cummins et al., 1999) Our data describing spatial access to supermarkets also differ from previous research in Canada and New Zealand (Apparicio et al., 2007; Pearce et al., 2008; Smoyer-Tomic et al., 2008), but are consistent with research from Wales and Northern England, and Australia (Burns and Inglis, 2007; Clarke et al., 2002). Our observation that the poorest LSOAs in Southampton were more likely to contain a convenience store than a supermarket is consistent with previous research from Glasgow and New Zealand (Macdonald et al., 2009; Pearce et al., 2008). The higher presence of convenience stores in the poorest areas of Southampton may be considered a spatial inequality. Residents of poorer areas may be disproportionately disadvantaged by their local stores because they are less likely to have access to a private car to travel to other shopping opportunities and may also be more likely to keep daily activities to a more localised space (Coveney et al., 2009; Cummins et al., 2005).

Our consumer nutrition environment survey results further confirm that product availability, price, variety and quality differ by size and type of grocery store. We found that large supermarkets sold a high variety of all healthy and less healthy products surveyed and that discount supermarkets offered the cheapest price for these healthy and less healthy products. By contrast, convenience stores, the second smallest store type we surveyed, stocked the dearest healthy products and had less than half of these healthy products available for purchase. Similarly, convenience stores were more likely to sell poor quality fruit and vegetables than larger supermarkets. These findings are consistent with previous US studies which have shown that the availability of foods from a healthy food basket significantly improves with store size (Laska et al., 2010), and that discount supermarkets offer the cheapest price for a selection of healthy foods and convenience stores the highest price (Block and Kouba, 2006).

Our analysis of the consumer nutrition environment in Southampton also showed that there was no difference in the availability or cheapest price of all, healthy and unhealthy food products examined across the five different levels of neighbourhood deprivation. We did, however, observe a significant difference in the variety of healthy products and quality of fresh fruit and vegetables across the five levels of neighbourhood deprivation. Poorer variety and quality were more frequent in more deprived neighbourhoods. After controlling for price, we found that residents living in the most deprived neighbourhoods had 11–34% greater risk of low variety of healthy products, and 69–76% greater risk of poor quality fruit and vegetables than residents living in more affluent neighbourhoods of Southampton.

The lack of association between availability and price of food products and level of neighbourhood deprivation found in our study is consistent with a previous study which found that level of neighbourhood deprivation was not a predictor of the price of 15 types of fruit and vegetables in Scotland (Cummins et al., 2010). This Scottish study further concluded that the availability and price of healthy foods was more closely associated with store type and having access to a medium or large supermarket, rather than level of neighbourhood deprivation (Dawson et al., 2008). Unlike the evidence from US which shows higher cost of healthy foods in disadvantaged urban areas (Chung and Myers, 1999; Hendrickson et al., 2006), it appears that the few studies from the UK show little difference between poorer and more affluent neighbourhoods.

There is little research investigating variety and quality and our study is, to our knowledge, the first to have examined product variety according to neighbourhood deprivation in the UK. Our findings suggest that affluent areas have a greater variety of healthy products than poorer areas. Consistent findings have been observed in Australia where studies in Brisbane and Melbourne showed that variety of vegetables was highest in the most affluent areas and poorest in the most disadvantaged areas (Ball et al., 2009; Winkler et al., 2006). A US study by Zenk et al. (2009) found a positive trend for area affluence and fruit and vegetables variety, however the association was not significant. A more recent US study showed a significant positive association between fruit and vegetable variety and the probability that consumers purchase fruits and vegetables (Martin et al., 2012). It should be noted that the measure of variety in these US studies differed from that used in the current study, which measured variety of a specific food product (ie. number of different types of peppers) rather than overall variety of a product range (ie number of vegetables). These differing definitions of variety may influence study findings. A study that investigated the quality of fruit and vegetables by neighbourhood deprivation in Scotland revealed results similar to ours, that stores in more deprived neighbourhoods tended to have the lowest quality fruit and vegetables (Cummins et al., 2009). Similarly, research from the US has shown lower quality fresh produce in low income neighbourhoods (Block and Kouba, 2006; Glanz et al., 2007). Our findings concerning quality thus confirm existing knowledge and show variations in quality by neighbourhood deprivation are also applicable in the different setting of southern England.

4.1. Strengths and limitations

A key strength of our study was that information on 99% of grocery stores in the city of Southampton was collected. A particular strength of the Consumer Nutrition Environment Tool was the consideration of product variety and quality as additional variables influencing consumer choice. The results of our study illustrate the importance of considering variety in order to provide a more accurate interpretation of the availability of healthy and less healthy products beyond a product being available or not.

One limitation of our study was the subjective measurement of fruit and vegetable quality as shown by the low inter-rater reliability results. Future work may benefit from using photographs or a simple two-point scale of acceptable/ unacceptable to provide a more accurate measure of product quality.

A more significant limitation was our use of a count of grocery stores within LSOAs as a measurement of access to grocery stores. This container method assumes that grocery shopping opportunities are constrained by administrative geographies and confined to the area close to home. It does not consider boundary issues such as the location of grocery stores in neighbouring areas or connectivity issues such as railway, river or road barriers. We acknowledge that alternative approaches, such as a buffer zone around each grocery store, could have been applied however, would have fractured the social homogeneity of LSOA blocks used in this study. Future analyses will compare individualised activity zones and LSOA boundaries.

A third limitation is the cross sectional and ecological nature of this study. Cross sectional studies assume that outcome variables are stable over time. However, variables such as price, availability and quality of food products are likely to vary as a result of external factors including seasonal variation, wholesale supply and transport costs. In addition, ecological analysis does not permit us to assess whether there was a direct link between the environmental determinants and individual dietary patterns. The Consumer Nutrition Environment Tool measured the environmental exposures to foods indentified as predictors of better and poorer dietary patterns among women of childbearing age which means our findings may not be generalisable to the broader population. Our study also excluded specialty stores such as green grocers and butchers and therefore does not consider the full local food environment. For feasibility reasons only food stores selling both shelf and fresh foods were included in our study.

4.2. Implications

Variety within a product range may be an important influence on purchasing patterns. It has been suggested that taste is the most important influence on dietary choices (Glanz et al., 1998a). We speculate that whether or not a consumer's preference is available may also influence if they do or do not purchase the product. For example, if a consumer prefers red apples and only green apples are available they may not purchase any apples. Furthermore, product quality may impact on dietary inequalities in a similar way. Cummins et al. (2009) suggest that if an item is bruised, blemished or moulding it may be less likely to be purchased. We found that fresh items fitting this description were more apparent in the most disadvantaged neighbourhoods.

While these observational findings suggest that product variety and quality may be environmental determinants of dietary inequalities further work is needed to provide a clear understanding of how these factors are contributing to or caused by consumer choice. Is lower variety and quality the result of poor turnover and financial loss for store managers, or is it because the fresh produce available is not enticing enough for consumers to buy? Research from Connecticut, US shows that non-supermarket food retailer managers perceive there is little consumer demand for healthy foods, but the introduction of government subsidies encouraged retailers to supply healthy foods according to the subsidy guidelines (Andreyeva et al., 2011). Efforts to improve the variety and quality of healthy products in more disadvantaged neighbourhoods in the UK may encourage consumers to purchase and consume more fresh produce. However, incentives and support for store managers to endure short periods of financial loss may be required for such strategies to be successfully implemented.

The lack of difference in price between affluent and more deprived neighbourhoods should not negate the impact that the cost of food can have on the household budgets of less affluent families. Research has shown that healthy foods can be more expensive than less healthy products (Drewnowski, 2010; Mooney, 1990) and that the cost of food is the second most influential factor on food purchasing and consumption patterns after taste (Glanz et al., 1998b). Unlike research from Australia which showed lower food prices in more deprived neighbourhoods (Ball et al., 2009; Winkler et al., 2006), we found that the cheapest price of healthy, less healthy and all products combined was similar across the five levels of neighbourhood deprivation. We speculate that this similarity in food price may be contributing to dietary inequalities in the UK because consumers who have a limited disposable income are constrained by how much they can spend on food. They are therefore more adversely affected by food prices (Furey et al., 2002). This raises an interesting question about the term 'affordability' because what is affordable to higher income earners may not be affordable for consumers with lower incomes or those who rely on receiving benefits.

5. Conclusion

Our results suggest that stores in more affluent LSOAs have significantly more variety and better quality of healthy food products and that these two environmental factors may be contributing to the poorer dietary choices of residents in the most deprived neighbourhoods. Our study helps address a gap in the food environment literature and suggests that the variety and quality of healthy food products should be considered in addition to accessibility, availability and affordability in future research investigating associations between the local food environment and dietary inequalities. Further research is required to explore with consumers and store managers, the underlying reasons for differences in variety and quality between affluent and poorer areas. Efforts to improve the variety and quality of healthy products in more disadvantaged neighbourhoods in the UK may encourage consumers to purchase and consume more fresh produce and thus reduce dietary inequalities.

Acknowledgements

We are grateful to the managers of the grocery stores we visited, to Jamie Lawrence for assistance with data collection and Greg Deakin for computing support. We are also grateful to all those working on the Southampton Initiative for Health, the larger intervention project of which this study is part. This study is funded by the Medical Research Council (UK), NIHR Biomedical Research Unit (Nutrition, Diet and Lifestyle), University Hospital Southampton NHS Foundation Trust, and is supported by NHS Southampton City. Christina Black is a NIHR Doctoral Research Fellow. There are no conflicting interests.

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Appendix H Peer-reviewed paper about the consumer nutrition environment methodology

Black et al. International Journal of Behavioral Nutrition and Physical Activity 2014, 11:69
http://www.ijbnpa.org/content/11/1/69

INTERNATIONAL JOURNAL OF BEHAVIORAL NUTRITION AND PHYSICAL ACTIVITY

METHODOLOGY Open Access

Measuring the healthfulness of food retail stores: variations by store type and neighbourhood deprivation

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Abstract

Background: The consumer nutrition environment has been conceptualised as in-store environmental factors that influence food shopping habits. More healthful in-store environments could be characterised as those which promote healthful food choices such as selling good quality healthy foods or placing them in prominent locations to prompt purchasing. Research measuring the full-range of in-store environmental factors concurrently is limited.

Purpose: To develop a summary score of 'healthfulness' composed of nine in-store factors that influence food shopping behaviour, and to assess this score by store type and neighbourhood deprivation.

Methods: A cross-sectional survey of 601 retail food stores, including supermarkets, grocery stores and convenience stores, was completed in Hampshire, United Kingdom between July 2010 and June 2011. The survey measured nine variables (variety, price, quality, promotions, shelf placement, store placement, nutrition information, healthier alternatives and single fruit sale) to assess the healthfulness of retail food stores on seven healthy and five less healthy foods that are markers of diet quality. Four steps were completed to create nine individual variable scores and another three to create an overall score of healthfulness for each store.

Results: Analysis of variance showed strong evidence of a difference in overall healthfulness by store type ($p < 0.001$). Large and premium supermarkets offered the most healthful shopping environments for consumers. Discount supermarkets, 'world', convenience and petrol stores offered less healthful environments to consumers however there was variation across the healthfulness spectrum. No relationship between overall healthfulness and neighbourhood deprivation was observed ($p = 0.1$).

Conclusions: A new composite measure of nine variables that can influence food choices was developed to provide an overall assessment of the healthfulness of retail food stores. This composite score could be useful in future research to measure the relationship between main food store and quality of diet, and to evaluate the effects of multi-component food environment interventions.

Keywords: Food environment, Consumer nutrition environment, Diet quality, Dietary inequalities

Background

There is increasing evidence that the food environment is an important determinant of dietary behaviour and obesity [1,2]. With obesity accounting for almost 21% of health care costs in the US [3] and the UK's NHS spending more than £5 billion a year on obesity-related health problems [4], governments are exploring policy options that modify the food environment to make healthier choices easier for consumers [5,6].

Glanz et al. [7] have developed a conceptual model to guide food environment research. The focal points of the model are the four types of food environments: *community nutrition environment, consumer nutrition environment, organisational nutrition environment* and *information environment*. The majority of food environment research has focused on the community nutrition environment [1], which measures the number, type, location and accessibility

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of food sources [7]. Fewer studies have assessed the consumer nutrition environment [8] which considers factors that influence food choice within stores such as availability, price, promotions, placement, variety, quality and nutrition information [7].

Assessment of the consumer nutrition environment in retail food stores is important because of the global convergence of shopping habits away from smaller specialty stores towards stores that stock a wider range of products [9]. Consumer's dietary choices are affected by the products sold, prices charged and promotional strategies used in their main food stores [10]. More healthful food store environments could be defined as those which promote healthful food choices such as selling good quality healthy foods or placing them in prominent locations to prompt purchasing.

A number of tools to assess the consumer nutrition environment have been developed [11,12], with the vast majority for use in the United States (US). Few tools have undergone reliability or validity testing or provide the level of detail required to assess linkages between retail food environments and dietary behaviour [11,13,14]. A great proportion of tools measure two in-store factors: availability and price [11,12,15]. A smaller number of tools have assessed variety and/or quality of fruit and vegetables [16-18], in-store advertising and/or product placement [13,19,20] or price promotions and nutrition labelling [21].

Some tools enable the creation of a composite score of the in-store environment including the widely used Nutrition Environment Measures Survey–Stores (NEMS-S) [17] and the CX^3 Food Availability and Marketing Survey [20]; both developed for the US context. The NEMS-S scores and CX^3 store scores incorporate three in-store factors: availability of healthier products, fruit and vegetable quality, and price or in-store advertising. The Health Responsibility Index was developed to measure the in-store environment of nine supermarkets in the UK [21]. It measured sodium content, nutrition labelling and information, and price promotions on twelve frequently consumed processed products known to be high in sodium. Composite scores incorporating several consumer nutrition environment factors can provide an overall evaluation of the store environment and have been shown to help communities and policy makers in the US identify priority areas and inform interventions [20]. However, no score has included more than three in-store factors or included standardised measures that can be used to statistically assess relationships between diet and in-store environments or monitor relative change in environment over time.

There is a gap in the literature for a comprehensive tool that measures multiple in-store factors concurrently on healthy and less healthy products, particularly outside the US. Such a tool could provide a thorough evaluation of differences in the retail food stores environment by store type and neighbourhood deprivation and may identify target sites for interventions.

In the literature, supermarkets are portrayed as offering the healthiest shopping environment for consumers and small convenience stores the poorest [22,23]. These broad categories however, cover a heterogeneous group of stores [10,24]. In the UK for example, there are four different types of supermarkets that target different consumer groups [9,10] and are likely to offer different shopping environments. Research that excludes the full range of environmental exposures or measures only healthy or less healthy foods may be misrepresenting the food environment within these stores.

Area based differences in the consumer nutrition environment have been observed in the US but no clear trend has been seen in other high income countries [25,26]. In-store assessments based on a limited number of environmental factors and foods may be missing important socio-economic differences. An observation tool that evaluates several environmental exposures of foods commonly used to assess dietary disparities may provide a more complete environmental assessment.

This study addresses a current gap in the literature by developing a comprehensive consumer nutrition environment observational tool to measure the 'healthfulness' of food retail stores in the UK and testing differences by store type and neighbourhood deprivation.

Methods

Consumer nutrition environment tool development

A list of all retail food stores and their postcodes in six council boundaries (Southampton, Eastleigh, Fareham, Gosport, Havant, Portsmouth) within Hampshire, UK, was compiled in July and August 2010. Store information was obtained from council Food Safety Registers and on-line business directories (yellow-pages and yell.com). Between July 2010 and June 2011 trained fieldworkers 'ground-truthed' the study area and collected data in 601 of the 606 retail food stores.

A consumer nutrition environment tool was designed to measure nine factors that can affect consumer's food choices. Data on number of *varieties*, *price*, *promotion*, *shelf placement* and *store placement* were collected on seven healthy and five less healthy products. In addition, information on the type of *nutrition information* and availability of a *healthier alternative* were collected for less healthy products. The *quality* of two fruits and four vegetables and opportunity for *single sale* of the two fruits were also measured. Table 1 describes the definitions and measurement scales of the variables included in the tool. Information on fruit and vegetable quality was collected using a published quality indicator [18]. Data on the remaining variables were collected using

Table 1 Variables measured in the consumer nutrition environment tool

	Variable	Definition	Measurement scale
I	Variety	*The number of different choices within a product range based on: product flavour, products size, fair trade/ organic range or no-name/low-cost range*	*Not available, 1, 2, 3, 4, 5+*
II	Price	*Price of the cheapest item, £ per portion, for each product*	*Pound sterling per portion*
III	Promotions	*Whether or not the product category was on price promotion*	*Yes/no*
IV	Shelf placement	*Where on the shelf the cheapest item for each product was placed*	*Bottom shelf, other, prominent (eye-level)*
V	Store placement	*Which part of the store the cheapest item for each product was placed*	*Inconspicuous, noticeable, prominent*
VI	Quality	*Level of quality of the two fruit and four vegetables*	*Poor, medium, good* [18]
VII	Healthier alternative	*Whether or not a healthier option was available for less healthy products*	*Yes/no*
VIII	Nutrition information	*The type of nutrition information available on the cheapest item for each product*	*None, other[a], back-of-pack, front & back of pack*
IX	Single fruit sale	*Whether or not single sale of the two fruit measured was possible*	*Yes/no*

[a] For example recipe card.

novel measures. The tool and survey protocol are available in the Additional file 1. The median time taken to complete the survey across the 601 stores was 11 minutes (IQR: 7, 15).

The 12 food products were: peppers, tomatoes, lettuce, onions, apples, bananas, wholemeal bread, oven chips, sausages, crisps, sugar and white bread. Products were selected because they discriminate between better or poorer dietary patterns, are frequently consumed in England [27] and could be measured in a large survey. The food products selected represent items from short and long food frequency questionnaires (FFQ) used to determine differences in dietary quality among a number of populations including young women, young children and older adults [28-31]. These foods represent the UK Department of Health's dietary recommendations and foods known to contribute to nutrition-related chronic diseases [29].

The level of agreement between fieldworkers was assessed by the Kappa statistic on a sample of 14 stores (large supermarket (n = 2), discount supermarket (n = 1), small supermarket (n = 4), 'world' store (n = 1), convenience store (n = 5), petrol store (n = 1)). The relative consistency of *price* responses was assessed using the coefficient of variation: the standard deviation of difference divided by the mean (%). Cronbach's alpha was used to assess the internal consistency of all nine components of the healthfulness score.

Healthfulness score development

In 2012, a composite score of healthfulness was created for each store surveyed, where each of the nine in-store variables were weighted equally. Seven steps were taken to create the healthfulness scores (Figure 1). Individual scores for each of the nine variables were calculated using steps one to four. All scores were constructed such that higher scores represented more healthful environments. Principal components analysis was applied in an attempt to weight the nine variables however no interpretable patterns were identified.

The process of creating the scores involved: i) converting *price* measures to pound per portion (using standard portion sizes [32]) and for each store, subtracting the mean healthy item price from the mean less healthy item price, ii), imputing missing values, due to field work error, using the mean value for the variable of that store type, iii) creating summed scores for each store for *quality* of fruit and vegetables, *single fruit sale*, *nutrition information* on and *healthier alternative* of less healthy products, iv) creating a score for *variety*, *shelf placement*, *store placement* and *promotions* for each store by calculating the difference between the sum of less healthy scores and the sum of the healthy scores, v) standardising all scores vi) creating a composite score for each store by summing the nine standardised variable scores and dividing by nine, vii) standardising the healthfulness scores (sample mean = 0, SD = 1).

For stores which sold no healthy items the rounded 99th centile of healthy items was imputed as the mean healthy price score. This value represented the time, travel or health costs consumers could bear for healthy products not being available. Stores with no less healthy items were given a mean less healthy price score of zero. Overall, less than 1% of score components were imputed.

Predictors of healthfulness – store type and neighbourhood deprivation

Stores were classified into seven categories based on a combination of the Local Authority Enforcement Monitoring System (LAEMS) [33] and previous UK research [34] (Table 2). Store categorisation was confirmed during data collection. A box plot was created to examine the spread of healthfulness scores across the seven store types. To assess differences in store healthfulness and individual in-store factors by store type, analysis of variance was used for normally distributed variables and

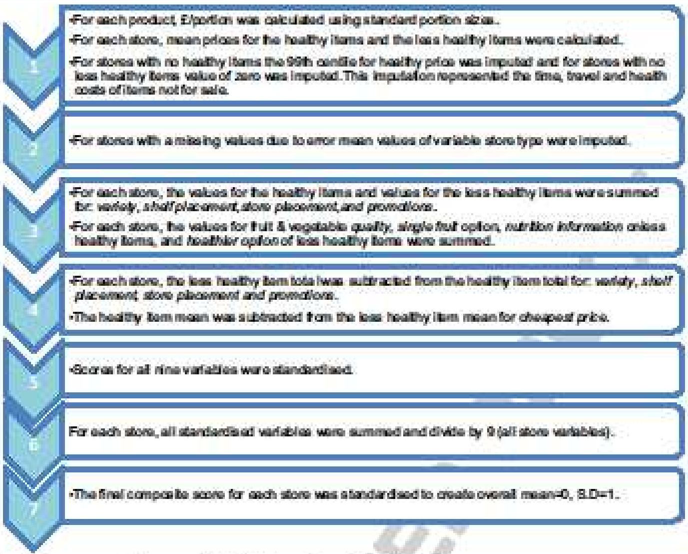

Figure 1 Process to create a composite score of healthfulness for retail food outlets.

Kruskal Wallis test for non-parametric variables, and Chi squared test was used for categorical variables.

Neighbourhood deprivation was measured using the 2007 English Index of Deprivation (ID) income domain. The index of multiple deprivation (IMD) was not applied because of circularity with the access to services domain which included an access to grocery stores measure. The ID is available for Lower Super Output Areas (LSOA), small areas constructed from the 2001 English census that are socially homogenous and have a population size

Table 2 Retail food outlet categorisation system

Code	Store type	Description	Examples
0	Premium supermarket	5+ manned cash registers	Waitrose, M&S
		Promoted as offering highest quality goods and service	
1	Large supermarket	5+ manned cash registers	Tesco, Sainsburys, Asda, Morrisons
		All foods & many varieties	
		Majority of supermarket share	
2	Discount supermarket	5+ manned cash registers	Aldi, Lidl, Iceland, Netto, Kwiksave
		Heavily promoted as low price stores	
3	Small supermarket	1-4 manned cash registers	Tesco express, Co-op, Sainsburys local
		Smaller store of known brand name	
4	'World' store	1-4 manned cash registers	Asian supermarkets, Polish supermarkets, World foods
		Products for specific ethnicities	
5	Convenience store	1-4 manned cash registers	Spar, OneStop, MACE, Independent stores
		Limited number of products	
		Independents & 'symbols'*	
6	Petrol station store	Sell petrol/diesel	Shell Select, Tesco petrol station, BP, M&S
		Includes small supermarkets that sell petrol	

* 'Symbol' convenience stores are affiliated with a symbol group brand such as OneStop and Spar.

between 1000–1500 residents [35]. Each LSOA in the study area (n = 550) was assigned to a quintile of deprivation using the national ranks of 2007 ID income domain [35] (1 = most deprived and 5 = least deprived). Test for trend was performed to examine differences in store healthfulness and individual in-store variables by neighbourhood deprivation. Differences by LSOA rural and urban classification were not assessed because more than 98% of the study area was classified as urban [36] leaving inadequate variability.

Results

The response rate for retail food stores in the study was 99% (n = 601). Four convenience and two 'world' stores refused to take part in the study. Table 3 presents the sample by store type and neighbourhood deprivation quintile. The greatest proportion of stores was convenience stores (45%, n = 268), followed by small supermarkets (21%, n = 127); large supermarkets made up 5% (n = 32) of the sample. Most retail food stores were located in the second most deprived and middle deprivation neighbourhoods (26%, n = 154 and 28%, n = 171 respectively).

Inter-rater reliability revealed almost perfect agreement for *single fruit sale, healthier alternative* and *nutrition information, variety and promotions* (kappa ≥ 0.85) [12]. The inter-rater reliability for *store placement* and *shelf placement* showed substantial agreement (kappa ≥ 0.73). However, *quality* of fruit and vegetables showed moderate agreement between field workers (kappa = 0.60). The coefficient of variation observed for *price* was 17%, which showed little variation in price between field workers across all products. The Cronbach's alpha for the standardised components of the healthfulness score was 0.86.

Predictors of healthfulness score

Figure 2 indicates that the healthfulness scores were poorer for 'world', convenience, and petrol stores. Discount supermarkets had the lowest median score of all supermarkets (Table 4) and showed the greatest spread of healthfulness scores for supermarkets. Healthfulness scores were highly positive for premium and large supermarkets, indicating these stores offered the most healthful environments for consumers. Small supermarkets showed more variation in healthfulness scores than premium and large supermarkets, though scores remained predominantly above zero suggesting better than average healthfulness. Discount supermarkets, 'world', convenience and petrol stores all showed a varied distribution. ANOVA revealed evidence of a difference in healthfulness according to store type ($p < 0.001$). Store type explained 53% of the variance of healthfulness. Adding neighbourhood deprivation quintiles to the model did not change the variance explained. Table 4 shows that the nine individual variables followed similar trends to the composite score across the seven different store types.

Figure 3 shows a tendency towards store healthfulness improving with increasing levels of neighbourhood affluence. However, the test for trend revealed that this association was not significant ($p = 0.09$). Examination of the relationship between individual components of the healthfulness score with neighbourhood deprivation highlighted several disparities (Table 5). Fresh produce *quality* declined as level of neighbourhood deprivation increased ($p < 0.01$). The presence of *nutrition information* on less healthy items was greatest in the most affluent neighbourhoods while price *promotions* favoured less healthy products in all neighbourhoods except the most deprived (both $p < 0.01$). Prominent *shelf* and *store placement* of healthy products was slightly better in more affluent neighbourhoods ($p = 0.04$ and $p = 0.05$ respectively) and the availability of *healthier alternatives* of less healthy foods was worst in the most deprived neighbourhoods ($p = 0.03$). Product *variety, price* and *single fruit sale* were not associated with neighbourhood deprivation (all $p \geq 0.3$).

Table 3 Store sample by store type and level of neighbourhood deprivation

Store type	Most deprived	2	3	4	Least deprived	Total n	(%)
Premium supermarket	1	5	2	2	0	10	(2)
Large supermarket	7	9	8	4	4	32	(5)
Discount supermarket	8	7	12	3	5	35	(6)
Small supermarket	13	31	34	24	25	127	(21)
'World' store	17	20	16	6	2	61	(10)
Convenience store	44	72	77	39	36	268	(45)
Petrol station store	10	10	22	8	18	68	(11)
Total n	100	154	171	86	90	601	
(%)	(17)	(26)	(28)	(14)	(15)		(100)

Discussion

The composite score of healthfulness varied across different types of retail food stores. Similar trends were observed for the scores of the nine component variables (variety, price, quality, promotions, shelf placement, store placement, nutrition information, healthier alternatives and single fruit sale) across the seven store types. These findings suggest that the composite score provided good representation of the individual components. Large and premium supermarkets consistently offered environments that supported more healthful food choices and small supermarkets generally offered healthful environments. Discount supermarkets, convenience, 'world' and petrol stores offered less healthful environments. However, these store types had widely spread scores, indicating that there were examples of better practice for each of these less healthful store types.

Black et al. International Journal of Behavioral Nutrition and Physical Activity 2014, 11:69
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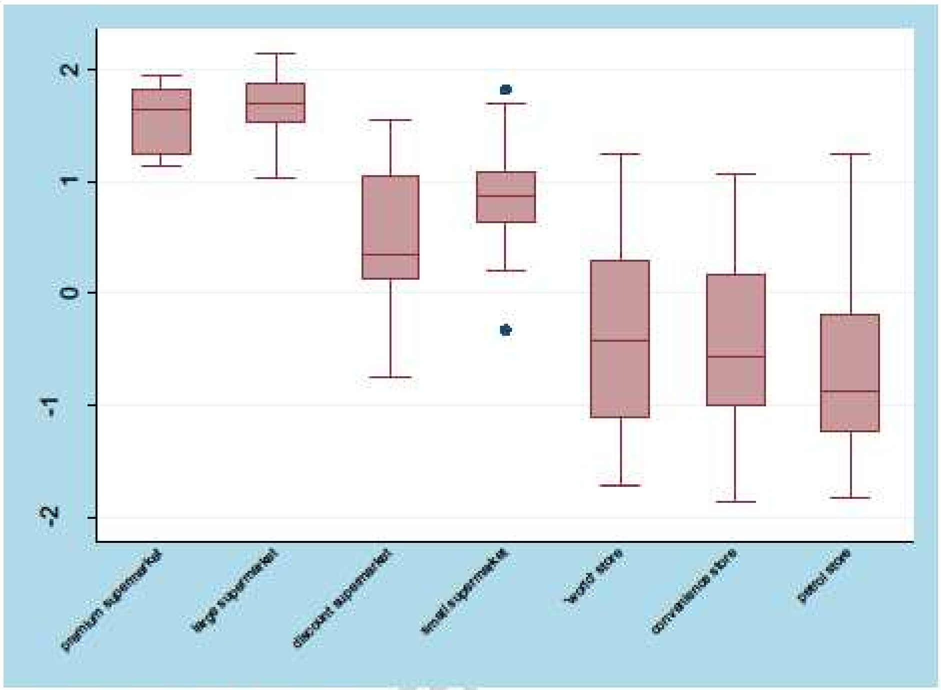

Figure 2 Box and whisker plot of store healthfulness by store type.

Level of neighbourhood deprivation did not predict store healthfulness. However, there was a trend towards affluent neighbourhoods having in-store environments more supportive of healthful food choices. The trends observed across the nine individual variable scores showed some disparities. Strong associations were observed for better quality produce and nutrition information in more affluent neighbourhoods, but unexpectedly, strong associations for healthier price promotion practices in the most deprived neighbourhoods. Weaker associations were found for poorer placement of healthy items and poorer availability of healthier alternatives in more disadvantaged neighbourhoods. No neighbourhood disparities were identified for product variety, price or single fruit sale. These results show how the composite score averages several multi-directional trends across the individual components. The healthfulness score also showed high internal ($\alpha = 0.86$) [12] consistency which indicates that the components measure one internally consistent underlying construct.

Our finding that large and premium supermarkets offered environments that support consumers choosing healthful foods is consistent with previous research [11,37,38]. Unlike previous research [39-41], store size did not necessarily determine overall store healthfulness. Smaller versions of large supermarkets offered more healthful shopping environments than bigger discount supermarkets. Discount supermarkets offered the least supportive environment for healthy eating of all supermarkets in our study with the median composite score for discount supermarkets considerably (0.6 SD) lower than other supermarkets. Previous research in England has shown poorer quality and availability of healthy foods in discount supermarkets [42]. However, research from Scotland revealed better availability of healthy foods in discount stores and cheaper prices [43]. Our analysis of the component variables revealed that discount supermarkets had many more varieties of less healthy than healthy products, promoted less healthy products more than healthy products and had fewer healthier alternatives of less healthy foods than other supermarkets. These findings suggest that discount supermarkets may be a site for future intervention, particularly for researchers or policy makers addressing health inequalities.

Table 4 Individual variable and composite scores by store type

Variable	Premium supermarket	Large supermarket	Discount supermarket	Small supermarket	'World' store	Convenience store	Petrol store	Possible range[f] Min	Possible range[f] Max	p-value
	Median (IQR)[d]									
Composite score	1.7	1.7	0.3	0.9	-0.4	-0.6	-0.9	-1.9	2.2	<0.001[a]
	(1.2 to 1.8)	(1.5 to 1.9)	(0.1 to 1.0)	(0.6 to 1.1)	(-1.1 to 0.3)	(-1.0 to 0.2)	(-1.2 to -0.2)			
Variety	8	8	-8	-6	-2	-9	-7	-25	35	<0.001[a]
	(7 to 8)	(6 to 9)	(-10 to 1)	(-8 to -2)	(-5 to 0)	(-11 to -7)	(-8 to -5)			
Price	0.03	-0.03	-0.01	0.02	0.04	0.03	0.02	Higher score is more healthful		0.002[a]
	(0 to 0.05)	(-0.04 to -0.01)	(-0.04 to 0.01)	(0.01 to 0.05)	(-0.12 to 0.1)	(-0.06 to 0.08)	(-0.21 to 0.1)			
Promotions	0.5	0	-1	-1	0	-1	-1	-5	7	<0.001[a]
	(-1 to 1)	(-1 to 1)	(-3 to 0)	(-2 to -1)	(-0.4 to 0)	(-1 to 0)	(-1 to 0)			
Shelf placement	5	7	7	5	0	-3	-5	-15	21	<0.001[a]
	(4 to 7)	(5 to 9)	(4 to 9)	(4 to 7)	(-3 to 4)	(-6 to 3)	(6 to 1)			
Store placement	4	4	4	4	1	-4	-4	-15	21	<0.001[a]
	(4 to 5)	(4 to 5)	(3 to 5)	(3 to 4)	(-4 to 5)	(-6 to 2)	(6 to 1)			
Quality	17	17	17	17	5	5	0	0	18	<0.001[b]
	(17 to 17)	(16 to 18)	(15 to 18)	(15 to 17)	(0 to 10)	(0 to 13)	(0 to 8)			
Healthier alternative	4	5	2	3	0	1	1	0	5	<0.001[b]
	(4 to 5)	(5 to 5)	(2 to 3)	(2 to 3)	(0 to 1)	(1 to 2)	(0 to 2)			
Nutrition information	13	14	13	15	4	11	9(9 to 12)	0	15	<0.001[b]
	(10 to 13)	(12 to 15)	(13 to 14)	(15 to 15)	(2 to 7)	(9 to 13)				
Single sale of two fruits[e]	100%	97%	26%	87%	23%	19%	21%	0	2	<0.001[c]

[a]Oneway analysis of variance, [b]Kruskal-Wallis test, [c]Chi square test, [d]Median and interquartile range (IQR) were provided for both parametric and non-parametric variables for ease of reading, [e]Percentage of two fruits available for single sale was provided because this variable was categorical, [f]Possible range of scores for each variable except composite score which shows actual range of composite score values.

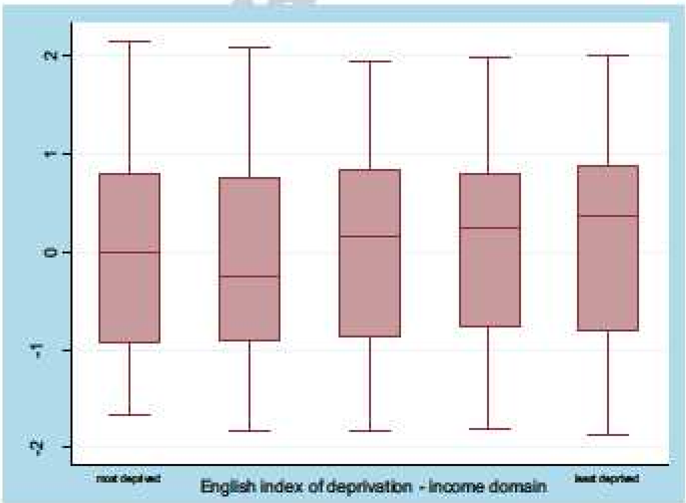

Figure 3 Box and whisker plot store healthfulness by level of neighbourhood deprivation.

Black et al. International Journal of Behavioral Nutrition and Physical Activity 2014, 11:69
http://www.ijbnpa.org/content/11/1/69

Table 5 Individual variable and composite scores by neighbourhood deprivation

	Most deprived	2	3	4	Least deprived	Possible range[e]		
Variable			*Median (IQR)*[c]			*Min*	*Max*	*p-value*
Composite score	0	-0.2	0.2	0.2	0.4	*-1.9*	*2.2*	0.09[a]
	(-0.9 to 0.8)	(-0.9 to 0.8)	(-0.9 to 0.8)	(-0.7 to 0.8)	(-0.8 to 0.9)			
Variety	-7	-7	-7	-7	-7	*-25*	*35*	0.6[a]
	(-9 to -2.5)	(-10 to -2)	(-9 to -2)	(-8 to -4)	(-10 to -3)			
Price	0.02	0.03	0.02	0.03	0.02	*Higher score is more healthful*		0.5[a]
	(-0.04 to 0.06)	(-0.05 to 0.08)	(-0.04 to 0.06)	(-0.01 to 0.06)	(-0.01 to 0.06)			
Promotions	0	-1	-1	-1	-1	*-5*	*7*	<0.001[a]
	(-1 to 0)	(-1 to 0)	(-1 to 0)	(-2 to 0)	(-2 to 0)			
Shelf placement	2	0	3	3	4	*-15*	*21*	0.04[a]
	(-5 to 7)	(-5 to 5)	(-4 to 6)	(-3 to 6)	(-3 to 6)			
Store placement	1	0	2	2	2	*-15*	*21*	0.05[a]
	(-5 to 4)	(-5 to 4)	(-4 to 4)	(-4 to 4)	(-4 to 4)			
Quality	9	8	13	12	14	*0*	*18*	0.002[a]
	(1 to 15)	(0 to 15)	(3 to 17)	(0 to 17)	(3 to 17)			
Healthier alternative	1	2	2	2	2	*0*	*5*	0.03[a]
	(1 to 2)	(1 to 3)	(1 to 3)	(1 to 3)	(1 to 3)			
Nutrition information	12	12	12	12	13	*0*	*15*	0.003[a]
	(9 to 14)	(9 to 14)	(9 to 14)	(10 to 15)	(11 to 15)			
Single sale of two fruits[d]	42%	36%	39%	43%	43%	*0*	*2*	0.4[b]

[a]Spearman test for trend, [b]Chi square test, [c]Median and inter-quartile range (IQR) was provided for both parametric and non-parametric variables for ease of reading, [d]Percentage of two fruits available for single sale was provided because this variable was categorical, [e]Possible range of scores for each variable except composite score which shows actual range of composite score values.

The healthfulness score we developed to measure overall in-store environment demonstrated the ability to discriminate within store types as well as between. For example, stores that are generally classified as 'unhealthy', such as petrol and convenience stores [44,45], revealed a spread in healthfulness scores from poor to good. This finding indicates there are examples of better, more healthful practices within less healthy store types and may also identify further subgroup categorisation of stores [46]. Further exploration of the specific differences and characteristics behind the better practices of more healthful stores may inform future store categorisation or identify targets for interventions to improve the environment of the least healthful food stores. Examples of successful initiatives to improve retail food stores exist [47], with interventions using multi-pronged strategies proving particularly effective [48]. Our composite measure of store healthfulness may provide a useful evaluation tool for future interventions addressing multiple in-store variables. In particular, the parametric nature of the healthfulness score provides more flexibility in statistical analyses than skewed measures.

Our results showed a trend for poorer store healthfulness in more deprived neighbourhoods however, this trend was not significant. Whilst no prior research has measured the full range of consumer nutrition environment factors included in this study, investigations in Scotland, England and Australia have shown little variation in availability and price by area level deprivation [49-51]. There are some illustrations in these countries for poorer in fruit and vegetable quality [18,52] and greater promotion of less healthy products [21] in retailers located in more deprived areas however research is limited. In the US disparities in availability, price, variety and quality of healthy food exist and favour more affluent, predominantly white neighbourhoods [37,53]. More frequent prominent placement of less healthy items in poorer Latino areas compared with wealthier white areas has been observed but the findings were not significant [19]. Country differences may be due to the higher levels of urban residential segregation in the US than countries such as Australia and the UK [54]. The geography of food retailing may also differ across countries. In the UK for example, over the last two decades major retailers have adopted an urban regeneration agenda locating large stores on the periphery of towns [55] as well as opening smaller stores in city and town centres [9,10]. These supermarket developments

Black et al. International Journal of Behavioral Nutrition and Physical Activity 2014, 11:69
http://www.ijbnpa.org/content/11/1/69

may have addressed some of the socioeconomic disparities in food access in the UK.

Strengths and limitations

This study is the first to develop an overall measure of the consumer nutrition environment combining nine different variables into a single standardised score. The composite score characterised multiple environmental factors independent of measurement type; categorical, dichotomous and continuous measures were all represented equally in an overall score that was normally distributed. Using a standardised score provides a robust measure to conduct and interpret analyses and could ease examination of environmental and health/behavioural associations. The foods selected in this study are items which account for the most variance in tools used to discriminate between better and poorer dietary patterns in young women, young children and older adults. This selection could enable assessment of the relationship between environmental attributes of foods directly measured during dietary assessments in various populations in future research.

This study measured a much larger sample of stores than previous work [13,16,20] and covered 99% of retail food stores in the study area. This coverage provides a thorough representation of the variation of healthfulness of retail food stores and enhances confidence in the accuracy of the study results.

Good to excellent kappa statistics (0.73-0.95) were returned for almost all variables. These results are similar to other in-store audit tools (kappa >0.70) [56]. The sample of stores included in this reliability test however was small (n = 14) compared to similar studies (n = 30 to 85) [13,17,19]. The reliability (kappa 0.60) for fruit and vegetable quality was higher than the results reported in some studies [17], but lower than the results of others [57]. Future work using photos or a simple two-point scale of acceptable/unacceptable can provide a more consistent measure of quality as has been used in previous work [17,58]. Convergent validity against an alternative observational tool was not tested due to the intensive resources required for in-store audits. Data were collected from all store types and levels of neighbourhood deprivation over eleven months. Some aspects of seasonality or small price fluctuations may be been accounted for however, test-retest reliability and stability of items over time were not measured.

While our study was novel in assessing nine different in-store variables, three variables were restricted in their assessment. Shelf placement, store placement and nutrition information were all measured on the cheapest item available for each product assessed. This restriction may have missed the opportunity to appropriately score the location of heavily promoted less healthy branded products, particularly in supermarkets which sell own-brand products. Other studies have assessed a specific brand and size of product [59] however, this approach is limited if not all stores stock that particular brand and size. For feasibility reasons specialty stores and restaurants were excluded. This study also has cross sectional and ecological limitations and the relationship between store healthfulness and diet was not assessed.

Conclusion

This study used a large sample of retail food stores (n = 601) to develop a composite measure of the consumer nutrition environment incorporating nine different variables. The composite score showed good internal consistency and represented overall trends of the individual variables across seven different store types and five levels of neighbourhood deprivation. The composite measure showed differences between and within store types identifying opportunities for intervention in discount supermarkets and other store types with environments less supportive of healthful food choices. The standardised composite score developed in this study can offer greater flexibility in statistical analyses of environment-diet relationships in future observational and interventions studies than single in-store measures, which can be skewed. The products included in this tool relate to dietary quality measures, thus this tool can be used to examine relationships between environmental attributes of foods directly measured during dietary assessments in various populations in future research.

Additional file

Additional file 1: Consumer nutrition environment audit tool and survey protocol.

Competing interests

Christina Black, Georgia Ntani, Hazel Inskip, Steve Cummins, Graham Moon and Janis Baird have no competing interests to declare and no financial disclosures to make.
Cyrus Cooper has no conflicts of interest to declare and has received consultancy, lecture fees and honoraria from AMGEN, GSK, Alliance for Better Bone Health, MSD, Eli Lilly, Pfizer, Novartis, Servier, Medtronic and Roche.

Authors' contributions

CB and JB conceived of the study, designed the audit tool, coordinated the data collection, healthfulness score development and analyses, and wrote the first draft of the manuscript. GN and HMI contributed to the development of the healthfulness score and performed the statistical analyses. CC, SC and GM participated in the design of the study and helped to draft the manuscript. All authors read and approved the manuscript.

Acknowledgements

Christina Black is supported by a United Kingdom National Institute for Health Research (NIHR) Doctoral Research Fellowship. Steve Cummins is supported by a United Kingdom NIHR Senior Fellowship. This project was supported by the United Kingdom Medical Research Council and the NIHR Nutrition Biomedical Research Centre, University of Southampton. The views expressed in this publication are those of the author(s) and not necessarily those of the NHS, the NIHR or the Department of Health.

We are grateful to the managers of the retail food stores we visited, to Jamie Lawrence for assistance with data collection and Patsy Coakley for computing support.

Funding sources

This research and the authors of this paper are supported by the following funding sources: United Kingdom NIHR fellowships, United Kingdom Medical Research Council and the NIHR Nutrition Biomedical Research Centre, University of Southampton.

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Received: 21 October 2013 Accepted: 13 May 2014
Published: 23 May 2014

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doi:10.1186/1479-5868-11-69
Cite this article as: Black *et al.*: Measuring the healthfulness of food retail stores: variations by store type and neighbourhood deprivation. *International Journal of Behavioral Nutrition and Physical Activity* 2014 11:69.

Appendix I Organisational nutrition environment audit tool

Geographical Area: **SSCC:** **Year SSCC opened:**	**MC code:** **LSOA code:** **IMD:**
Interviewer:	**Date:**

NUTRITION, EXERCISE & WELL-BEING STUDY

Organisational Nutrition Environment audit tool

We are interested in the food-related activities and environment in Sure Start.

This questionnaire is designed to find out about food policies, food provision and food-related information.

Your answers are strictly **confidential** and only your job title, not your name, will be put on the questionnaire. I will take the completed questionnaire away.

Please choose the answers that best describe the food-related activities over the last 12 months in the Sure Start Children's Centre where you work.

Thank you very much for your help

Staff position:

Duration worked at SSCC:……………………..……………years

This questionnaire has been compiled by the Southampton Initiative for Health team
Medical Research Council Lifecourse Epidemiology Unit
University of Southampton
July 2011

About your Sure Start Children's Centre

In this section, we want to know a little bit more about the Sure Start Children's Centre (SSCC) where you work.

1(a) Approximately how many children attend your centre each day? ☐

1(b) Approximately how many adults attend your centre each day? ☐

2(a) On average, how many hours does a child stay at your centre per day? ☐

2(b) On average, how many hours does an adults stay at your centre per day? ☐

3(a) How often is food provided for children attending your centre?

- Always ☐
- Often ☐
- Sometimes ☐
- Never ☐

3(b) How often is food provided for adults attending your centre?

- Always ☐
- Often ☐
- Sometimes ☐
- Never ☐

4(a) How often do parents bring food into your centre?

(Applies to food brought for both children and/or adults)

- Always ☐
- Often ☐
- Sometimes ☐
- Never ☐

Food guidelines and/or policy

This section is about the types of food that are provided in your centre.

5(a) Does your centre have guidelines and/ or a written policy about the types of foods that can be eaten within the centre?[1]

No guidelines	☐	(If No go to question 8)
Verbal guidelines	☐	
Written policy	☐	→ please ask for a copy of the policy
Unsure	☐	(If unsure go to question 8)

5(b) Does your centre policy and/or guidelines specifically refer to the following?[2]

		Yes	No	Unsure
i	Promoting water consumption			
ii	Promoting milk consumption			
iii	Promoting fruit consumption			
iv	Promoting vegetable consumption			
v	Promoting breastfeeding			
vi	Promoting healthier packaged snacks (low sugar, salt) (e.g. bread sticks)			
vii	Promoting healthy foods during celebrations (e.g. birthdays, Easter, Christmas)			
viii	Restricting less healthy packaged snacks (e.g. crisps, sweet biscuits)			
ix	Restricting soft drinks			
x	Restricting squash/ fruit drinks			
xi	Restricting 100% fruit juice			
xii	Restricting common food allergens (e.g. peanut products)			
xiii	Food safety practices			
xiv	Other (please specify)........................			

3

6(a) When do the food-related guidelines and/or policy apply?[1]

		Always	Often	Sometimes	Never
i	Food provided for children by your centre				
ii	Food provided for children by parents				
iii	Food provided for parents by your centre				
iv	Food provided for parents by parents				
v	Food provided for staff by your centre				

6(b) Are these guidelines and/or food policy explained to parents?[2]

- No parents are informed ☐
- Some parents are informed ☐
- Most parents are informed ☐
- All parents are informed ☐
- Unsure ☐

7(a) What actions are taken if food or drinks not meeting the guidelines or policy are provided by parents?[2]

....

....

....

7(b) On occasions when food or drinks not meeting the guidelines are provided by parents, how often does the above action occur?[2]

- Always ☐
- Often ☐
- Sometimes ☐
- Never ☐

7(c) Who is responsible for taking these actions?[2] ....

4

Supporting healthy eating

In this section, we want to know a little bit more about how parents and children attending your centre are supported to eat healthy foods.

8. How regularly do the following practices occur at your centre?

		Always	Often	Sometimes	Never
i	When food is served children are sat down at a table with adequate space [2,3]				
ii	Parents join children at the table when food is consumed[1]				
iii	Staff join children at the table when food is consumed[1]				
iv	Children determine how much they want to eat[1]				
v	Parents consume the same food that is offered to the children				
vi	Staff consume the same food that is offered to the children[1]				
vii	Children are encouraged to try new or less favoured foods[1]				
viii	Parents are encouraged to try new or less favoured foods				
ix	Children are told to hurry and finish eating[3]				
x	Food is used as a reward or treat, or to comfort children[2]				
xi	Children and parents are encouraged to wash their hands before eating[3]				

9. How often are activities specifically about healthy eating incorporated into sessions held at your centre?[1]

- Always ☐
- Often ☐
- Sometimes ☐
- Never ☐

10. How often do staff discuss healthy eating with parents attending your centre?

Always ☐

Often ☐

Sometimes ☐

Never ☐

11. How regularly are training opportunities on healthy eating provided for staff?[1]

More than once a year ☐

About once a year ☐

Less than once a year ☐

Never ☐

12. On a scale of one to ten, with one being not important and ten being very important, how important is healthy eating as one of the many issues you help parents with at your centre?[2]

1 2 3 4 5 6 7 8 9 10

Not important *Very important*

13. How available are the following resources at your centre?[1]

		Readily available	Available on request	Not available
i	Leaflets/ posters about healthy eating or weight loss for adults			
ii	Leaflets/ posters about healthy eating for children			
iii	Leaflets/ posters about weaning or breast-feeding			
iv	Courses about learning to cook or cooking on a budget			
v	Courses about healthy eating or weight loss			
vi	Fruit & vegetable or healthy food box scheme			

14. If you have a café within your centre do the healthy eating guidelines/ policy apply to all foods sold at the café ?

Yes ☐ No ☐

6

15. Please indicate the extent to which you believe each of the following factors hinder the promotion of healthy food at your centre:[2]

		Major problem	Minor problem	Not a problem
i	Food safety regulations			
ii	Parents not adhering to or undermining healthy eating guidelines			
iii	Parents don't believe or trust your advice			
iv	You do not feel confident enough to discuss healthy eating			
v	Lack of links with nutrition experts and community nutrition organisations			
vi	Cost of healthy food			
vii	Children's food preferences/ behaviour			
viii	Other (please state)			

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That's all the questions.

Thank you very much for your help

Appendix J Organisational nutrition environment survey instructions

Organisational nutrition environment audit tool
SURVEY INSTRUCTIONS

This tool has been developed to assess the organisational food environment in Sure Start Children's Centres (SSCC) for the Southampton Initiative for Health. The tool includes 15 questions which aim to identify the presence of a food policy, clearly understand the healthy eating ethos, understand what types of foods are served, and the importance placed on healthy eating in the centre.

The questionnaire will be administered to both an individual in a managerial position and two other staff members such as a play worker, community development worker or health worker (nursery nurse). By administering the questionnaire to these different positions we hope to clarify whether or not all staff members are informed and aware of the nutrition environment of the centre. We hope to understand if there is consistency in the centres attempt to promote healthy eating.

To ensure consistency of data collection it is essential that protocol is followed closely.

Training:

Data Collectors: Each data collector will undergo training. The training will consist of an hour meeting in which the data collectors will practice administering questionnaires with a member of the research team both face-to-face and over the phone. The team member will give constructive feedback to the data collector. The data collectors will be instructed ask questions in a non-judgemental fashion, not react to answers given by participants and not make any leading remarks that may bias the participant's response. It is important not influence the participant's answers and interact with all participants in a consistent manner in order to extract the most accurate data from the participants.

Before starting

Time: All questionnaires are to be administered between 9am-5pm.

Requesting management permission: All SSCC managers will be contacted by email to ask permission to conduct the survey with 3 staff members from their centre. Once permission has been sought each centre coordinator can be called.

Contact centre: When calling the centre ask to speak to the coordinator. Introduce yourself as a member of the research team at the University of Southampton that is working with Sure Start. Mention that you have been in contact with the centre manger (name) who has given their permission or us to contact the centre to complete a short survey with three staff members working at the centre (Sure Start and visiting staff such as health workers). Ask if they would be willing to complete the survey and name two other staff members who could also give 10-15 minutes of their time. Suggest that you are available now if it is an appropriate time for them. Remember to include a range of different staff groups from the centres.
It is appropriate to call the centre up to 6 times. The 6th time will be the last time to call the centre. The centre will then be labelled or identified as unwilling to participate or unavailable.

If possible try to complete all the information at the top of the cover sheet of the questionnaire before phoning the centre so as to reduce the amount of time spent on the phone with the SSCC employees.

1

Please complete the following information before you commence the survey and use the appropriate codes as noted below:

Geographical Area:

Geog area name	Geog area code
Southampton	1
Havant	2
Gosport	3
Eastleigh	4
Fareham	5
Portsmouth	6

SSCC:

Geographical area code	SSCC name	SSCC code	MC code	IMD code	LSOA code
1	Swathling	1	1.1	3	E01017144
1	Lordswood/ Bassett	2	1.1	3	E01017144
1	Portswood	3	1.2	3	E01017158
1	North Shirley	4	3.1	3	E01017246
1	Freemantle	5	4.1	3	E01017144
1	Central	6	4.1	1	E01017156
1	Townhill Park and Harefield	7	1.3	4	E01017174
1	Millbrook, Redbridge and Maybush	8	3.2	1	E01017245
1	Greenways	9	3.3	2	E01017251
1	Weston	10	2.1	1	E01017281
1	Woolston, Merryoak and Peartree	11	2.2	2	E01017276
1	Bitterne and Bitterne Park	12	1.3	2	E01017276
1	Thornhill	13	2.2	1	E01017166
1	Sholing	14	2.2	1	E01017169
2	Park Futures	15	5.0	1	E01022966
2	Sharps Copse	16	6.0	1	E01022915
2	Links	17	7.0	1	E01022934
2	Trospacc	18	8.0	2	E01022904
2	Hayling	19	9.0	3	E01022938
2	Crookhorn Lane	20	10.0	4	E01022952
2	Mill Hill and Small Steps	21	10.1	1	E01022959
2	The Orchard	23	11.0	1	E01022915
3	Rowner	24	12.0	2	E01022821
3	Haven	25	13.1	2	E01022803
3	Little Waves	26	14.0	1	E01022833
3	Stubblee Hill	27	15.0	3	E01022810
3	Haselbridge	28	16.0	3	E01022810
3	The Tree House	29	17.0	5	E01022815

Year SSCC Opened: 19__

Interviewer:

Interviewer name	**Interviewer initial**
Beatrice Paganini	BP
Christina Black	CB

Date: DD/MM/YY

Staff Position (SP):

Position	**SP code**
Manager/Centre Coordinator/Family Support work coordinators	1
Health staff/Nurses	2
Community Development Worker	3
Family Support Workers	4
Playcare Development Workers	5
Admin/Business Support	6
Playworker/Outreach Playworker	7

Materials Needed:

- Appropriate number of questionnaires, pen, telephone, centre telephone numbers, name of centre manager and coordinator.

Data Collection

Data is to be collected over the phone with SSCC employees.

Call centre at agreed time. Introduce yourself explain that you have spoken to SSCC manager (mention their name) and ask if they have time to complete the questionnaire over the phone, which will take about 10-15 minutes to complete.

If individual on phone refuses: Ask if there is any other employee available to answer the questionnaire or if there is a more appropriate time to call.

If the individual accepts proceed by reading the introduction statement on the front of the questionnaire sheet:

> We are interested in the food-related activities and environment in Sure Start.
>
> This questionnaire is designed to find out about food policies, food provision and food-related information.
>
> Your answers are strictly **confidential** and only your job title, not your name, will be put on the questionnaire. I will take the completed questionnaire away.

3

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