

Neighbourhood food environment and area deprivation: spatial accessibility to grocery stores selling fresh fruit and vegetables in urban and rural settings

Dianna M Smith¹, Steven Cummins^{1*}, Mathew Taylor², John Dawson^{2,3,4}, David Marshall², Leigh Sparks³, Annie S. Anderson⁵

¹Healthy Environments Research Programme, Department of Geography, Queen Mary, University of London, London, UK

²University of Edinburgh Business School, William Robertson Building, 50 George Square, Edinburgh EH8 9JY, UK

³Institute for Retail Studies University of Stirling, Stirling FK9 4LA, UK

⁴ESADE, Av. Pedralbes 60, 08034 Barcelona, Spain

⁵Centre for Public Health Nutrition Research, Ninewells Medical School, University of Dundee, Dundee DD1 9SY, UK

*Corresponding author: Dr Steven Cummins

Healthy Environments Research Programme, Department of Geography, Queen Mary, University of London, Mile End Road, London, UK E1 4NS

Email: s.c.j.cummins@qmul.ac.uk

Tel: 020 7882 7653

Words: 3495 Date: August 2008

Abstract

Background The 'deprivation amplification' hypothesis suggests that residents of deprived neighbourhoods have universally poorer access to high quality food environments which in turn contribute to the development of spatial inequalities in diet and diet-related chronic disease. This paper presents results from a study which quantified access to grocery stores selling fresh fruit and vegetables in four environmental settings in Scotland.

Methods Spatial accessibility, as measured by network travel times, to 457 grocery stores located in 205 neighbourhoods in four environmental settings (island, rural, small town and urban) in Scotland was calculated using Geographical Information Systems. The distribution of accessibility by neighbourhood deprivation in each of these four settings was investigated.

Results Overall, the most deprived neighbourhoods had the best access to grocery stores and grocery stores selling fresh produce. Stratified analysis by environmental setting suggests that the least deprived compared to the most deprived urban neighbourhoods have greater accessibility to grocery stores than their counterparts in island, rural and small town locations. Access to fresh produce is better in more deprived compared to less deprived urban and small town neighbourhoods, but poorest in the most affluent island communities with mixed results for rural settings.

Conclusions The results presented here suggest that the assumption of a universal 'deprivation amplification' hypothesis in studies of the neighbourhood food environment may be mis-guided. Associations between neighbourhood deprivation and grocery store accessibility vary by environmental setting. Theories and policies aimed at understanding and rectifying spatial inequalities in the distribution of neighbourhood exposures for poor diet need to be context specific.

Keywords: Neighbourhood, diet, deprivation, access, travel times, environment, inequality, urban, rural

Introduction

Studies investigating the role of the neighbourhood social and physical environment in the development of poor diet have become common in recent years(1). Research has found that food consumption patterns vary between neighbourhoods and that living in a disadvantaged neighbourhood is independently associated with a poor diet(2-4). Much of this work has been situated within an 'ecological' public health perspective whereby the neighbourhood food environments to which individuals are exposed have been hypothesized to exert an independent effect on diet and diet-related chronic disease through influencing food purchase and consumption patterns(5). It has been hypothesised that a process of 'deprivation amplification' might be at work, where residents of the most deprived communities are exposed to the lowest quality neighbourhood food environments(6).

Much work has been done in the USA on how local availability of the components of a healthy diet may be an important mediating factor between neighbourhood deprivation and diet quality(7-10). Healthier foods have been found to be less readily available in poorer compared to more affluent areas and proximity to certain categories of food store have been positively associated with individual diet(11, 12). The presence of a neighbourhood supermarket has been particularly associated with an increased consumption of fresh fruits and vegetables(13-16). A number of studies have documented spatial inequalities in access to these stores, with fewer supermarkets and greater numbers of small grocery stores available to residents of more disadvantaged neighbourhoods(7, 9, 17). Spatial inequalities in accessibility suggest that adherence to recommended intakes of fresh fruits and vegetables may be harder for residents of more disadvantaged neighbourhoods.

However, recent research undertaken in the United Kingdom has been more equivocal. Some studies have found no independent association between food retail provision, individual diet and fruit and vegetable intake(18, 19) and minimal differences between deprived and affluent areas in the availability of a 'modest but adequate' diet(20). Conversely, other studies have uncovered poorer access to supermarkets in deprived areas(21) as well as increasing inequalities in grocery store access(22). This conflicting evidence also extends to recent qualitative work. In one study in England, few low-income consumers reported any problems in accessing supermarkets, despite transport difficulties, or perceived problems in the choice of fruit and vegetables(23) but these findings are balanced by evidence of a complex relationship between perceived accessibility constraints and transport options at the household level(24). Two before-and-after studies have attempted to evaluate the effect on fruit and vegetable intake of the introduction of food supermarkets in deprived urban neighbourhoods, again with conflicting results. One study in Leeds reported improvements in fruit and vegetable consumption, with the largest impacts seen amongst those with the lowest baseline intakes(25). The second study, undertaken in Glasgow, found little evidence for any effect on fruit and vegetable consumption patterns(26, 27). Similar lack of associations from observational studies have been found in Australia(28, 29) and New Zealand(30, 31).

The lack of agreement in findings within the UK may be due to the pragmatic case-study approach of most studies which focus on small geographic areas such as one city or community and have a tendency to document the experience of deprived urban neighbourhoods. Such an approach, though valid, does not allow the comparison of associations between neighbourhood deprivation and food

accessibility for the full range of urban and rural settings. In addition, researchers have also tended to characterise neighbourhood food environment exposures purely on the basis of store location rather than directly investigate the availability of healthy items *within* these stores. In this paper we use a Geographical Information Systems (GIS) approach to; firstly, investigate how spatial accessibility to grocery stores, as measured by travel times using motorised transportation along the road network, varies by neighbourhood deprivation in a range of urban and rural settings across Scotland; and secondly, investigate whether spatial accessibility to fresh fruit and vegetables within these settings also varies by neighbourhood deprivation.

Data and methods

Selection of study sites

Data on the availability of fruit and vegetables were collected in nine 'sentinel' sites stratified by deprivation and urban/rural status across Scotland. These locations were chosen to represent the full range of environmental settings across the country and included islands, rural areas, smaller towns and urban centres(32). Sentinel sites were initially selected by stratifying all available data zones by the Scottish Executive's Urban-Rural Classification Scheme (SEUR). Data zones are the core small-area statistical geography used in Scotland. There are currently 6505 data zones with a mean population of 778 (range 500-1000).

To select sentinel sites, each of the 6505 data zones were grouped into three environments; urban (SEUR 1 and 2), small town (SEUR 3 and 4) and rural (SEUR 5 and 6). Data zones within each of these environments were then divided into deciles of deprivation using the 2006 Scottish Index of Multiple Deprivation (SIMD), an area-

based measure of relative deprivation(33). The SIMD is a publicly available continuous measure of compound social and material deprivation calculated using data such as current income, employment, health, education and housing. Within the top and bottom deciles of each of the three environments one data zone was randomly selected as the nucleus of the sentinel site. For each of the six nuclei, additional data zones were added to build an overall sentinel site consisting of contiguous data zones that corresponded to a recognised community. Thus six sentinels were initially constructed; urban affluent (Broughty Ferry, Dundee), urban deprived (Scotstoun/Drumchapel, Glasgow City), small town affluent (Ellon, Aberdeenshire), small town deprived (Kilbirnie, North Ayrshire), rural affluent (Haddington, East Lothian) and rural deprived (Dornoch, The Highlands). However, this process did not select island communities (SEUR rural) and, as expected, the numbers of grocery stores available in some settings were too small to conduct meaningful analyses. We therefore purposively selected four further sentinel sites to enhance coverage of the range of settings and boost small numbers of observations. Additional sites selected, on the basis of SEUR classifications, were Eilean Siar & Orkney (islands), Cupar, Fife (small town affluent) and Inverness (urban mixed). In total 205 data zones were selected. The final sample of study sites ensured coverage of the four main environmental settings in Scotland: island, rural, small town and urban (table 1).

<insert table 1 here>

Table 1 provides an overview of selected characteristics for each sentinel site, as well as showing the distribution of data zones by income quintile and area

type/sentinel site. Overall, deprivation is concentrated in the urban areas, although some of the most deprived data zones (in Q5) are located in Kilbirnie. The majority of data zones in rural areas were classified in one of the three least deprived quintiles (Q1-Q3). Island areas had a fairly even distribution of data zones between Q2-Q4, and the small town areas had similar numbers of data zones within each of the five quintiles. Within the four types of environment, the more deprived sentinels had relatively lower levels of household car ownership.

Census of food retail stores within study sites

In order to collect data on the availability of fresh fruit and vegetables we first required data on grocery store provision within the selected study sentinel sites. There is no single comprehensive directory of food stores and other outlets that sell food in Scotland thus data were combined from a variety of secondary sources. Data on the street address and postcode of grocery stores selling food for home consumption (excluding takeaway/fast-food and coffee shop outlets) were initially obtained from industry (Institute of Grocery Distribution) and commercial sources (Marketscan and Catalist). These data were supplemented using the company websites of the major Scottish multiple retailers (Tesco, Somerfield, Asda, Sainsbury and Morrisons), discounters (Aldi, Lidl) and freezer centres (Iceland, Farmfoods), online retail directories (Yell.com) and websites of symbol groups (Spar, Londis, Budgens, Costcutter). In addition, data from local authority registers (The Public Register of Food Premises) were also obtained. Data were combined, deduplicated and cleaned on the basis of matching address and postcodes. Postcode validity was ascertained by joining the retail data with Ordnance Survey Code-Point information and identifying which postcodes could not be grid-referenced.

In total, 466 unique retail facilities were identified including both permanent and mobile/non-permanent locations such as farmers' market stalls. Of these locations, 22 had a missing, incorrect or incomplete postcode. Postcode errors were resolved by using the Royal Mail online address/postcode checker(34) and electronic searches of company websites and directories for 13 of the 22 uncertain locations. The final dataset of geo-coded retail food sources for analysis included 98.1% (n=457) of the initially identified food retail facilities.

Data on availability of fresh fruit and vegetable within stores

Data on the availability (yes/no) of a range of fresh fruit and vegetables were obtained from instore visits by trained surveyors to all the identified food outlets in the food retail census during two periods October/November 2005 and February/March 2006. Information on the 12 fresh produce items were collected using the Healthy Eating Indicator Shopping Basket (HEISB) tool(35). Items included in this study were: apples, bananas, white grapes, oranges, potatoes, onions, carrots, broccoli, round lettuce, cucumbers, red peppers and tomatoes.

Calculating spatial accessibility

Travel time to the nearest store was calculated in ArcGIS 9.3 using the network analyst extension. Access is measured in travel time (minutes) by motorised transport between each origin (the population-weighted centroid of each of the 205 data zones in the study) and the closest store (based on x and y coordinates for that store). The use of a road-based network distance rather than straight-line distance between the centroids and stores is essential for obtaining the most realistic accurate

results.(36) The road network was represented by a hierarchy of road types which affected the speed of vehicle travel, with the largest roads (here, A-roads) being the fastest option.

Population-weighted centroids by datazone are not available for Scotland, so were created by identifying all of the output areas within a given data zone and obtaining the 'master postcode' (MPC) for each output area (the most populous postcode in that output area). The x and y coordinates of all the MPCs for every output area in each data zone was then obtained and the MPCs were weighted by their output area population. The MPC for the most populous output area within a data zone therefore has the highest weight. The mean of the x and y coordinates from all of the output areas within a data zone were then calculated - this is the population-weighted centroid for that datazone.

In a small number of cases (4.4%, n=12) the population-weighted centroids fell outside of data zone boundaries, because data zones were groups of islands or coastal areas surrounding an inlet or cove. In these instances, we moved each centroid to the MPC coordinates that were closest to the projected location. Following the initial analysis, 0.74% (n=2) of the origins failed to locate a store. We were able to manually locate a store for each of these two centroids and estimate the travel time along local roads within a distance of +/- 5 metres, giving us 100% coverage of all possible travel time observations.

Firstly, the shortest travel time from each population-weighted centroid to any store was identified. Secondly, in order to better understand community access to the

fresh fruit and vegetables, we measured vehicle travel time to the nearest store and nearest 'large' store that stocked any of the defined fresh produce. Travel times to 'large' stores were calculated as they offer the greatest choice and availability of fresh produce items(33). Large stores were defined as outlets with a floorspace in excess of 15,000 square feet. Finally, we calculated travel times to the nearest stores with three categories of availability for the 12 fresh produce items: 1-4 items only, 5-8 items only and 9-12 items only.

Analysis

In order to investigate whether travel times to each of the specified destinations varied by neighbourhood deprivation the 205 data zones within the sentinel sites were ranked and categorised into quintiles of income deprivation using the income domain of the 2006 SIMD. Travel times were not normally distributed and thus required the use of nonparametric tests to identify the magnitude of relationships between income deprivation and store accessibility by car. Fifteen origins in the island sentinel sites did not have road access to a large store selling produce. These centroids were excluded from the analysis. The median travel time to each store was calculated and Spearman's rank order correlations were undertaken to test whether associations between quintiles of neighbourhood deprivation and median travel time to stores existed. Travel times to the nearest stores with increasing availability of fresh fruit and vegetables (1-4 items; 5-8 items; 9-12 items) were also analysed in this way. Results are displayed with sentinel sites stratified into the four environmental settings: island, rural, small town and urban.

Results

Overall, median travel time to the nearest store ($p=0.001$), nearest store with fresh produce ($p<0.000$) and nearest large store with fresh produce ($p=0.056$) varied by neighbourhood deprivation. Travel times to stores were shorter in the most deprived (Q5) compared to least deprived (Q1) data zones (table 2). When comparing the travel times for the entire sample, the differences between income quintiles were small for any single type of store.

<insert table 2 here>

Stratified analyses (table 2) indicate that the above relationships hold true for urban settings, with median travel times to nearest store ($p=0.006$) and nearest store with produce ($p<0.000$) varying by neighbourhood deprivation. Residents of deprived urban neighbourhoods thus have better access to food stores and fresh produce than their more affluent counterparts. For rural settings the reverse is true. Median travel times to the nearest store and nearest store with fresh produce were longer in the more deprived compared to the least deprived neighbourhoods, with a correlation coefficient of 0.358 for large stores in rural settings ($p=0.035$). The median travel times to the nearest stores and the nearest stores with produce were greatest in the most affluent income quintiles in both island and small town settings. For all settings, large stores selling fresh produce were furthest away within each quintile of deprivation. Absolute differences in median travel times to large stores compared to nearest store and nearest small store selling fresh produce were substantial across quintiles of deprivation.

Median travel times to stores selling 1-4 ($p<0.000$) and 5-8 ($p<0.000$) fresh produce items varied by neighbourhood deprivation with travel times shorter in the most deprived compared to the least deprived neighbourhoods (table 3). This relationship, though in the same direction, was weaker for stores selling 9-12 fresh produce items ($p=0.488$). Shops selling 9-12 fresh produce items were closer than stores selling fewer fresh produce items in Q1 to Q3. Stores selling 5-8 items had the lowest travel times for Q4 and shops selling only 1-4 items had the lowest median travel times for Q5.

<insert table 3 here>

In island settings, median travel times to stores selling 5-8 items were greater in the least deprived compared to the most deprived neighbourhoods ($p=0.034$). For urban settings median travel times to all store categories were lower in the most deprived compared to the least deprived neighbourhoods (1-4, $p<0.000$; 5-8, $p=0.001$; 9-12, $p=0.155$). For rural settings, stores selling any number of fresh produce items were further away in the most deprived compared to least deprived neighbourhoods. Median travel times to rural stores selling 9-12 fresh produce items were more similar between income quintiles compared to other stores. Finally, residents of the most income deprived neighbourhoods in small town settings had a shorter journey to stores selling 5-8 produce items compared to their least deprived counterparts ($p=0.102$). Stores selling 9-12 items were closest in Q1 to Q3; stores selling 5-8 items were closest in Q4 and Q5.

In general, though patterns were clear at the extremes of income deprivation for both travel times to all grocery stores and travel times to stores selling fresh produce, the relationships outlined above were highly non-linear in nature.

Discussion

The results reported here demonstrate that in general, contrary to the 'deprivation amplification' hypothesis, residents of the most deprived neighbourhoods have shorter travel times to grocery stores than residents of the least deprived communities. However, stratifying this analysis by environmental setting suggests that this relationship may not necessarily be universally true, but depend on the type of environment under investigation.

In contrast to studies in North America which suggest that residents of deprived urban neighbourhoods are at a locational disadvantage(7, 17), here residents of the most deprived urban areas had shorter median travel times to the nearest grocery store compared to residents of the least deprived. In comparison to UK work, this study adds further weight to the suggestion that 'food deserts' may not exist in urban areas in the UK(19, 20, 37). However, poorer spatial accessibility to grocery stores in deprived neighbourhoods may well exist in island, rural and small town settings.

There has been no UK work directly comparing access to fresh fruit and vegetables across a range of environmental settings. In this study grocery stores selling fresh produce are closer to residents of the most deprived compared to the least deprived neighbourhoods for every 'availability' category. In urban settings, median travel times were significantly shorter for all availability categories compared to the least

deprived places but these findings are not supported by earlier work undertaken in the US(8) and Australia(28, 29) where no differences in neighbourhood densities of grocery stores selling fruit and vegetables were found. For each deprivation quintile stores selling the full range of fresh produce items are closer than those selling the least. For island, rural and small town settings the locational disadvantage was more mixed, though stores with the greatest availability were further away in the most deprived neighbourhoods in island and small town settings. Within deprivation quintiles, stores with the greatest number of available items were closer than stores with the fewest. Such patterns may reflect the differing social, economic and planning histories of those places as well as stage of economic development. As such, in order to have confidence in these findings, replication of results for island, rural and small town settings are required.

This study is limited in that, for practical reasons, a relatively small, but diverse, number of communities were sampled across Scotland. However, within each of those communities a census of stores was undertaken and all identified food stores surveyed. This is a major improvement on existing work which relies on geographically limited samples in one setting(8, 22, 38), although we were unable to sample stores outside of the study area to control for any boundary/edge effects. We also have no information on residents shopping behaviour which may condition the use of local shopping facilities. We also assume residents patronise the nearest store and proximity represents at least a measure of access. However other socio-relational and socio-economic factors may also be important such as; income, time, social meaning and acceptability, quality, transport cost and availability, and mobility (6, 39, 40). Finally, travel times were calculated via the road system. This assumes

that residents have access to motorised transport. However access to a car to shop varies by setting and by area deprivation (as illustrated by relatively low rates of household car ownership in Scotstoun/Drumchapel), increasing travel times and thus reducing relative access for those groups without cars. Public transport is a more realistic option for car-less residents in the urban areas, however, the lack of access to a car for shopping could greatly increase the travel times to shops in the more sparsely populated areas where public transport options may be limited. However a recent study in the Western Isles found that 91.4% of respondents used a car to access food stores despite car-ownership limited to 75% in the same group(41). This indicates that use of motorised transport in such settings is almost universal. Although walking times were not calculated for this analysis, the drive times provided give a good indication of relative accessibility between area types and income deprivation quintiles, which is the primary objective of this paper.

Although every effort was made to ensure a diverse sample of data zones within each type of area, nearly all of the most deprived data zones (Q5) were located in urban areas. This is representative of the Scottish social context, where the greatest levels of income deprivation are concentrated in urban areas with greater affluence in less populated regions (42).

Despite these limitations the data presented here suggest that even though the most disadvantaged urban neighbourhoods have better access to stores selling a range of fresh produce, residents of deprived neighbourhoods in rural and remote areas may face problems accessing fresh fruit and vegetables. Current policy initiatives such as the new 'Healthy Start' welfare foods scheme(43) provide vouchers which can only

be used for fresh, rather than canned, frozen and dried, fruits and vegetable underlining the importance of good access to these commodities for the poorest families. In Scotland policies and interventions targeted at more rural and remote communities may help reduce spatial inequalities in diet and diet-related chronic diseases.

Funding

This work was supported by the Food Standards Agency (Scotland) as part of the project '*Assessing Healthy Food: A National Assessment and Sentinel Mapping Study of Food Retailing in Scotland*' (Grant Ref: S04005). DS is supported by the award of Philip Leverhulme Prize to SC. SC is also supported by a National Institute of Health Research Fellowship.

References

1. Black JL, Macinko J. Neighborhoods and obesity. *Nutrition Reviews* 2008;**66**(1): 2-20.
2. Anderson A, Hunt K. Who are the healthy eaters? Eating patterns and health promotion in the West of Scotland. *Health Education Journal* 1992;**51** (1): 3-10.
3. Forsyth A MS, Anderson A. Diets for disease? Intraurban variation in reported food consumption in Glasgow. *Appetite*. 1994:259-74.
4. Shohaimi S, Welch A, Bingham S, et al. Residential area deprivation predicts fruit and vegetable consumption independently of individual educational level and occupational social class: a cross sectional population study in the Norfolk cohort of the European Prospective Investigation into Cancer (EPIC-Norfolk). *J Epidemiol Community Health* 2004 August 1, 2004;**58**(8): 686-91.
5. Cummins S, Macintyre S. Food environments and obesity--neighbourhood or nation? *International Journal of Epidemiology* 2006;**35**: 100-4.
6. Macintyre S. Deprivation amplification revisited; or, is it always true that poorer places have poorer access to resources for healthy diets and physical activity? *International Journal of Behavioral Nutrition and Physical Activity* 2007 Aug;**4**.
7. Zenk SN, Schulz AJ, Israel BA, James SA, Bao SM, Wilson ML. Neighborhood racial composition, neighborhood poverty, and the spatial accessibility of supermarkets in metropolitan Detroit. *American Journal of Public Health* 2005 Apr;**95**(4): 660-7.
8. Zenk SN, Schulz AJ, Israel BA, James SA, Bao SM, Wilson ML. Fruit and vegetable access differs by community racial composition and socioeconomic position in Detroit, Michigan. *Ethnicity & Disease* 2006 Win;**16**(1): 275-80.
9. Morland K, Wing S, Roux AD, Poole C. Neighborhood characteristics associated with the location of food stores and food service places. *American Journal of Preventive Medicine* 2002;**22**(1): 23-9.
10. Morland K, Filomena S. Disparities in the availability of fruits and vegetables between racially segregated urban neighbourhoods. *Public Health Nutrition* 2007 Dec;**10**(12): 1481-9.

11. Laraia BA, Siega-Riz AM, Kaufman JS, Jones SJ. Proximity of supermarkets is positively associated with diet quality index for pregnancy. *Preventive Medicine* 2004 Nov;**39**(5): 869-75.
12. Moore LV, Roux AVD, Nettleton JA, Jacobs DR. Associations of the local food environment with diet quality - A comparison of assessments based on surveys and geographic information systems. *American Journal of Epidemiology* 2008 Apr;**167**(8): 917-24.
13. Rose D, Richards R. Food store access and household fruit and vegetable use among participants in the US Food Stamp Program. *Public Health Nutrition* 2004 Dec;**7**(8): 1081-8.
14. Morland K, Wing S, Diez-Roux A. The Contextual Effect of the Local Food Environment on Residents' Diet: The Atherosclerosis Risk in Communities Study. *American Journal of Public Health* 2002;**92**(11): 1761-7.
15. Zenk SN, Schulz AJ, Hollis-Neely T, et al. Fruit and vegetable intake in African Americans - Income and store characteristics. *American Journal of Preventive Medicine* 2005 Jul;**29**(1): 1-9.
16. Lane SD, Keefe RH, Rubinstein R, et al. Structural violence, urban retail food markets, and low birth weight. *Health & Place* 2008;**14**(3): 415-23.
17. Vojnovic I, Jackson-Elmoore C, Holtrop J, Bruch S. The renewed interest in urban form and public health: Promoting increased physical activity in Michigan. *Cities* 2006 2006/2;**23**(1): 1-17.
18. White M. Food access and obesity. *Obesity Reviews* 2007;**8**: 99-107.
19. Pearson T, Russell J, Campbell MJ, Barker ME. Do 'food deserts' influence fruit and vegetable consumption?--a cross-sectional study. *Appetite* 2005;**45**: 195-97.
20. Cummins S, Macintyre S. A systematic study of an urban foodscape: The price and availability of food in Greater Glasgow. *Urban Studies* 2002 Oct;**39**(11): 2115-30.

21. Clarke G, Eyre H, Guy C. Deriving indicators of access to food retail provision in British cities: Studies of Cardiff, Leeds and Bradford. *Urban Studies* 2002 Oct;**39**(11): 2041-60.
22. Guy CM, David G. Measuring physical access to 'healthy foods' in areas of social deprivation: a case study in Cardiff. *International Journal of Consumer Studies* 2004;**28**(3): 222-34.
23. Dibsall LA, Lambert N, Bobbin RF, Frewer LJ. Low-income consumers' attitudes and behaviour towards access, availability and motivation to eat fruit and vegetables. *Public Health Nutrition* 2003 Apr;**6**(2): 159-68.
24. Whelan A, Wrigley N, Warm D, Cannings E. Life in a 'food desert'. *Urban Studies* 2002 Oct;**39**(11): 2083-100.
25. Wrigley N, Warm D, Margetts B. Deprivation, diet, and food-retail access: findings from the Leeds 'food deserts' study. *Environment and Planning A* 2003;**35**: 151-88.
26. Cummins S, Petticrew M, Higgins C, Findlay A, Sparks L. Large scale food retailing as an intervention for diet and health: quasi-experimental evaluation of a natural experiment. *Journal of Epidemiology and Community Health* 2005 Dec;**59**(12): 1035-40.
27. Cummins S, Findlay A, Higgins C, Petticrew M, Sparks L, Thomson H. Reducing inequalities in health and diet: findings from a study on the impact of a food retail development. *Environment and Planning A* 2008 Feb;**40**(2): 402-22.
28. Winkler E, Turrell G, Patterson C. Does living in a disadvantaged area entail limited opportunities to purchase fresh fruit and vegetables in terms of price, availability, and variety? Findings from the Brisbane Food Study. *Health & Place* 2006 Dec;**12**(4): 741-8.
29. Winkler E, Turrell G, Patterson C. Does living in a disadvantaged area mean fewer opportunities to purchase fresh fruit and vegetables in the area? Findings from the Brisbane food study. *Health & Place* 2006 Sep;**12**(3): 306-19.
30. Pearce J, Witten K, Hiscock R, Blakely T. Are socially disadvantaged neighbourhoods deprived of health-related community resources? *International Journal of Epidemiology* 2007 Apr;**36**(2): 348-55.

31. Pearce J, Hiscock R, Blakely T, Witten K. The contextual effects of neighbourhood access to supermarkets and convenience stores on individual fruit and vegetable consumption. *Journal of Epidemiology and Community Health* 2008 Mar;**62**(3): 198-201.
32. Dawson J, Marshall D, Taylor M, Cummins S, Sparks L. *Assessing healthy food: A sentinel mapping study of healthy food retailing in Scotland, Executive Summary*. Food Standards Agency Scotland,; 2007.
33. The Scottish Government. *Scottish Index of Multiple Deprivation 2006*: Statistics; 2006.
34. Mail R. *Royal Mail Postcode Checker*. [cited 2008 August 8th]; <http://www.royalmail.com/portal/rm>. Available from:
35. Anderson AS, Dewar J, Marshall D, et al. The development of a healthy eating indicator shopping basket tool (HEISB) for use in food access studies - identification of key food items. *Public Health Nutrition* 2007 Dec;**10**(12): 1440-7.
36. Witten K, Exeter D, Field A. The Quality of Urban Environments: Mapping Variation in Access to Community Resources. *Urban Studies* 2003;**40**(1): 161/77.
37. Cummins S, Macintyre S. "Food deserts" - evidence and assumption in health policy making. *British Medical Journal* 2002 Aug;**325**(7361): 436-8.
38. Macintyre S, Maciver S, Sooman A. Area, class and health: should we be focusing on places or people? *Journal of Social Policy* 1993;**22**: 213-34.
39. Cummins S. Neighbourhood food environment and diet - Time for improved conceptual models? *Preventive Medicine* 2007 Mar;**44**(3): 196-7.
40. Cummins S, Curtis S, Diez-Roux AV, Macintyre S. Understanding and representing 'place' in health research: A relational approach. *Social Science & Medicine* 2007 Nov;**65**(9): 1825-38.
41. Nisbet L, Marshall D. Retail provision and store choice in remote island communities. *Academy of Marketing Annual Conference*. Aberdeen, July 2008.
42. McLoone P, Boddy FA. Deprivation and mortality in Scotland, 1981 and 1991. *BMJ* 1994;**309**(6967): 1465-70.

43. Healthy Start [cited 2008 August 8th 2008] Available from:
<http://www.healthystart.nhs.uk/>

Table 1 Descriptive table of sentinel sites

Sentinel site	Population (2004)	% of households with no car (2001)	<i>n</i> data zones	Distribution of data zones by 2006 income quintile*				
				Q1	Q2	Q3	Q4	Q5
Island mixed/deprived: Eilean Siar	18,683	30.2	25	0	3	12	10	0
Island mixed: Orkney	12,365	20.5	17	5	10	2	0	0
Rural affluent: Haddington	20,816	19.2	26	9	9	7	1	0
Rural deprived: Dornoch	6,679	20.7	9	0	4	3	2	0
Small town deprived: Kilbirnie	13,223	30.4	17	3	3	2	5	4
Small town affluent: Ellon & Cupar	7,622	22.2	10	4	2	3	1	0
Urban affluent: Broughty Ferry	13,535	26.8	17	8	3	3	1	2
Urban deprived: Scotstoun/Drumchapel	41,992	53.9	51	2	2	5	12	30
Urban mixed: Inverness	25,748	33.1	33	10	5	4	9	5

*1=least deprived; 5=most deprived

Table 2 Relationship between SEUR category, neighbourhood income deprivation and median travel time to nearest store

SEUR Category	Store Type (<i>n</i> data zones)	Median Travel Time (Minutes)	Median Travel Time (Minutes) By 2006 Income Quintile*					Spearman's Rank	
		Median (95% CI)	Q1	Q2	Q3	Q4	Q5	<i>P</i>	<i>p</i>
All	Nearest store (205)	7.7 (6.9-9.0)	11.7	9.0	5.8	7.7	6.4	-0.237	0.001
	Nearest store with produce (205)	9.0 (7.6-10.4)	14.3	10.4	6.6	10.2	7.5	-0.271	<0.000
	Nearest large store with produce (187)	37.7(32.1-40.8)	48.3	43.4	37.3	39.6	37.2	-0.140	0.056
Island	Nearest store (42)	11.8 (8.5-15.8)	19.1	10.4	7.7	16.8	N/A	0.019	0.905
	Nearest store with produce (42)	12.9 (8.6-17.8)	34.5	10.4	7.9	16.8	N/A	-0.027	0.867
	Nearest large store with produce (27)	32.1 (14.1-62.9)	91.7	45.7	20.3	100.7	N/A	0.063	0.753
Rural	Nearest store (35)	7.7 (3.8-9.6)	9.0	7.4	5.6	26.4	N/A	-0.050	0.774
	Nearest store with produce (35)	9.0 (6.1-12.3)	9.4	11.9	6.8	26.4	N/A	-0.072	0.682
	Nearest large store with produce (34)	45.3 (24.9-56.1)	53.1	59.0	67.4	182.1	N/A	0.358	0.035
Small Town	Nearest store (27)	9.0 (6.9-11.6)	14.1	9.0	5.8	8.9	10.1	-0.184	0.359
	Nearest store with produce (27)	9.2 (7.0-14.2)	14.2	10.8	5.8	10.1	10.1	-0.183	0.361
	Nearest large store with produce (27)	51.1 (37.0-63.3)	20.9	26.3	13.7	22.0	30.5	0.121	0.546
Urban	Nearest store (101)	6.4 (4.8-7.7)	9.8	8.2	5.6	5.5	5.1	-0.270	0.006
	Nearest store with produce (101)	7.7 (6.4-9.9)	15.2	9.9	6.4	6.8	6.5	-0.355	<0.000
	Nearest large store with produce (99)	33.3 (29.6-39.1)	51.6	29.3	26.3	31.3	37.2	-0.141	0.165

*1=least deprived; 5=most deprived

Table 3 Relationship between SEUR category, neighbourhood income deprivation and median travel time to nearest store selling a specified number of fresh fruit and vegetable items

SEUR Category	Number of Fruit and Vegetable Items (<i>n</i> data zones)	Median Travel Time (Minutes)	Median Travel Time (Minutes) By 2006 Income Quintile [*]					Spearman's Rank	
		Median (95% CI)	Q1	Q2	Q3	Q4	Q5	<i>P</i>	<i>p</i>
All	1-4 items (192)	23.0 (19.4-26.8)	27.4	35.7	21.2	24.9	11.3	-0.287	<0.000
	5-8 items (187)	18.0 (15.3-20.6)	23.9	21.1	21.9	15.7	13.2	-0.298	<0.000
	9-12 items (198)	15.7 (13.5-18.2)	20.1	13.8	7.7	18.3	15.3	-0.05	0.488
Island	1-4 items (31)	47.9 (23.0-79.1)	57.3	51.1	24.9	83.4	N/A	0.018	0.925
	5-8 items (33)	21.6 (14.0-28.8)	57.1	24.0	15.2	16.8	N/A	-0.371	0.034
	9-12 items (37)	15.6 (9.8-27.3)	58.3	10.1	9.0	30.8	N/A	0.048	0.778
Rural	1-4 items (34)	30.7 (19.4-49.6)	27.5	41.1	21.2	62.4	N/A	-0.028	0.873
	5-8 items (34)	32.7 (14.6-39.5)	14.3	24.8	37.8	48.6	N/A	0.284	0.184
	9-12 items (34)	13.0 (9.0-16.2)	13.0	13.3	8.7	20.1	N/A	-0.122	0.492
Small Town	1-4 items (27)	22.2 (11.3-36.1)	19.1	35.0	35.7	52.5	43.5	0.124	0.583
	5-8 items (21)	20.8 (12.6-40.5)	38.1	27.6	37.6	18.7	14.9	-0.367	0.102
	9-12 items (27)	14.8 (8.3-21.7)	14.2	24.3	7.1	21.4	18.2	0.049	0.809
Urban	1-4 items (100)	19.0 (14.8-23.2)	27.2	28.5	10.7	20.0	11.1	-0.383	<0.000
	5-8 items (99)	14.8 (12.2-17.2)	22.4	13.2	19.7	14.0	13.2	-0.317	0.001
	9-12 items (100)	17.7 (13.7-20.0)	21.2	23.2	8.9	17.2	14.6	-0.143	0.155

*1=least deprived; 5=most deprived