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Food outlet availability, deprivation and obesity in a multi-ethnic sample of pregnant women in Bradford, UK

L.K. Fraser [a,*], K.L. Edwards [b], M. Tominitz [a], G.P. Clarke [a], A.J. Hill [c]

[a] School of Geography, University of Leeds, United Kingdom
[b] School of Clinical Sciences, University of Nottingham, United Kingdom
[c] Institute of Health Sciences, University of Leeds, United Kingdom

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ABSTRACT

The obesogenic environment model would suggest that increased availability or access to energy dense foods which are high in saturated fat may be related to obesity. The association between food outlet location, deprivation, weight status and ethnicity was analysed using individual level data on a sample of 1198 pregnant women in the UK Born in Bradford cohort using geographic information systems (GIS) methodology. In the non South Asian group 24% were obese as were 17% of the South Asian group (BMI > 30). Food outlet identification methods revealed 886 outlets that were allocated into 5 categories of food shops. More than 95% of all participants lived within 500 m of a fast food outlet. Women in higher areas of deprivation had greater access to fast food outlets and to other forms of food shops. Contrary to hypotheses, there was a negative association between BMI and fast food outlet density in close (250 m) proximity in the South Asian group. Overall, these women had greater access to all food stores including fast food outlets compared to the non South Asian group. The stronger association between area level deprivation and fast food density than with area level deprivation and obesity argues for more detailed accounts of the obesogenic environment that include measures of individual behaviour.

Introduction

The conceptualisation of an obesogenic environment has changed the way that obesity is viewed and is key to national policy documents to address obesity e.g. (Foresight, 2007). The obesogenic environment model operates on several levels and describes the changes in daily living, transport, and access to recreational facilities, foods and food outlets that have contributed to positive energy balance and weight gain. In this vein, the food industry has come under scrutiny, especially in the ways that fast food is marketed and made available to children and families. A number of US studies have shown that older children who consume greater quantities of fast food are heavier and have greater total energy intakes (Bowman, Gortmaker, Ebbeling, Pereira, & Ludwig, 2004; Foresight, 2007; Niemeier, Raynor, Lloyd-Richardson, Rogers, & Wing, 2006; Taveras et al., 2005). Similarly, there is longitudinal evidence that increases in fast food consumption are associated with increased weight gain from adolescence to adulthood (Pereira et al., 2005).

It follows that the availability of, or access to food may be related to obesity. This could be via proximity to multiple fast food outlets or the way that people shop at large out of town supermarkets and stockpile food at home may relate to eating habits and obesity. However, supportive evidence is far from compelling even though there has been increasing attention to the location of food outlets, especially those selling fast foods. Evaluations of the relationship between location of fast food outlets and weight status has yielded positive associations (more fast food outlets associated with increased BMI/obesity) in 3 studies (Davis & Carpenter, 2009; Jeffery, Baxter, McGuire, & Linde, 2006; Mehta & Chang, 2008), negative associations in 2 studies (more fast food outlets associated with decreased BMI/obesity) (Morland & Evenson, 2009; Pearce, Hiscock, Blakely, & Witten, 2009), and no association in 4 studies (Burdette & Whitaker, 2004; Casey et al., 2008; Rundle et al., 2009; Wang, Cubbin, Ahn, & Winkleby, 2008). Furthermore, studies that have assessed fast food outlet location and its relationship to fast food and other food consumption have also shown conflicting results (Davis & Carpenter, 2009; Jeffery et al., 2006; Morland & Evenson, 2009; Pearce et al., 2009; Simmons et al., 2005).

In contrast, the relationship between fast food outlet density and deprivation is much clearer. Research from the UK, US and New Zealand has shown higher numbers of fast food outlets in areas of high

* Corresponding author. Room G02, East Building, School of Geography, University of Leeds, Leeds LS2 9JT, United Kingdom.
E-mail address: l.k.fraser@leeds.ac.uk (L.K. Fraser).

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deprivation (Block, Scribner, & DeSalvo, 2004; Burns & Inglis, 2007; Cummins, McKay, & MacIntyre, 2005; Fraser & Edwards, 2010; Lewis et al., 2005; Macdonald, Cummins, & Macintyre, 2007; Morland, Wing, Roux, & Poole, 2002; Pearce, Blakely, Witten, & Bartie, 2007; Powell, Chaloupka, & Bao, 2007; Reidpath, Burns, Garrad, Mahoney, & Townsend, 2004; Simon, Kwan, Angelescu, Shih, & Fielding, 2008; Smoyer-Tomic et al., 2008; Zenk & Powell, 2008). Likewise, there is good and longstanding evidence of a relationship between obesity and socioeconomic status, especially in women (Sobal & Stunkard, 1989). Recent consideration of English population data confirms that for women obesity prevalence increases with increasing levels of deprivation, regardless of the way deprivation is measured, and that prevalence of obesity for women in unskilled occupations is twice that of those in professional occupations (NOO, 2010).

There has been relatively little attention paid to whether access to, and the consumption of, fast food are related to ethnicity, outside the US at least, and how this is related to obesity. US studies show, for example, higher intakes of fast foods in non-Hispanic black youth (Bowman et al., 2004), but a recent review of ethnic disparities in obesity risk found no studies in the UK which had assessed predictors of obesity in ethnic subgroups (El-Sayed, Scarborough, & Galea, 2011). This is important information for the UK for two reasons. First, South Asians are at higher risk than the white population for obesity development and associated co-morbidities such as coronary heart disease and type 2 diabetes (Misra & Khurana, 2011). Recognising this, lower cut-offs for obesity and abdominal obesity have been proposed for South Asians but without consensus as to exactly what these cut-offs should be. Second, Asian and Asian British are the largest non-white ethnic group in the UK, comprising 4% of the total UK population in the last national census (Census, 2001). Originating mainly from India, Pakistan, and Bangladesh they are concentrated in large urban areas in the UK. Bradford, in the north of England, is typical with South Asians making some 19% of its city population. Many are of Pakistani/Kashmiri origin and are over-represented in poorer inner city areas associated with social and physical deprivation.

We have reported elsewhere on the relationship between fast food outlet geography, deprivation and obesity in children (Fraser & Edwards, 2010). Analysis within another large city in the north of England showed a significant positive correlation between fast food outlet density and deprivation. In addition, fast food outlet density was associated with child obesity even when controlling for deprivation. However, there was no association between distance to the nearest fast food outlet and child obesity. Given the inconsistent results for the existing adult studies of fast food outlet location and obesity (as described above), one of the aims of the present study was to investigate these relationships in a sample of adult women. A further study aim therefore was to investigate the relationships between food outlet access, deprivation and obesity in South Asian and white women and explore any differences between these two groups. This was conducted via a newly recruited birth cohort: the Born in Bradford study (BiB, 2006). Although these participants were pregnant at the time of recruitment their booking weight is a reasonable proxy for pre-pregnancy weight and booking visits normally occur around 12 weeks of gestation in the UK.

Methodologically, studies in this area are challenging. Many rely on telephone interviews and weight is rarely directly measured, often relying on self-report. In addition, the range of food outlets investigated rarely goes beyond the most popular fast food companies and actual food consumption is often not measured. Measuring access to food outlets is also difficult but developments in geographic information systems (GIS) and linkage with population data have permitted developments in spatial analyses.

This study aimed to measure access to all food outlets in part of a northern UK city and investigate the relationship with body weight, obesity, and small area based deprivation in a multi-ethnic sample of adult women using geographic information systems (GIS) methodology. It was hypothesised that food outlet availability would be related to deprivation and availability would be greater for South Asian participants. In addition, those women who have greater access to food outlets, especially those selling fast foods, would be more likely to be obese.

Methods

Study area

The study area was five contiguous inner city wards in Bradford Metropolitan District Council in the UK. These wards were chosen because they had a range of ethnic population mix (1.2%–63.8% South Asian). There are 8850 wards in total in England and Wales. The population in these wards in Bradford varied from 14,000 to 16,000 (Census, 2001). Although this area in Bradford is predominantly deprived, there is a range of less deprived to very deprived areas within the study area (IMD score range 5.8–75.7)(IMD, 2007). A radius of one ward in each direction was included in order to minimise edge effects in the analysis (see Fig. 1).

Food outlet identification

Food outlet details were obtained from two sources; the Bradford Metropolitan District Council's list of food outlets for health and hygiene purposes (e.g. for licenses/inspections; (Council)) and the Bradford Yellow Pages (index of local businesses). The printed copy of the yellow pages was used as the online version did not contain postcodes. Previous research has shown that using an amalgamation of sources yields a more complete picture when building a GIS model (Pearce et al., 2009).

The accuracy of the data collection was validated by physical 'groundtruthing' a sample of the study area. A random selection of output areas (OAs)(see Data analysis section) were visited to ascertain whether the expected number of food outlets was the same as the actual number; that is, to ensure both that a food outlet existed where the list expected one, and whether there were any additional food outlets over and above what was expected. In order to ascertain the minimum number of OAs to visit to ensure accuracy of over 90% a sample size calculation (Bland, 2000) was undertaken (significance of 0.05). To account for the clustering this sample size was multiplied by the design effect (see below). A sample size of 90 OAs was determined.

$$n = \frac{f(\alpha, P)(\rho 1(1-\rho 1)) + (\rho 2(1-\rho 2))}{(\rho 1 - \rho 2)^2}$$

n = sample size
$\rho 2$ = proportion in total
α = significance level
P = power

$$\text{DEFF} = \frac{a + \dfrac{b}{m}}{a + b}$$

DEFF = design effect
a = variance between clusters
b = variance within clusters.

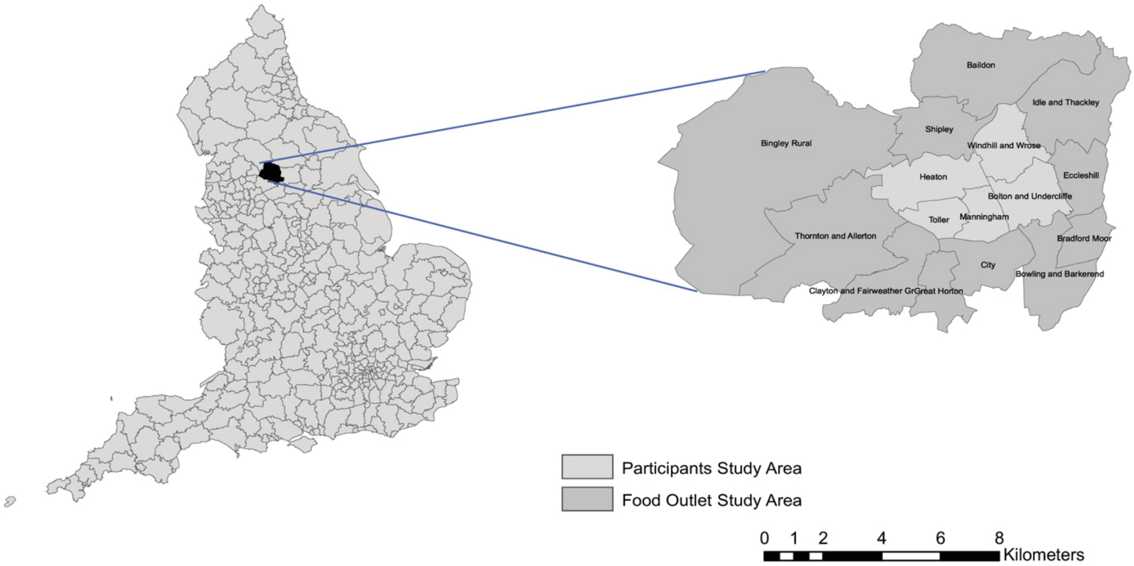

Fig. 1. Bradford study area.

In total, 1271 food outlets were identified in the food outlet study area. There were 819 OAs in the study area which were stratified by deprivation quintile (each OA was linked to their Index of Multiple Deprivation (IMD, 2007) score and then all 819 OAs were ranked and 5 equal quintiles produced). Of these, 90 OAs (15 per quintile) were randomly selected to determine which OAs would be visited. Randomisation was achieved using a random number generator.

In the 90 OAs visited, 148 food outlets were expected and 136 of the expected food outlets were present (i.e. twelve missing). Of these 136, twelve had a new name (but were still trading in the same Food Standards Agency (FSA) category). There were 14 extra outlets (10 in the ground-truthed area and 4 other outlets which were missing from original dataset). This gave an accuracy of 98.6%. The database was updated with the results of the ground-truthing which resulted in 1273 outlets, 15 of which were removed as they were wholesalers, leaving 1258 outlets. Other outlets whose primary function was not to sell food were removed from the database for analysis (e.g. canteens, pubs). Pubs were removed as it was difficult to determine which of these premises sold food so this may have underestimated food access for the non South Asian population (South Asian women are less likely to use pubs). This resulted in 886 outlets in the final database.

Food outlets were manually re-categorised for mapping and analysis using a combination of the FSA category, outlet name and local knowledge. This resulted in 22 categories which were reduced for analysis into the five categories shown in Fig. 2. The food outlets that sold meals were classified as fast food or 'other eating out'. The other food outlets were separated into supermarkets, specialist food shops which sold a particular food group (e.g. butcher or baker) and retail shops which were smaller shops selling food e.g. convenience stores. The number of food outlets in each category

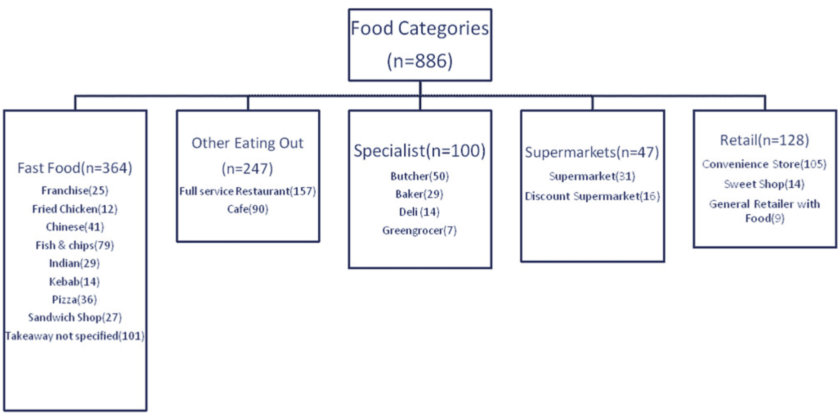

Fig. 2. Food outlet categories for analyses.

was: fast food 364, other restaurants/cafes 246, specialist 100, supermarkets 47 and retail shops 128.

Individual level participant data

Individual data were from participants in the Born in Bradford Study (BiB, 2006). This is a birth cohort that has recruited 13,000 children born in Bradford, UK between 2007 and 2010. The cohort recruited pregnant mothers at 28 weeks of pregnancy. At the time of analysis data were available on a sub-cohort of 1485 women who lived in the study area. These data included age, ethnicity, height, weight at booking of pregnancy and weight at 28 weeks of pregnancy. Booking weight was available for 1198 women who formed the sample for analyses.

Ethnic group was recoded into a binary variable where participants were coded as South Asian or non-South Asian (876 and 322 women respectively). The non South Asian group consisted of 269 (84%) participants who self categorised as white, 27 (8%) other ethnicity, 15 (5%) mixed group, 6 (2%) black and 5 (1%) not known. This allowed for ethnic specific weight status algorithms to be used. Weight at first ante-natal clinic visit (Booking weight) was used as an indicator of pre-pregnancy weight. This weight, along with height, was used to calculate Body Mass Index (BMI) at booking. The BMI was used as a continuous outcome variable and to classify participants as obese or not. The standard BMI > 30 was used for all participants but for the South Asian participants ethnic specific BMI cutoffs were also used to classify the participants as obese or not, recalculating obesity using BMI > 25 (Misra et al., 2009; Who, 2004) in separate analyses. The result tables are all reported for BMI > 30 for both ethnic groups, but any differences in results when using the ethnic specific cut-offs are highlighted in the text. Ethical approval was obtained from the Bradford Research Ethics Committee (Ref 07/H1302/112).

Data analyses

The centroid of the postcode for each food outlet was converted to XY coordinates (using ArcGIS v9.3) in order to allocate each outlet to a Census Output Area (OA) and lower Super Output Area (SOA). These are census geographical areas: an OA contains on average 125 households and SOAs consist of 4–6 OAs. An SOA of residence was assigned to each participant (via postcode of residence) which allowed an Index of Multiple Deprivation code for the area (IMD, 2007) to be assigned to each individual as a proxy for individual level deprivation. Area based measures of deprivation have been shown to show similar associations with health outcomes to individual level measures of deprivation (Smith, Hart, Watt, Hole, & Hawthorne, 1998).

Four measures of food access were used. Firstly, the distance to the nearest food outlet (proximity) in each category for each participant was calculated using ArcGIS v9.3. This allowed for food outlets outside the SOA of residence to be included in the analysis. The distance calculated was straight line (Euclidian) distance. The second method used in the proximity analysis was the number of outlets within each food outlet category in a 250 m, 500 m and 1000 m radius of the individual's residential postcode. This was achieved by the use of buffers in ArcGIS v9.3. Third, the number (density) of food outlets of each category in each SOA was calculated by mapping these outlets (ArcGIS v9.3). Each individual participant was assigned a density number for each category based upon their SOA of residence. Finally, the presence of multiple fast food outlets has been shown to be associated with obesity (Thornton, Bentley, & Kavanagh, 2009). Therefore, further analyses of the fast food outlets were undertaken where clusters of fast food outlets within the study area were identified. A cluster was defined as postcode areas in which there were 3 or more fast food outlets. Buffers of 250, 500 m and 1000 m of these clusters were created and the proportion of individuals and their obesity status within these buffers were calculated for both ethnic groups.

The statistical analyses were performed at the individual level to avoid the ecological fallacy (where area level results are attributed to individuals but the relationships do not hold at the individual level). First, univariable generalised estimating equation (GEE) models with booking BMI as the outcome and maternal age, deprivation score, food access measure as the independent variables were undertaken for both ethnic groups. Note, these models were run for each of the four different food access measures described above. Next, the independent variables that were significant in the univariable analyses were combined in the multivariable analyses in a forced entry method. Then the univariable generalised estimating equation (GEE) models were repeated but with obesity status as the outcome. Again, the independent variables that were significant in the univariable analyses were combined in the multivariable analyses in a forced entry method. GEE accounts for clustering at SOA level and produces population averaged (marginal) results. All statistical analysis were performed using STATA 10 and statistical significance was set at $p < 0.05$.

Results

In the non-South Asian group, 24% ($n = 78$) were obese and in the South Asian dataset 17% ($n = 149$) were obese (cut off BMI > 25: 46% ($n = 401$) obese; cut-off BMI > 27.5: 29% ($n = 254$) obese). Overall the South Asian group were significantly older (27.7 years vs 26.6 years, $p = 0.001$), had a lower mean BMI (25.3 vs 26.2, $p = 0.02$) and lived in more deprived areas (mean IMD, 2007 49.2 vs 34.5, $p < 0.001$). There was no significant association between deprivation score and BMI in either ethnic group.

Food outlet availability and deprivation

Table 1 shows the correlation coefficients between the level of deprivation (IMD) and the number of food outlets in each category. There were significant positive correlations between deprivation and the number of food outlets of all types and within each buffer distance measure (thus higher deprivation was associated with a higher density of food outlets). There were also significant negative associations between deprivation and the distance from each individual's residence to the nearest outlet in each category of food outlet (thus higher deprivation was associated with living closer to all types of food outlets).

Food access and ethnicity

Table 2 describes the first three food access measures (i.e. the proximity measures and density measure) in the two stratified datasets. The South Asian group had significantly more food outlets in all categories within 250 m, 500 m and 1000 m of residence and also significantly higher food outlet density in the SOA of residence. In addition, the mean distances to all food outlets were smaller for the South Asian group.

Fast food outlet clusters

There were 7 clusters of fast food outlets identified within the study area: 6 clusters had 3 outlets per postcode; one cluster had 4 outlets per postcode; none had more than four. Table 3 shows that as the distance from a cluster of high density fast food (FF) outlets increased the proportion of the South Asian group who were obese

Table 1
Correlation between deprivation and food access.

Type of food outlet	Distance from residence to nearest outlet (m)	Correlation coefficients (IMD score)[a]			
		Number within 250 m of residence	Number within 500 m of residence	Number within 1000 m of residence	Density: number of outlets per SOA
FastFood	−0.38	0.25	0.63	0.72	0.37
Other Restaurant	−0.41	0.42	0.50	0.64	0.24
Retail	−0.44	0.36	0.60	0.76	0.36
Specialist	−0.44	0.25	0.54	0.73	0.30
Supermarket	−0.47	0.13	0.38	0.61	0.34

[a] All correlation coefficients $p < 0.001$.

decreased from 19.2% within 250 m of these clusters to 16.0%/16.5% within 750 m/1000 m of these clusters but these differences were not statistically significant ($\chi^2 = 0.11$, $p = 0.73$). A similar trend was seen in the non South Asian group. The highest proportion of obese (24.4%) was found for populations living within 250 m of a FF cluster and the lowest proportion (22.8%) for those within 1000 m; but this was not a linear trend and again this difference is not statistically significant ($\chi^2 = 0.10$, $p = 0.93$).

Predictors of BMI

In the univariable analyses (data available as on online Appendix A) for the non South Asian group, maternal age had the strongest significant association with BMI in this group with BMI increasing by 0.16 units for every year increase in age. Deprivation was not significantly associated with BMI. There were three food access measures with borderline significance: the number of specialist food shops per SOA, the number of specialist food shops within 500 m of the participant's residence, and the number of retail shops within 250 m of the participant's residence. All these food access measures were negatively associated with BMI. The multivariable GEE models with booking BMI as the dependent variable for both groups are shown in Table 4 (including maternal age, deprivation and food access measures which were significant from the univariable analyses).

In the multivariable models which adjusted for age and deprivation score, the number of specialist food shops per SOA was significantly and negatively associated with BMI i.e. one more specialist food shop per SOA was associated with a decrease of 0.75 BMI units (model a). A similar association was shown for the number of 'retail shops' selling food per SOA (model b).

In the univariable analyses (data available as on online Appendix A) for the South Asian Group, maternal age had the strongest significant association with BMI, with BMI increasing by 0.31 units for every year increase in age. Deprivation was not significantly associated with BMI. There were three food access measures which were significantly associated with BMI: the number of other restaurants per SOA, the number of FF outlets within 250 m of the participant's residence, and the distance to the nearest FF outlet from the participant's residence. The number of 'other restaurants' was negatively associated with BMI, i.e. having an increase in 'other restaurants' was associated with a decreased BMI. The number of FF outlets within 250 m of the participants residence was however also negatively associated with BMI, i.e. more FF outlets was associated with a decreased BMI. This was confirmed with the positive association between the distance to the nearest FF outlet and BMI i.e. the further the participant lived from a FF outlet the higher their BMI.

In the multivariable models for the South Asian group, again adjusting for age and deprivation score, the number of fast food outlets within 250 m of the participant's residence was significantly negatively associated with BMI i.e. one fast food outlet within 250 m of participant's residence was associated with a decrease of 0.18 BMI units (model c). A similar association was shown for the number of retail shops within 250 m of the participants residence (model d) and the significant association with between the distance from residence to the nearest fast food outlet and BMI remained i.e. the further the participant lived from a FF outlet the higher their BMI (model e).

Predictors of obesity

In the univariable analyses (data available as on online Appendix A) for the non South Asian group age and deprivation were not significantly associated with obesity. The number of retail shops and the number of specialist shops per SOA were borderline significantly associated with obesity (negative association).

The multivariable GEE models with obesity status as the dependent variable for both groups are shown in Table 5.

For the non South Asian group (adjusting for age and deprivation), the presence of one more specialist food shop per SOA was associated with a 50% (95%CI: 7–73%) reduction in odds of being

Table 2
Food access measures stratified by ethnic group.

	Distance from residence to nearest outlet(m)		Number within 250 m of residence		Number within 500 m of residence		Number within 1000 m of residence		Density: number of outlets per SOA	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
South Asian (n = 876)										
FastFood	223	151	2.1	2.2	7.3	4.1	24.6	10.9	2.4	2.8
Other Restaurant	283	154	0.8	1.0	3.0	2.8	11.9	9.2	1.3	3.3
Retail	258	196	1.2	1.3	4.0	3.2	12.3	7.0	1.1	1.3
Specialist	294	209	0.9	1.1	3.1	2.5	9.4	5.8	0.9	1.7
Supermarket	675	415	0.2	0.6	0.8	1.1	3.1	2.7	0.3	1.0
Non South Asian (n = 322)										
FastFood	225	138	1.6	1.9	5	3.6	17.5	8.8	2.1	2.0
Other Restaurant	484	304	0.3	0.7	1.3	1.7	7.2	7.5	0.6	1.8
Retail	383	250	0.5	0.7	1.6	1.8	5.7	4.7	0.9	0.9
Specialist	600	336	0.2	0.5	0.7	1.26	2.9	4.1	0.3	0.9
Supermarket	901	367	0.04	0.2	0.2	0.6	1.3	1.7	0.1	0.4

Table 3
Obesity and proximity to a high density cluster of fast food outlets.

Distance from residence to fast food outlet cluster[a]	Asian			Non South Asian		
	Number of participants	Number obese	Percentage obese	Number of participants	Number obese	Percentage obese
250 m	73	14	19.2	45	11	24.4
500 m	245	42	17.1	123	27	21.9
750 m	425	68	16.0	199	47	23.6
1000 m	630	104	16.5	250	57	22.8
Total	876	149	17.0	322	78	24.2

[a] Fast food outlet cluster: 3 or more outlets per postcode ($n = 7$).

obese (model f). Having one more retail shop per SOA was associated with a 31% (95%CI: 4–49%) reduction in the odds of being obese (model g). In both these models increased deprivation was significantly associated with being obese.

In the South Asian group, the presence of one more fast food outlet within the SOA of participant's residence was associated with a 6% (95%CI: 2–13%) less chance of being obese (model i). A similar but stronger effect size was shown with an increase of one supermarket within the SOA of participant's residence was associated with a 9% (95%CI: 3–33%) less chance of being obese (model j). A similar association was shown with the presence of a supermarket within 250 m of residence (model k).

When the South Asian group were analysed using the BMI cut-offs of >25 and >27.5 for obesity the results showed (data available as on online Appendix A): for the cut-off BMI > 25, the presence of one more fast food outlet within 250 m of participant's residence was associated with a 6% (95%CI: 1–11%) less chance of being obese. A similar but stronger effect size was shown with an increase of one other restaurant within 250 m of participant's residence being associated with a 16% (95%CI: 4–27%) less chance of being obese.

For the cut-off BMI > 27.5, the presence of one more fast food outlet within 250 m of participant's residence was associated with a 9% (95%CI: 1–117%) less chance of being obese. The presence of one more fast food outlet within the SOA of participant's residence was associated with a 7% (95%CI: 1–13%) less chance of being obese. Due to the relationship between deprivation and food outlet access (Table 2) interaction terms between all food access measures and deprivation were included in the initial multivariable models but were not significant so were removed from the final models.

Discussion

As hypothesised, this study has shown that food outlet availability differs by deprivation and ethnicity. However, the relationship between food outlet access and obesity was in the opposite direction to that hypothesised, although there was some evidence of a relationship between obesity and proximity to clusters of fast food outlets. In addition, there were differences in the associations between food outlet availability and obesity in the two ethnic groups.

The lack of association in either ethnic group between deprivation and BMI or obesity in the majority of the models was unexpected. Within the South Asian participants area level deprivation scores may not be as useful as individual level variables. Individual level variables such as household income were collected in the BiB dataset but had large amounts of missing data, especially within the South Asian group, so could not be used. In the non South Asian group the sample size was small ($n = 322$) and so may have been underpowered to detect a significant effect of deprivation, should one exist. Although area based deprivation measures show similar associations with health outcomes sometimes they can underestimate relationships compared to individual level deprivation measures (Krieger, 1992).

Individuals in higher areas of deprivation had greater access to fast food outlets and to other forms of food shops. The relationship between deprivation and fast food outlets is similar to previous work in the UK (Cummins et al., 2005; Fraser & Edwards, 2010; Macdonald et al., 2007), New Zealand (Pearce et al., 2007) and the US (Block et al., 2004; Morland et al., 2002; Pearce et al., 2007;

Table 4
Multivariable generalised estimating equation models (Gaussian) predicting BMI (**non South Asian $n = 322$**: model a. Wald chi^2 = 15.0, $p = 0.002$, model b. Wald chi^2 = 14.9, $p = 0.002$; **South Asian $n = 876$**: model c. Wald chi^2 = 87.1, $p < 0.001$, model d. Wald chi^2 = 66.8, $p < 0.001$, model e. Wald chi^2 = 66.3, $p < 0.001$).

	β coefficient	95% confidence interval		p-value
Non South Asian				
Model a				
Deprivation	0.02	−0.01	0.05	0.16
Number of specialist food outlets per SOA	−0.75	−1.41	−0.09	0.03
Age	0.17	0.06	0.28	0.003
Model b				
Deprivation	0.02	−0.01	0.05	0.14
Number of retail outlets per SOA	−0.67	−1.32	−0.03	0.04
Age	0.17	0.06	0.28	0.002
South Asian				
Model c				
Deprivation	0.02	−0.03	0.04	0.11
Number of fast food outlets within 250 m of residence	−0.18	−0.33	−0.02	0.03
Age	0.32	0.24	0.39	<0.001
Model d				
Deprivation	0.03	0.004	0.04	0.01
Number of retail outlets within 250 m of residence	−0.30	−0.54	−0.05	0.02
Age	0.32	0.24	0.39	<0.001
Model e				
Deprivation	0.02	−0.003	0.04	0.08
Distance from residence to nearest fast food outlet	0.68	0.10	1.27	0.02
Age	0.31	0.24	0.39	<0.001

Table 5
Multivariable generalised estimating equation (Logistic) models predicting obesity status (**non South Asian $n = 322$**: model f. Wald chi$^2 = 8.9$, $p = 0.03$, model g. Wald chi$^2 = 7.9$, $p = 0.04$, model h. Wald chi$^2 = 10.9$, $p = 0.01$; **South Asian $n = 876$**: model i. Wald chi$^2 = 37.9$, $p < 0.001$, model j. Wald chi$^2 = 44.6$, $p < 0.001$, model k. Wald chi$^2 = 40.9$, $p < 0.001$).

	Odds ratio	95% Confidence Interval		*p*-value
Non South Asian				
Model f				
Deprivation	1.01	0.99	1.03	0.05
Number of specialist food outlets per SOA	0.50	0.27	0.93	0.03
Age	1.03	0.98	1.08	0.19
Model g				
Deprivation	1.01	1.00	1.03	0.05
Number of retail outlets within SOA	0.69	0.51	0.96	0.02
Age	1.04	0.99	1.09	0.13
Model h				
Deprivation	1.01	0.99	1.02	0.12
Number of supermarkets per SOA	0.60	0.47	0.84	0.003
Age	1.04	0.99	1.09	0.12
South Asian				
Model i				
Deprivation	1.01	0.99	1.02	0.09
Number of fast food outlets per SOA	0.93	0.87	0.98	0.01
Age	1.10	1.06	1.15	<0.001
Model j				
Deprivation	1.01	0.99	1.02	0.11
Number of supermarkets per SOA	0.81	0.67	0.97	0.03
Age	1.10	1.06	1.15	<0.001
Model k				
Deprivation	1.01	0.99	1.02	0.19
Number of supermarkets within 250 m of residence	0.76	0.57	1.00	0.05
Age	1.10	1.06	1.15	<0.001

Reidpath et al., 2004; Zenk & Powell, 2008). Interestingly, the greater access to food shops in general is contrary to previous work on ‘food deserts’ (Wrigley, 2002) where areas of higher deprivation were shown to have poorer access to food shops especially those selling ‘healthier’ foods.

The relationship between fast food outlet access (number within 250 m of residence) and BMI in the South Asian group was in the opposite direction to that hypothesised. Namely, there was a negative association between BMI and fast food outlet density in close (250 m) proximity. This relationship was also seen for obesity status i.e. more fast food outlets within the SOA of the residence being associated with a lower likelihood of being obese. This could be an example of increased access not necessarily being related to increased consumption i.e. living next to a fast food outlet does not mean that a participant eats in that outlet. Unfortunately there was no fast food consumption data available for this cohort. This South Asian group also showed a negative association between the number of supermarkets and likelihood of obesity. Since the foods available for purchase tend to be more extensive and offer a wider variety of foods, the option of healthier alternatives is possible. Again however no consumption data were available for these participants. The use of BMI as an outcome measure may also explain some of these null findings. It has been shown in South Asian adults that waist-to-height ratios or measures of body fat such as DEXA scanning correlate better with adverse health outcomes related to obesity (e.g. hypertension)(El-Sayed et al., 2011).

Analysis of data from the non South Asian group revealed no significant association between BMI or obesity and access to fast food outlets or other restaurants. The observed significant association in this group was access to specialist food shops (butchers, delis, greengrocers). The presence of one more specialist food shops within the SOA of residence was associated with a lower BMI and a 50% less chance of being obese. Specialist food shops, as defined in this study, generally offer the option of healthy foods such as fruit and vegetables, making this association plausible. Interestingly, the relationship with the number of retail shops per SOA was similar in this group. Retail shops include convenience stores which sell less healthy foods but often also offer healthier alternatives.

The direct comparison of the ethnic groups in terms of food outlet access was unable to account for differences in purchasing behaviours between the two ethnic groups. There is no current literature from the UK describing whether the South Asian population in the UK frequent fast food outlets and restaurants in similar patterns to the White population. A proportion of the participants were first generation migrants to the UK and may not have developed western shopping and eating out practices. Again, food consumption information may have been helpful to assess this.

In this dataset more than 95% of the participants lived within 500 m of a fast food outlet so it is perhaps not surprising that the expected direction of association was not seen in the analyses. This degree of saturation has not been demonstrated previously but may be characteristic of inner cities currently in the UK. The relationships between proximity to the largest cluster of fast food outlets and the proportion of each group who were obese was in line with expectations. This analysis did describe the hypothesised association with the highest proportion obese in both groups living within 250 m of a cluster of fast food outlets. It should be noted that previous work from Australia has also shown a positive association between obesity and the presence of/access to more than one fast food chain (Thornton et al., 2009).

This study has strengths and limitations. It was a cross sectional study so no causal inference can be made. There is also no food consumption data available and previous research has shown mixed results on the relationship between increased access to fast food outlets and fast food consumption (Pearce et al., 2009; Thornton et al., 2009). The booking BMI was only available for 81% of the participants. Booking weight is a reasonable proxy for pre-pregnancy weight and booking visits normally occur around 12 weeks of gestation in the UK. However, there may be some participants who were seen for booking visits later in pregnancy and this may differ by ethnicity. In addition, there were several measures of access used in this study including number of outlets per SOA which are subject to artificial boundary effects i.e. ignores the density in adjacent SOAs, and food outlets in these areas are possibly closer/easier to access. We did use buffers around residences and had sampled our food outlets from extra wards surrounding the study area to prevent the edge effects. Using Euclidian distance to measure access to nearest outlet is not ideal as this does not take into account street (network) distance and barriers to access e.g. rivers (Clarke, Eyre, & Guy, 2002). In addition, there are many other potential confounding factors in the relationship between food access and obesity including physical activity levels, access to car(s) and food costs that have not been adjusted for in these analyses due to lack of available data. This study was only of pregnant women and these findings may not be relevant to the male population especially within the South Asian population where the male role in society differs greatly from the female. The use of area based deprivation measures rather than individual deprivation measures may have underestimated associations between deprivation and weight status in this dataset.

As far as we are aware at the time of writing, this study is the first to address possible ethnic differences in these issues in the UK. The debate over South Asian specific obesity cut-offs is ongoing (Misra et al., 2009; Who, 2004). It is of note that the results of the food outlet analyses did differ when the different BMI cut-offs for obesity in the South Asian group were used (e.g. one extra fast food outlet was associated with a 6% less chance of being obese using the standard BMI cut-off (BMI > 30) but this changed to a 7% less chance of being obese when a lower cut-off was used (BMI > 25)). Importantly the direction of associations did not change. There is also debate over the use of BMI as a predictor of the consequences of obesity within the South Asian population and whether other measures such as body fat and waist to height ratio are more useful predictors. Waist measurements in pregnancy are not useful and body fat data was not collected in the mothers in the BiB cohort.

In conclusion, this study has highlighted the degree of exposure to food outlets, especially fast food outlets, within the city of Bradford and especially within a sub-group of the South Asian community. This is strongly linked with measured deprivation. Accordingly, it is an important factor for planning authorities to assess when applications for further food outlets are made. In Los Angeles there has been a recent ban on the opening of new fast food outlets in the most deprived areas. Further research is required to incorporate other constituents of the obesogenic environment such as transport and green spaces to assess the interplay between individuals and their environment. In addition, these types of analyses would benefit from the inclusion of measures of purchasing behaviour and activity level.

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Appendix A. Supporting information

Supplementary information associated with this article can be found, in the online version, at doi:10.1016/j.socscimed.2012.04.041.

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