Is ethnic density associated with health in a context of social disadvantage? Findings from the Born in Bradford cohort.

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Abstract

Objectives

In this study we aimed to test the associations between area-level ethnic density and health for Pakistani and White British residents of Bradford, England.

Design

The sample consisted of 8610 mothers and infant taking part in the Born in Bradford cohort. Ethnic density was measured as the percentage of Pakistani, White British or South Asian residents living in a Lower Super Output Area. Health outcomes included birth weight, preterm birth and smoking during pregnancy. Associations between ethnic density and health were tested in multilevel regression models, adjusted for individual covariates and area deprivation.

Results

In the Pakistani sample, higher ethnic density was associated with lower birth weight (b -0.82, 95% CI -1.63; -0.02), and higher South Asian density was associated with a lower probability of smoking during pregnancy (OR 0.99, 95% CI 0.98; 1.00). Pakistani women in areas with 50-70% South Asian residents were less likely to smoke than those living in areas with less than 10% South Asian residents (OR 0.39, 95% CI 0.16;0.97). In the White British sample, neither birth weight nor preterm birth was associated with ethnic density. The probability of smoking during pregnancy was lower in areas with 10-29.99% compared to < 10% South Asian density (OR 0.79, 95% CI 0.64; 0.98).

Conclusion

In this sample, ethnic density was associated with lower odds of smoking during pregnancy but not with higher birth weight or lower odds of preterm birth. Possibly, high levels of social disadvantage inhibit positive effects of ethnic density on health.

Key words: ethnic density, birth weight, preterm birth, smoking during pregnancy, multilevel, England, Pakistani, deprivation.

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Introduction

The first comprehensive documentation of ethnic inequalities in health in Britain was based on the Fourth National Survey of Ethnic Minorities in 1997 (Modood and Berthoud 1997). The survey revealed that ethnic minority groups with the lowest socioeconomic status (SES) had the worst health status, and Pakistani and Bangladeshi people reported the highest prevalences of cardiovascular disease, diabetes, mental illness and poor self-rated health (Nazroo 1997). The most affluent groups on the other hand, including White British, Chinese and Indian respondents, scored highest across a range of health outcomes. These findings were confirmed in the 1999 Health Survey, with a risk of illness around three to four times higher for Pakistani and Bangladeshi people than for the general population, and a risk of diabetes five times higher than average (NCSR 1999). The relatively poor health status of ethnic minorities in Britain is now a well documented phenomenon, as are higher rates of illness in ethnic minority groups across the world (Atkin 2009).

Ethnic minorities generally fare worse than average in terms of health and well-being, but there are examples of ethnic groups being healthier than expected based on their demographics and socially disadvantaged position, such as the Hispanic paradox in the USA (Abraído-Lanza, Chao, and Florez 2005; Markides and Coreil 1986). One explanation is that social capital and strong community bonds reduce stress, provide social and tangible support, and promote healthy behaviour in Hispanic communities (Pickett and Wilkinson 2008). The Hispanic paradox prompts the ethnic density hypothesis, which states that individuals living in areas with more people of their own ethnic group enjoy better health than those in less ‘ethnically dense’ areas. Apart from the benefits of social support, areas with high ethnic density may provide a shield against discrimination and stigmatization, increasing people's perception of safety (Whitley et al. 2006; Pickett and Wilkinson 2008). This in combination with increased levels of social capital could give residents a sense of belonging that they lack in relation to the wider society. Services may be more appropriately designed and facilities more suited to the needs of a specific ethnic group in areas where they have clustered for some time (Whitley et al. 2006). While certain health effects may apply to ethnic minority groups only, such as protection against discrimination, other effects may 'spill over' to other groups, such as the impact of social norms regarding health related behaviour. For example, a recent study showed that White and African American mothers in areas with more Hispanic residents had lower rates of smoking and a reduced risk of infant mortality (Shaw and Pickett 2013).

Evidence on the ethnic density hypothesis

Two systematic reviews have been published on ethnic density. One looks at physical health (Bécares, Shaw, et al. 2012) and one at mental health (Shaw et al. 2012), and both studies report mixed findings. They vary depending on the ethnic group studied, the area level measure used, the included health outcomes, and research settings. The evidence is strongest for there being an impact on health behaviours and mental health (Bell et al. 2007; Shaw, Pickett, and Wilkinson 2010; Bécares, Nazroo, and Stafford 2011), while results for birth outcomes and self-rated health are inconsistent (Bécares, Nazroo, et al. 2012; Astell-Burt et al. 2012; Sturm and Gresenz 2002; Masi et al. 2007; Mason et al. 2010; Walton 2009; Asher et al. 2012; Jenny, Schoendorf, and Parker 2001). The only UK study on birth outcomes and ethnic density so far found no associations between ethnic density and birth weight, but preterm delivery was less likely for Pakistani mothers living in areas with 5 to 30% ethnic density as compared to mothers living in areas with 0 to 5% ethnic density (Pickett et al.

2009). This study was limited by low ethnic density levels for most ethnic groups and small sample sizes.

Disentangling compositional and contextual factors

The lack of conclusive evidence on the ethnic density hypothesis can partly be attributed to underpowered analyses, lack of variation in ethnic density levels within study samples, the use of different ‘area’ measures and the inclusion of covariates on the basis of availability rather than theory (Riva, Gauvin, and Barnett 2007; Halpern 1993). However, arguably the most important and often ignored methodological issue in these multilevel studies is the strong association between ethnic density and other contextual and compositional neighbourhood factors. Most studies have not considered ethnic density in the context of social disadvantage, but rather have considered it as a separate area characteristic acting independently of other individual and contextual factors (Halpern 1993).

Qualitative research suggests that the neighbourhood social network is not just an added bonus, but is a necessity to cope with the negative influences of social disadvantage (Campbell and McLean 2003; Whitley et al. 2006). While some research concludes that social capital can act as a buffer for social disadvantage in minority groups (Pearson and Geronimus 2011; Van Der Wel 2007; Bohn and Richter 2011), other studies show that social capital does not provide health benefits in the context of poverty (Gorman and Sivaganesan 2007; Beaudoin 2009). The latter argument is consistent with sociological theories on the interdependency of social, economic (income, assets) and cultural (education, skills, knowledge) capital that suggest a compounding effect of disadvantage rather than the amelioration of one disadvantage by the positive effect of another (Bourdieu 1986). There have been persuasive arguments for the incorporation of these approaches into research on social and ethnic inequalities in health (Carpiano 2007; Stephens 2008). The unique setting of our study illustrates the importance of putting ethnic density research in context.

Aim and hypotheses

The aim of our study is to provide evidence on the associations between ethnic density and health in a sample of White British and Pakistani residents of Bradford Metropolitan District. Birth weight and preterm birth were selected as health outcomes, because of the gaps in the literature on the associations between birth outcomes and ethnic density, and because lower birth weight and preterm birth are related to adverse perinatal outcomes, in addition to a number of chronic diseases of adulthood, including cardiovascular disease and type 2 diabetes (Moster, Lie, and Markestad 2008; Johnson and Schoeni 2011; Hack, Klein, and Taylor 1995). Smoking during pregnancy was included because it is a health behaviour that is much more prevalent and more accepted among White British than Pakistani women, and therefore likely to be influenced by interactions with neighbours of other ethnic groups and social norms in a neighbourhood.

We explore these associations by testing the following three hypotheses:

1) For Pakistani residents, higher ethnic density is associated with higher birth weight and lower rates of preterm birth.

2) For White British residents, higher ethnic density is not associated with higher birth weight and lower rates of preterm birth.

3) For Pakistani and White British residents, higher South Asian density is associated with lower odds of smoking during pregnancy.

Methods

Research setting

Bradford is a city in the North of England with a population of over half a million (ONS 2012a). At the time of the census of 2011, 64% of the population in Bradford classified themselves as White British and 20% as Pakistani, with percentages of Pakistani ethnic density up to 85% in the inner city areas (ONS 2012a). The city is characterized by social inequalities, and its 'segregation along ethnic and social lines' has been named as a cause of social unrest and riots in the past (Ouseley 2001). Bradford ranks as the 26th most deprived out of 326 local authorities using the Index of Multiple Deprivation (IMD) 2010. The city received the fifth and sixth worst ranking, respectively, for income and employment (ONS 2011). Given Bradford's wide range in the percentage of residents from Pakistani origin across neighbourhoods and the marked social inequalities within Bradford Metropolitan District (Figure 1a, 1b), this setting offers a unique perspective to research on ethnic density effects in the context of social disadvantage. Although the district is deprived overall, with many LSOAs falling within the 20% most deprived in the country, areas with high White British density outside the city centre are more affluent (Figure 1a, 1b).

[Insert Figure 1a and 1b]

Data and study sample

Bradford scores below the national average on most health indicators, and on infant mortality in particular (Small 2012). Infant mortality in the district was 7.9 per 1000 for the period January 2008-December 2010, compared to a national average of 4.6 per 1000, and life expectancy is lower for both males and females (ONS 2012b). Born in Bradford (BiB) is a longitudinal multi-ethnic birth cohort study aiming to examine the impact of environmental, psychological and genetic factors on maternal and child health and wellbeing. The eligible study population consists of all women who give birth at the Royal Infirmary in Bradford, which is the single maternity unit for this region (Figure 2). Mothers were only excluded if they planned to move away from Bradford before the end of their pregnancy (Raynor 2008). Women were invited to participate when they attended the clinic for an oral glucose tolerance test, which is offered to all women between 26 and 28 weeks gestation. The full cohort BiB cohort includes 13 776 pregnancies of 12 453 women, between March 2007 and December 2010 (Figure 2). A detailed protocol for the recruitment phase and the cohort profile have been published (Raynor 2008; Wright et al. 2013). Ethnical approval for the data collection was granted by Bradford Research Ethnics Committee (Ref 07/H1302/112).

Observations excluded from the analyses presented here are multiparous births, stillbirths, second or third pregnancies within the cohort, families living outside Bradford, or cases for which individual-level and area-level data could not be merged (Figure 2) (Wright et al. 2013). Only Pakistani and White British infants were selected for the analyses, as other ethnic minority groups were much smaller and did not have a similar distribution of ethnic density ranging from very low to very high. For the analysis of birth weight, only term babies were considered, to distinguish between low birth weight due to premature birth and small for gestational age. Table 1 gives a description of the study sample by ethnic group.

[Insert Figure 2]

Health outcomes

Birth weight was measured in grams and rounded at 10 grams, and preterm birth was defined as being born before 37 completed weeks of pregnancy. Smoking during pregnancy is a binary variable (yes/no) derived from questions on ‘ever smoked’, current smoking status (at baseline), smoking during the first three months of pregnancy and smoking since the fourth month of pregnancy.

Ethnic density

The term ethnic density in this paper refers to the density of the same ethnic group, unless stated otherwise. Ethnic density is measured as both a categorical and continuous variable, because any effects of ethnic density effect are not necessarily linear and reliance on the categorical variable only may introduce bias (Bennette and Vickers 2012; Royston, Altman, and Sauerbrei 2006). The categorical variable for the Pakistani sample consists of five roughly equal categories: < 35% Pakistani residents, 35-49.99% Pakistani residents, 50-59.99% Pakistani residents, 60-70% Pakistani residents and > 70% Pakistani residents. For the White British group, ethnic density is also analysed in five categories with approximately even numbers: <55% White British residents, 55-74.99%, 75-84.99%, 85-90% and >90%. Given the low prevalence of smoking in Pakistani, Bangladeshi and Indian women, it is hypothesized that regardless of the specific ethnic group, South Asian density could lower the odds of smoking during pregnancy in areas with high density. A measure of South Asian density was therefore used in relation to smoking during pregnancy. The five categories of roughly equal numbers are as follows: < 10%, 10-29.99%, 30-49.99%, 50-70%, and > 70% South Asian residents, which include Pakistani, Bangladeshi and Indian residents.

Covariates

Covariates used in the statistical models were maternal height, parity, sex of the baby, cohabitation status, country of birth, consanguinity (parents are related, for example cousins), measures of SES (maternal education, employment status of the father, receiving means-tested benefits, and self-reported financial situation), and area deprivation (IMD 2010) (Table 1) (Badshah et al. 2008; Shami et al. 1991; Margetts et al. 2002; Pearl, Braveman, and

Abrams 2001; Pattenden, Dolk, and Vrijheid 1999). To avoid 'mathematical coupling' between the health domain of the IMD and health outcomes, this domain was removed from the index (Adams and White 2006).

Statistical analysis

All regression analyses were performed with Stata 12 (StataCorp 2011). Area-level variation was tested in empty models at the level of Middle Super Output Areas (MSOAs) and Lower Super Output Areas (LSOAs). Developed by the Office of National Statistics, MSOAs have a population between 5000 and 15000, and LSOAs fall within MSOAs and have a population of 1000 to 3000 (ONS 2012c). LSOAs were chosen for this study as they showed more area-level variation.

Area deprivation and ethnic density were correlated, with a correlation coefficient of 0.502 ($p<0.0001$) in the Pakistani sample and a coefficient of -0.301 ($p<0.0001$) in the White British sample. As multicollinearity may affect the reliability of the results, ethnic density and area deprivation were first explored separately in two random intercepts multilevel models, and then both included in the final model. For example, the equations for the final models that estimate health outcomes in the Pakistani sample are as follows:

birth weight = b_{0j} + b_1*maternal height + b_2*consanguinity + b_3*country of birth + b_4*parity + b_5*sex baby + b_6*cohabitation b_7*time at address + b_8*maternal education + b_9*deprivation + b_{10}*ethnic density + ε_{ij}

logit (probability of preterm birth) = b_{0j} + b_1*maternal age + b_2*maternal height + b_3*consanguinity +b_4*country of birth + b_5*parity + b_6*financial situation + b_7*deprivation + b_8*ethnic density + ε_{ij}

logit (probability of smoking) = b_{0j} + b_1*consanguinity +b_2*country of birth + b_3*parity + b_4*cohabitation + b_5*time at address + b_6*maternal education + b_7*financial situation + b_8*deprivation + b_9*ethnic density + ε_{ij}

In these models, b is the coefficient, b0 the intercept of the coefficient, b0j the random intercept, i is the individual, C stands for city, j is level 2 (LSOA), and ε is the residual error.

Geographic maps were constructed with ArcGIS^{TM}.

Results

The sample consists of 4561 Pakistani infants living in 182 LSOAs and 4049 White British infants spread out over 246 LSOAs (Table 1).

[Insert Table 1]

Pakistani women and infants

Pakistani women from the Born in Bradford sample living in areas with > 70% Pakistani are younger than average (t-test p=0.008), whereas Pakistani women in areas with < 35% ethnic density are older than average (t-test p=0.047). Higher ethnic density is associated with a longer period of time lived at the address (linear regression, p for trend < 0.0001), being less likely to be born in England (linear regression, p<0.0001), and more likely to be in a consanguineous marriage (linear regression, p<0.0001) (Table 2). In accordance with higher levels of area deprivation in higher density areas (linear regression, p for trend < 0.0001), the lowest average educational level is found in areas with 50-59.99% and areas with more than 70% Pakistani density (Pearson's chi square p<0.0001).

[Insert Table 2]

In the full model with ethnic density as a continuous variable, higher birth weight was associated with lower ethnic density (b -0.82, 95% CI -1.63; -0.02) and higher area deprivation (b 3.91, 95% CI 0.71; 7.11). When ethnic density was modelled as a categorical variable the association between ethnic density and birth weight was not statistically significant, but higher deprivation remained associated with higher birth weight (Table 3).

The highest category of ethnic density was associated with higher odds of preterm birth (b 1.66, 95% CI 1.06; 2.62), but this effect disappeared after taking into account area deprivation (Table 3).

[Insert Table 3]

Lower South Asian density was associated with a higher probability of smoking during pregnancy for Pakistani women if ethnic density was measured as a continuous variable (OR 0.99, 95% CI 0.98; 1.00, p=0.042). When ethnic density was measured as a categorical variable, areas with 50-70% South Asian residents had lower odds of smoking than areas with less than 10% South Asian residents (Table 4). The full model was a better fit than the model with ethnic density as the only area-level variable (LR chi square 23.68, p<0.0001), but not a better fit than the model with only area deprivation (LR chi square 6.35, p=0.174).

[Insert Table 4]

White British women and infants

Table 5 shows the main contextual and composition factors by ethnic density area category for White British women. Women were on average older if they were living in areas with higher levels of ethnic density (linear regression, p for trend < 0.0001), they were more likely to live with the father of the baby (linear regression, p for trend < 0.0001), less likely to receive benefits (Pearson's chi square p<0.0001), and on average these women had higher levels of education (Pearson's chi square p<0.0001).

[Insert Table 5]

In comparison with Pakistani babies, measures of SES had a bigger influence on birth outcomes for White British babies. Based on the model adjusted for confounders, it is estimated that babies born in a household receiving means-tested benefits with an educational level of the mother lower than 5 GCSE have an average birth weight of 3315 grams (95% CI 3274; 3355), compared to an average birth weight of 3499 grams (95% CI 3459; 3538) for White British babies born to mothers not receiving means-tested benefits with an educational level higher than A-levels.

There was no association between higher ethnic density and higher birth weight after the introduction of area deprivation (p=0.077) in the model (Table 6). Preterm birth was not associated ethnic density, or with area deprivation (p=0.074). The probability of smoking during pregnancy was lower in areas with 10-29.99% compared to < 10% South Asian density (p=0.030), while area deprivation was associated with increased odds of smoking (p<0.0001) (Table 7). However, when ethnic density was modelled as a continuous variable there was no evidence of a relationship (p=0.911).

[Insert Table 6]

[Insert Table 7]

Discussion

Key findings

The literature on ethnic density and birth outcomes shows some evidence of an association between better health and higher ethnic density for ethnic minorities (Shaw and Pickett 2013; Shaw, Pickett, and Wilkinson 2010; Walton 2009; Pickett et al. 2009; Jenny, Schoendorf, and Parker 2001). Relationships with birth outcomes have predominantly been found for US Hispanics, and Pakistani, Bangladeshi and Indian groups in the UK, but not for Black American, UK Black Caribbean and UK Black African groups. In this sample of Pakistani and White British women, associations between birth outcomes and ethnic density could not be demonstrated. Ethnic density in this sample seems to be an indicator of social disadvantage. This is confirmed by the strong correlation between ethnic density and area deprivation, and by the initial associations between minority ethnic density and poor health that disappeared once area deprivation was accounted for. In their study, Bell and colleagues (2007) attributed the lack of protective ethnic density effects in very high density areas to a higher level of deprivation. Even though our models were tested for the risk of bias caused by multicollinearity, which was found to be small (VIF < 2 for each of the variables) (O'brien 2007), areas with high levels of South Asian density were more deprived than the average deprivation level in Bradford, and much more deprived than the average for England. Social and tangible support from social networks in ethnically dense areas may not counteract the detrimental impact of social disadvantage on health outcomes in the most deprived areas. The unexpected positive association between area deprivation and birth weight for Pakistani infants suggests that this association is confounded by other factors, or that the measure used does not capture area deprivation accurately for Pakistani residents. The latter was confirmed in a latent class analysis of BiB data on socioeconomic status, which showed that Pakistani families were more likely than White British families to fall into a category of those who have a high uptake of means-tested benefits, but who are not materially deprived (Fairley et al. 2014).

South Asian density was found to be associated with lower odds of smoking during pregnancy in the White British and Pakistani group, which confirms our hypothesis and is in line with results from a recent US study (Shaw and Pickett 2013). However, no linear effect was found in the White British group, and there was no evidence for a difference in the odds of smoking between areas with the lowest and highest levels of South Asian density. A lower SES was associated with higher odds of smoking in both Pakistani and White British women, indicating that social disadvantage may inhibit the positive influence of social norms and support on health behaviour.

Strengths and limitations

A number of methodological issues limiting previous research on ethnic density effects were successfully addressed in this study. The sample was sufficiently large to model multifactorial multilevel relationships, covariates were identified from the literature and tested in individual models, levels of Pakistani ethnic density covered a broad range, the area level used in the analysis was determined based on the assessment of area-level variance, and the fact that data was collected from a single city allowed for a better understanding of the context of the research. However, this study was still affected by limitations that are often encountered in ethnic density research.

Firstly, although LSOAs showed more area-level variance than MSOAs in the multilevel analyses, these areas are determined by administrative boundaries rather than residents' perception of communities. Secondly, self-selection of residents into neighbourhoods was the reason for a careful consideration of the differences between residents in areas of varying ethnic density. However, without information on the exact motives behind residential choices, we could not adjust for self-selection in the analyses. Residents live in a certain area not just because they are attracted to the characteristics of the neighbourhood (Oakes 2004), but also because they are restricted by the means at their disposal and availability of appropriate housing. In the creation of areas with high minority ethnic density, there is an interaction between positive choices by residents, constraints imposed by outside agents, and supply side considerations like provision of certain sorts of housing stock by local and national policies. People who choose not to live in areas with a high percentage of their own ethnic group may have more financial flexibility to choose more expensive housing, they may be people who feel that ethnicity plays only a minor role in their identity, or they may not have a sense that neighbours are key for providing them with social support (Shon 2010).

Furthermore, this study made use of cross-sectional data only, and therefore does not take into account the length of exposure to area-level determinants of health. Mohnen et al. (2012) reported that especially for household with young children, the association between self-rated health and neighbourhood social capital grew stronger with longer duration of residence. In the case of our study, birth outcomes may be impacted by a long duration of residence in a neighbourhood, but for new residents it is more likely that low birth weight and preterm birth are influenced by psychosocial factors, health behaviour and environmental factors of their previous place of residence. To capture this longitudinal effect to some extent the measure 'duration of residence' was included in the analyses. In this study we found no evidence of an interaction between duration of residence in a neighbourhood and the effect of ethnic density on health.

Finally, although the BiB sample has been found to be representative of the maternal population of Bradford, results may not be generalizable to other populations and settings (Wright et al. 2013). The spatial patterning in Bradford according to SES and ethnicity is unique in the UK. Especially the ethnic composition of the city centre is different from other cities in England. In the Born in Bradford sample, only 4% of the Pakistani mothers live in LSOAs with less than 10% Pakistani residents. Or the Pakistani sample, 63% live in areas where they are in the majority, and 88% live in areas where there are more ethnic minorities than White British residents. Protective effects of ethnic density have previously been reported to show a non-linear pattern, and may exist for medium levels of ethnic density only (Shaw, Pickett, and Wilkinson 2010). Mechanisms of social support, cohesion and a shelter from discrimination might not be beneficial to health in areas where minority ethnic density and area deprivation are very high. If this is the case, our sample is not suitable for the detection of ethnic density effects. However, we did use continuous and categorical measures of ethnic density, and we tested for non-linear associations with ethnic density, which did not alter findings.

Recommendations for future research

Given the complicated associations between health, social disadvantage and ethnic density, ethnic density effects need to be studied in context. Qualitative research could address the issue of 'self-selection' into and out of areas, and provide insight into the importance of the ethnic composition of an area in relation to residential preferences.

Causal mechanisms should be explored further in order to clarify the nature and importance of ethnic density effects. These effects might vary by ethnic group. Social capital and related concepts referring to the potential benefits derived from social networks may function as a buffer of detrimental effects of social disadvantage for some, but they may be inhibited by a lack of economic and cultural capital for others. For example, evidence from the US showed that Latino density was associated with higher social cohesion, which in turn was associated with better mental health. Asian density on the other hand was associated with lower social cohesion, which correlated with worse mental health (Hong, Zhang, and Walton 2014).

We recommend the study of other health outcomes, as birth outcomes might not be sensitive enough to find associations with ethnic density and have previously been reported to remain remarkably stable in times of deprivation (Stein and Lumey 2000). For short term residents in particular, it is more likely that health behaviours are associated with ethnic density, through social networks, social support and norms in the community. In addition, health outcomes more likely to be associated with chronic stress, such as hypertension (Sparrenberger et al. 2008), cardiovascular morbidity and mortality (Öhlin et al. 2004) or health behaviours (Torres and Nowson 2007), might reveal an impact of ethnic density many years after settling in a neighbourhood. The influence of length of exposure on health is something that a longitudinal cohort study such as BiB can consider by studying the same residents over time.

Although this study provides another example of mixed results in ethnic density research, our findings indicate that this lack of consistency might be due to the associations between health, ethnic density and social disadvantage. Evidence from future studies will determine when ethnic density is beneficial to health and well-being, and when detrimental effects of social disadvantage have the upper hand.

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Table 1. Description of the study sample

	Pakistani N = 4561	White British N = 4049
Individual-level characteristics		
Maternal age in years, mean (sd)	28.2 (0.08)	27.1 (0.10)
Time lived at address in years, mean (sd)	5.31 (5.85)	4.57 (5.41)
Parity, % first child	36.3	52.3
Sex of the baby, % male	51.1	51.3
Mother born in England (%)	42.5	96.7
Consanguineous (%)	64.1	0.0
Living with baby's father (%)	93.1	70.3
Receiving means-tested benefits (%)	45.3	37.0
Maternal level education (%)		
< 5 GCSE	27.0	22.2
5 GCSE	32.7	38.3
A level	13.1	18.9
> A level	27.3	20.6
Occupation father (%)		
Non-manual	30.9	49.8
Manual	40.2	27.8
Self-employed	19.6	10.0
Student	1.3	1.4
Unemployed	6.9	9.4
Financial situation (%)		
Comfortable	26.8	26.5
Alright	41.8	40.5
Just about getting by	23.3	26.1
Quite difficult	6.3	5.1
Very difficult	1.7	1.8
Area-level characteristics		
Area deprivation (%)		
Quintile 1 (most deprived)	79.1	52.9
Quintile 2	14.3	20.7

Quintile 3	5.5	16.6
Quintile 4	0.3	4.7
Quintile 5 (most affluent)	0.2	3.4
Pakistani density: mean (sd)	54.1 (0.32)	11.4 (0.26)
White British density: mean (sd)	22.5 (0.32)	73.7 (0.36)
South Asian density: mean (sd)	61.7 (0.33)	14.7 (0.30)

Table 2 Composition of ethnic density areas Pakistani women and infants

Pakistani density	**< 35%**	**35-49.99%**	**50-59.99%**	**60-70%**	**> 70%**
Number of LSOAs	114	22	17	16	12
Number of observations	802	775	793	954	1013
Area-level characteristics	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**
Area deprivation (IMD 2010)	40.2	46.7	49.6	44.6	51.8
% residents born in England	85.9	78.5	68.5	67.0	60.4
Individual-level characteristics	**Mean, %**	**Mean, %**	**Mean, %**	**Mean, %**	**Mean, %**
Maternal age (years)	28.5	28.2	28.0	28.4	27.8
Time lived at address (years)	4.1	4.4	5.6	6.0	6.1
% first baby	36.0	34.2	35.23	37.6	37.5
% mothers born in England	50.0	40.5	42.50	41.5	38.5
% consanguineous	56.2	60.5	62.55	69.6	71.2
% living with baby's father	92.4	92.0	93.31	94.3	93.3
% mothers < 5 GCSE	18.9	22.4	29.62	25.3	31.7
% receiving means-tested benefits	42.5	45.5	49.49	44.8	45.6

Table 3 Ethnic density in relation to birth outcomes Pakistani infants

	β (95% CI)	OR (95% CI)
Multilevel models[1]		
	Birth weight	Preterm birth
Area deprivation (IMD 2010)	3.88 (0.67;7.10)*	1.02 (0.99; 1.05)
Ethnic density (versus < 35%)		
35-49.99%	-3.64 (-51.75;44.47)	1.24 (0.75; 2.05)
50-59.99%	-31.79 (-81.24;17.66)	1.40 (0.85; 2.30)
60-70%	-29.99 (-77.30;17.31)	0.96 (0.57; 1.60)
> 70%	-45.49 (-96.92;5.95)	1.44 (0.86; 2.40)

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

1) Random intercepts multilevel models were adjusted for maternal height, parity, sex of the baby, cohabitation status, maternal country of birth, consanguinity, and measures of SES (maternal education, employment status of the father, receiving means-tested benefits, and self-reported financial situation).

Table 4 Ethnic density in relation to smoking during pregnancy Pakistani women

	OR (95% CI)
Multilevel models[1]	
	Smoking during pregnancy
Area deprivation (IMD 2010)	1.00 (0.97;1.03)
South Asian density (versus <10%)	0.65 (0.25;1.67)
10-29.99%	0.47 (0.18;1.19)
30-49.99%	0.39 (0.16;0.97)*
50-70%	0.41 (0.17;1.02)
> 70%	

*** p < 0.001, ** p < 0.01, * p < 0.05.

1) Random intercepts multilevel models were adjusted for maternal height, parity, sex of the baby, cohabitation status, maternal country of birth, consanguinity, and measures of SES (maternal education, self-reported financial situation).

Table 5 Composition of ethnic density areas White British women and infants

White British density	**< 55%**	**55-74.99%**	**75-84.99%**	**85-90%**	**> 90%**
Number of LSOAs	82	33	30	34	65
Number of observations	710	727	792	736	897
Area-level characteristics	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**
Area deprivation (IMD 2010)	45.83	35.68	44.67	36.99	23.32
% residents born in England	78.45	91.53	93.11	94.23	94.90
Individual-level characteristics	**Mean, %**	**Mean, %**	**Mean, %**	**Mean, %**	**Mean, %**
Maternal age (years)	25.86	27.02	26.90	27.19	28.26
Time lived at address (years)	4.44	4.56	4.48	4.65	4.60
% first baby	53.73	50.43	48,82	51.82	56.42
% living with baby's father	63.56	68.69	69.53	71.06	77.90
% mothers < 5 GCSE	27.68	20.08	22.10	16.17	14.86
% receiving means-tested benefits	49.01	38.24	39.37	35.33	25.59

Table 6 Ethnic density in relation to birth outcomes White British infants

	β (95% CI)	OR (95% CI)
Multilevel models[1]		
	Birth weight	Preterm birth
Area deprivation (IMD 2010)	-3.26 (-6.88;0.36)	1.03 (1.00;1.06)
Ethnic density (versus < 55%)		
55-74.99%	36.97 (-16.82;90.76)	1.04 (0.63;1.71)
75-84.99%	21.39 (-30.38;73.15)	1.00 (0.63;1.60)
85-90%	22.81 (-30.08;75.69)	1.11 (0.69;1.78)
> 90%	46.54 (-7.68;100.76)	1.29 (0.79;2.10)

*** p < 0.001, ** p < 0.01, * p < 0.05.

1) Analyses were adjusted for maternal height, parity, sex of the baby, cohabitation status, and measures of SES (maternal education, employment status of the father, receiving means-tested benefits).

Table 7 Ethnic density in relation to smoking during pregnancy White British women

	OR (95% CI)
Multilevel models[1]	
	Smoking during pregnancy
Area deprivation (IMD 2010)	1.03 (1.02;1.05)***
South Asian density (versus	
<10%)	0.79 (0.64;0.98)*
10-29.99%	0.99 (0.72;1.30)
30-49.99%	1.13 (0.80;1.61)
50-70%	0.82 (0.50;1.34)
> 70%	

*** p < 0.001, ** p < 0.01, * p < 0.05.

1) Analyses were adjusted for maternal height, parity, sex of the baby, cohabitation status, and measures of SES (maternal education, employment status of the father, receiving means-tested benefits, and self-reported financial situation).

Figures