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Does the ethnic density effect extend to obesity? A cross-sectional study of 415,166 adults in East London

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SS is guarantor and corresponding author. SS affirms that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned have been explained.

Abstract

Objective: We examine the association between increasing own group ethnic density and obesity prevalence, by sex and ethnic group.

Setting: Cross-sectional study utilising electronic primary care records of 136 practices in a multi-ethnic population of East London.

Participants: Electronic primary care records of 415,166 adults.

Primary and secondary outcome measures: Prevalence of obesity per 10% increase in own-group ethnic density and risk of obesity by ethnic group, compared to White British.

Results: Compared to White British/Irish males, risk of obesity was significantly higher among Black ethnic groups and significantly lower among Asian and White Other minority groups. Among females, all ethnic groups except Chinese and White Other were at increased risk of obesity compared to White British/Irish. There was no association between increasing ethnic density and obesity prevalence, except among Black Africans and Indian females. A 10% increase in Black ethnic density was associated with a 15% increase in odds of obesity among Black African males (95%CI 1.07-1.24) and 18% among Black African females (95%CI 1.08-1.30). Among Indian females, a 10% increase in Indian ethnic density was associated with a 7% decrease in odds of obesity (95%CI 0.88-0.99).

Conclusion: Wider environmental factors may play a greater role in determining obesity than the ethnic composition of the area for most ethnic groups. Further research is needed to understand the mechanism through which increasing ethnic density is associated with increased risk of obesity among Black African ethnicity and decreased risk of obesity among Indian females.

Strengths and limitations of this study

- To date this is the largest study on ethnic density and obesity, including over 400,000 individuals.
- We were able to categories ethnicity into smaller, more homogenous groups, rather than using broad ethnic groupings.
- We were able to measure ethnic density at smaller, neighborhood level, rather than over large geographical areas.
- No data was available to adjust for other potential confounders of the relationship between ethnic density and obesity such as proximity to fast food establishments and availability of green space.

- We used Index of Multiple Deprivation as a proxy measure of individual deprivation; this may have inadequately measured individual deprivation.

Contributions

SH designed the study. SS extracted relevant data from electronic health records. SS and RM conducted statistical analysis and all authors contributed to, data interpretation and revising drafts produced by SS. All authors had full access to all the data collected, have checked for accuracy and have approved the final version of this manuscript.

Data Sharing

No additional data is available.

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Ethical approval

Ethical approval was not required as patient-level data are anonymised and aggregated patient data are reported in this study. All GPs in the participating east London practices consented to the use of their anonymised patient data for research and development for patient benefit.

Provenance

Freely submitted; externally peer reviewed.

Competing interests

The authors have declared no competing interests.

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Does the ethnic density effect extend to obesity? A cross-sectional study of 415,166 adults in East London

What is already known?

Increasing own-group ethnic density is protective against mental and psychological illness; recently it has been found protective against risk factors such as smoking.

However it is unknown whether the protective effects of increasing own-group ethnic density extend to obesity.

What this study adds?

Increasing own-ethnic density is not protective against obesity for most ethnic groups.

Among Black African females increasing own-group ethnic density is associated with increase risk of obesity.

Introduction

Tackling obesity is a major public health priority as worldwide prevalence continues to rise.[1] In England, 27% of men and women are obese and this is predicted to rise to over 40% by 2035.[2 3] Prevalence varies by ethnic group and gender, in England Bangladeshi and Chinese men have the lowest obesity rates, while Black Caribbean and Irish men have the highest. Among women, obesity prevalence is highest in the Black Caribbean, Black African and Pakistani groups, and lowest in the Chinese group.[4] Variation may be the result of differences between ethnic groups in socioeconomic status, diet, physical activity and cultural factors.[5] These in turn may be influenced by the ethnic composition of the area and the process of acculturation. This describes the tendency, over time, for minority groups to change their everyday behaviours and follow the cultural norms of the majority population around them. Studies exploring the effect of acculturation on weight find that as migrant populations move from low or medium-income countries to high-income countries, they adopt local less healthy dietary practices resulting in weight gain.[6] The association appears strongest among males, among females the relationship appears more complex, with some studies finding no or an inverse relationship between acculturation and weight.[7 8]

The ethnic density effect describes the association between the proportion of people of an ethnic grouping living in a defined geographical area, and health outcomes for individuals of that ethnic group living within the same area.[9 10] In the United Kingdom (UK), such associations have been found in the areas of mental health and more recently in smoking behaviour.[11-13] While the causal pathways through which the ethnic density effect operates have yet to be fully elucidated; the most researched hypothesis suggests that the buffering effect of increased own group ethnic density protects individuals against experiences of racism and discrimination alongside increased opportunity to build social capital.[9 14] While

these mechanisms provide plausible hypotheses for protection against mental illness, it is less clear how this pathway affects health behaviour such as smoking and whether it extends to obesity.

Previous studies have demonstrated that immigrants initially have lower weights relative to their host-country born counterparts; but with increasing duration of residence and in subsequent generations, the prevalence of obesity increases to levels of the predominant ethnic group.[15 16] Ethnic density may modify this process of acculturation. Higher levels of own group ethnic density may encourage individuals to follow traditional eating habits,[17] as well as experience less stress, through reduced incidences of discrimination and greater social support[14]; and stress is strongly associated with weight gain.[18 19]

For the purposes of this study, we hypothesise that high own group ethnic density, may exert a protective effect against acculturisation. This will in turn reduce the risk of obesity for ethnic minority individuals living in areas of high own group ethnic density to a greater extent than for those living in areas of low own group ethnic density. Current UK research on this topic is limited;[20] previous studies based in the United States (US), using ethnic density measured over large metropolitan areas, have found mixed effects.[21-23] Results in the UK may differ, due to differences in migratory history, ethnic composition, and the ability to measure ethnic density at smaller, more socially meaningful neighbourhood level.

There is an urgent need to understand the interplay between ethnicity, area-level ethnic density and risk of obesity, as obesity rates continue to rise among ethnic minority groups whilst stabilising among White majority populations.[24 25] Understanding the role of ethnic density may help develop tailored public health interventions to stem these widening disparities in obesity prevalence. To date, no UK studies have explored how the ethnic composition of an area may influence risk of obesity.

Using primary care data from three ethnically diverse, coterminous boroughs of East London, we report the prevalence of obesity among different ethnic groups and examine the association between own group ethnic density and obesity prevalence.

Method

Study setting

A cross-sectional observational study using demographic and clinical data extracted from electronic primary care health records of adults aged 18 and over living in, and registered with a GP practice, in the east London boroughs of Hackney, Tower Hamlets and Newham.

Obesity

Obesity measures were obtained by extracting data on body mass index (BMI) coded in primary care health records. This was then categorized into obese, overweight or normal/underweight based on a BMI above 30 kg/m^2, between 25 to 29.9 kg/m^2 or below 24.9 kg/m^2 respectively. We utilised BMI as it is routinely measured and used in primary care in contrast to other weight measures (e.g. waist circumference), which are poorly recorded. Uniform thresholds for obesity were used for all ethnic groups. We also performed a sensitivity analysis applying lower BMI thresholds to define obesity in South Asians, to reflect their increased risk of type 2 diabetes at lower levels of BMI.[26] Participants were included if they had had at least one BMI measure in the previous three years (2014-2017), and the most recent BMI was used. Women who were pregnant at the time of BMI measurement were excluded.

Ethnicity and ethnic density

Individual level ethnicity was extracted from primary care health records. Ethnicity is self-reported by the patient at registration or during consultation, and coded based on the UK Censuses categorization hierarchies. Reported ethnicity was collapsed to the 16 groups as defined in the 2011 UK Census.[27] Recording of adult ethnicity in primary care health records is over 90% across the study area, following previous incentives to extend and improve the quality of practice-based, self-reported ethnicity. [28 29]

We calculated a measure of ethnic density for each ethnic group based on geographical area and census data. Through discussion, we utilized Middle-layer Super Output Areas (MSOA) as our choice of area to calculate ethnic density, this has been used in previous local studies.[11] MSOA are census areas with between 2,000 and 6,000 households based on the 2011 UK Census. In the densely populated study area of East London this represents approximately 0.5km^2 and reflects the walking environment in which an individual would experience many of their daily interactions. We calculated ethnic density as the percentage of people from each ethnic group living within each MSOA. We obtained data on the number of people from each ethnic group from the 2011 census. We used census data rather than primary care data for the calculation of ethnic density as the census data includes the entire population, including individuals who may not be registered with a GP practice. We also performed a sensitivity analysis using primary care data to calculate ethnic density.

Socio-economic deprivation

A proxy measure of individual socio-economic deprivation (the Index of multiple deprivation, IMD) was obtained for each patient from his or her GP record. IMD is based on the Lower-layer Super Output Areas (LSOA) based on census data.[30] These each have an average of 1,500 residents with broadly similar social and economic conditions.

Demographic and clinical variables

Additional data on current age, sex, entry on chronic disease registers and borough of residence (Hackney, Newham or Tower Hamlets) was extracted from the electronic record. All values were the latest recorded before the study date of March 2017.

Data analysis

All analyses were carried out using Stata version 14 (Statacorp, College Station, TX, USA). All analyses were stratified by sex to account for established differences in obesity between men and women.

To examine odds of obesity for different ethnic groups (White Other, Black Caribbean, Black African, Indian, Bangladeshi, Pakistani, Chinese) compared to the majority British/Irish White ethnic group, we used a two-level logistic regression model, with individuals nested in MSOA. Age, borough, deprivation (IMD score), and presence of serious mental illness or diabetes were included in the model as these were independently associated with both obesity and ethnicity.

To assess the relationship between ethnic density and obesity, a similar two-level logistic regression model was used. A difference in ethnic density of 10% of the total population was set as the threshold interval above which an association with a change in the odds of being obese was sought. *A priori* confounders included age, borough and deprivation (IMD score). Analysis was conducted separately for each ethnic group using the relevant data on ethnic density.

We hypothesized that younger adults may be more acculturated to the majority ethnic group and thus show a different relationship between obesity and ethnic density, hence we stratified the analysis by those aged 18–35 years and those aged >35 years. To examine the

robustness of any association, we performed several sensitivity analyses including: broadening ethnic grouping into Black, Asian and White, using different thresholds of ethnic density and using different cut-offs for obesity status. We also repeated analysis using ethnic density calculated using electronic primary care records rather than census data.

Patient and Public Involvement

No patients or public were involved in the design of this study.

Results

From a total of 792,395 GP registered adults aged 18 and over on 5th March 2017, 755,381 were resident within the study area of interest. From this population 415,166 had a valid BMI measure within the last 3 years and were free of recorded pregnancy at the time of measurement. The mean age of the included population was 43.2 years and 48.3% were male. The largest ethnic group was White British/Irish, which represented almost a quarter (24.5%) of the included population. Over half the population were either overweight (31.9%) or obese (23.1%) (table 1).

The adjusted odds of obesity by ethnic group are reported in figure 1. In comparison with the White group those with the highest odds of obesity were Black African women (OR 3.10; [95% CI 2.99-3.22]), Caribbean (OR 2.20; [95% CI 2.10-2.30]), and Pakistani women (OR 2.07; [1.97-2.18]). In contrast, Chinese men (OR 0.28; [95% CI 0.24 -0.33]), and women (OR 0.17; [95% CI 0.14-0.20]), had significantly lower odds of obesity compared to the White population.

The association between a 10% increase in own-group ethnic density and the prevalence of obesity is described in Table 2. We found no association between increasing ethnic density and obesity prevalence for any of the ethnic groups except for Black African men and women and Indian women. A 10% increase in Black African ethnic density was associated with a 15% (95%CI 1.07-1.24) increased odds of obesity among Black African men and 18% increase among Black African women (95%CI 1.08-1.30). This association was present for both obese (BMI ≥30 kg/m^2) and overweight and obese (BMI≥25 kg/m^2) BMI categories; but was not present in those under 35 years of age (table 3). A 10% increase in Indian ethnic density was associated with a 7% (95%CI 0.88-0.99) decrease in odds of obesity among Indian women, there was no significant association among Indian men, and this association was not present for overweight Indian women or those under 35 years of age (table 3). For all other ethnic groups

in our study population we found no significant relationship between increases in own-group ethnic density and the odds of being obese. Sensitivity analyses using different thresholds for ethnic density, different BMI cut offs, different age groups and clustering related ethnic groups did not significantly differ from the main results (table 4).

Analysis was restricted to White British/Irish, Bangladeshi, Indian, Pakistani and Black African as they represented the majority resident groups in East London and demonstrated significant variation in density across study area (figure 2). Other groups were too small (Chinese) or too uniformly distributed (Black Caribbean) to be included in the analysis.

Discussion

Main findings

Overall, 23.1% of our study population were recorded as obese with considerable variation by ethnic group. Prevalence of obesity among men and women was highest among Black Africans and Caribbean groups (both ~39%) and lowest among Chinese ethnic groups (5%).

In men, odds of obesity were higher among Black ethnic groups compared to White British/Irish males and lower among Chinese, Indian, Bangladeshi, and White other ethnic groups. Among women, all ethnic groups except Chinese and White other had increased odds of obesity compared to White British/Irish women.

We found a 10% increase in Black African ethnic density was associated with a 15% and 18% increased odds of obesity among Black African men and women respectively. This association was present for both obesity and overweight BMI categories (table 4) but was not present in those under 35 years of age (table 3). Among Indian women, a 10% increase in

Indian ethnic density was associated with a 7% decrease in odds of obesity, but this association was not present at different cut offs for obesity or for Indian men.

Comparison with existing literature

The crude prevalence of obesity was lower in our study population (23%) compared to England (27%),[2] reflecting the younger age distribution of the east London population. Our findings of variation in prevalence of obesity among ethnic groups demonstrated similar trends to the 2004 HSE study of adult obesity among ethnic groups in England.[4] However, among Indian and Bangladeshi females, we found the odds of obesity were higher compared to White British/Irish females which was not apparent in the 2004 HSE.[4]

Despite a growing number of studies examining the ethnic density effect, empirical evidence on the mechanism and underlying pathways remains scant. Among studies exploring ethnic density, protective associations have most commonly been identified for mental health outcomes compared to studies examining physical health measures.[9] Such studies have recently been extended to risk taking behaviour such as smoking, where Mathur et al. found increasing ethnic density was associated with a significant reduction in smoking prevalence among all ethnic groups except Black Caribbean females.[11]

Our data suggest such protective associations do not extend to the risk of obesity among White British/Irish and Bangladeshi ethnic groups. Among Indian females, increasing ethnic density may be protective against obesity, however this was not a robust finding in sensitivity analysis and was not strongly significant (95%CI 0.88-0.99). Among Black Africans, however, increasing ethnic density was found to be strongly associated as a risk factor for obesity. This is consistent with findings from the US, which found ethnic density was a risk factor for obesity among certain ethnic groups. [22 23] However, there is little consistency between US studies in determining which ethnic groups are influenced by ethnic density,[21] and studies vary in their

use of ethnic group categorization and in the size of geographical area used to calculate ethnic density.

In contrast to US based studies, we were able to look at more specific ethnic groups, and measure ethnic density at a smaller geographical area, which may more accurately reflect the lived experience of local populations.

The lack of effect we saw for most ethnic groups may reflect the complex and competing cultural influences on weight, as well as the overwhelming influence of other factors – in particular the "foodscape", which describes the exposure of individuals to food establishments over a geographical area.[31 32]

Research among Black ethnic groups living in America suggests compared to other ethnic groups, Black ethnic groups have a strong preference for higher body weight.[33 34] Such cultural norms around bodyweight may be amplified in areas of increased ethnic density, where acculturation to the western preferences of body size may be weaker. For example, we found the association between Black Africans and increased same ethnic density only among older age groups (over 35 years); younger generations may be more acculturated to the western preferences of body size, preferring lower BMI.

The lack of variability in ethnic density among the Black Caribbean population meant we were unable to examine the association of ethnic density and obesity among this group. In a sensitivity analysis we clustered Black Africans and Black Caribbean together, finding no association between increasing Black ethnic density and prevalence of obesity among Black males or females (Table 4). This suggests the effects of ethnic density are not generalizable to other Black ethnic groups and may reflect distinct differences between Black Africans who are a more recent migratory group to the UK compared to Black Caribbean.[35]

Strengths and limitations

To date, this is the largest study of adult obesity prevalence among ethnic groups in England,

including over 400,000 individuals of who over 75% were from ethnic minority groups. It is among the first studies exploring the relationship between ethnic density and obesity in the UK.[20] The size of this study means that our findings are unlikely to have arisen by chance, reflected in our narrow confidence intervals for effect size. We explored the consistency of our results by performing a number of sensitivity analyses which confirmed no significant associations for different thresholds (above and below 25% ethnic density, different BMI cut offs, different age groups and clustering related ethnic groups) (table 3 and 4).

We were unable to adjust for other potential confounders of the relationship between ethnic density and obesity, such as availability of green space and density of fast food outlets. In addition we were not able to explore differences within ethnic groups in terms of migratory history and religion, which may influence diet and behavior. It is also possible that residual confounding occurred in our proxy measure of individual deprivation by using IMD. This may have inadequately measured individual deprivation and potentially masked any ethnic density effect.

Implications for practice and policy

The obesity epidemic, and associated health effects, is structured by social deprivation and by ethnic group. Our data suggest that environmental factors such as food, exercise and cultural norms play a greater role in determining obesity than the ethnic composition of the area. Health policy should continue to focus on the environmental factors that influence obesity such as the proximity of highly calorific food,[31] availability of green space[36] and encouraging active transport.[37]

Further understanding of the ethnic disparities in the UK obesity epidemic may best be served by learning from groups with the lowest prevalence of obesity such as the Chinese populations. Understanding the mechanisms through which Chinese immigrant populations in the UK

maintain a healthy body weight may help formulate policy ideas that may be relevant to other ethnic groups. Further research is also needed to explore why among Black Africans, increasing own-group ethnic density is associated with obesity and how this can be tackled to reduce the burden of obesity experienced by Black Africans living in the UK.

Ethical approval

All data were anonymised and managed according to the UK NHS information governance requirements. Ethical approval was not required for this observational study as it relied solely on the use of Read coded, non-identifiable data with results published in aggregate form.

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Table 1. Characteristics of the study population

Characteristic	Total	White		Black		Asian				Other	
		British/Irish	Other	African	Caribbean	Chinese	Bangladeshi	Indian	Pakistani	Mixed/ other	Missing/not stated
N	415,166	101,710	87,157	30,761	18,239	6,584	51,575	29,250	16,884	52,650	20,356
Mean age, years (SD)	43.2 (16.3)	45.9 (18.5)	37.6 (13.4)	46.6 (14.1)	55.0 (17.3)	37.0 (15.1)	43.2 (14.6)	44.8 (16.0)	44.2 (15.2)	43.4 (15.6)	36.7 (13.8)
Sex:											
Male (%)	48.3	48.0	45.8	47.2	41.8	38.4	53.0	53.6	56.2	46.2	49.7
IMD score (SD)	42.0 (9.6)	41.3 (10.1)	41.7 (9.9)	45.0 (8.8)	43.5 (8.3)	39.2 (12.1)	43.5 (9.1)	39.7 (7.9)	40.9 (7.3)	42.4 (9.2)	40.7 (10.7)
Residence:											
Hackney (n)	127,256	38,744	32,693	11,286	8,667	1,360	2,312	3,874	1,047	19,753	7,520
Newham (n)	172,357	29,274	31,229	16,407	7,642	1,953	19,831	22,450	14,741	22,842	5,988
Tower Hamlets (n)	115,553	33,692	23,235	3,068	1,930	3,271	29,432	2,926	1,096	10,055	6,848
Weight status:											
BMI <20 (%)	8.2	8.9	10.9	3.3	3.8	23.1	5.9	6.9	5.3	7.5	12.0
BMI 20-25 (%)	36.8	40.3	44.8	21.2	23.0	52.8	34.1	34.7	26.3	33.7	42.8
BMI 25-30 (%)	31.9	28.4	27.0	36.3	34.5	19.2	41.1	37.4	38.6	32.9	27.3
BMI >30 (%)	23.1	22.5	17.4	39.3	38.8	4.9	18.9	21.0	29.8	25.8	18.0

Table 2. Multi-level logistic regression of adjusted odds* of being obese given a 10% increase in own-group ethnic density for the study ethnic groups.

Ethnic group	Male		Female	
	OR (95%CI)	P-value	OR (95%CI)	P-value
Bangladeshi	1.00 (0.97-1.04)	0.72	1.00 (0.95-1.06)	0.89
Black African	1.15 (1.07-1.24)	<0.001	1.18 (1.08-1.30)	<0.001
Indian	1.03 (0.96-1.09)	0.44	0.93 (0.88-0.99)	0.02
Pakistani	1.06 (0.96-1.17)	0.22	1.05 (0.95-1.15)	0.32
White British/Irish	0.98 (0.93-1.04)	0.60	0.98 (0.93-1.04)	0.56

*Adjusted for age, deprivation and borough of residence

Table 3. Multi-level logistic regression of adjusted* odds ratio of 10% increase in area own-ethnic density and obesity prevalence by ethnic group, stratified by age group

	Under 35		Over 35	
Ethnic group	OR (95%CI)	p-value	OR (95%CI)	p-value
Male				
Bangladeshi	0.99 (0.94-1.05)	0.82	1.02 (0.98-1.07)	0.31
Black African	1.08 (0.96-1.28)	0.17	1.14 (1.06-1.23)	<0.001
Indian	1.04 (0.95-1.14)	0.41	1.02 (0.95-1.10)	0.63
Pakistani	1.18 (0.97-1.43)	0.09	1.02 (0.92-1.13)	0.73
White British	0.99 (0.89-1.10)	0.84	0.96 (0.91-1.00)	0.09
Female				
Bangladeshi	1.03 (0.96-1.13)	0.35	0.98 (0.93-1.04)	0.60
Black African	1.13 (0.90-1.43)	0.29	1.19 (1.08-1.31)	<0.001
Indian	0.91 (0.82-1.00)	0.67	0.94 (0.89-0.99)	0.03
Pakistani	0.99 (0.83-1.18)	0.92	1.05 (0.94-1.17)	0.40
White British	1.05 (0.95-1.16)	0.37	0.96 (0.91-1.01)	0.13

*Adjusted for age, deprivation and borough of residence

Table 4. Sensitivity analysis

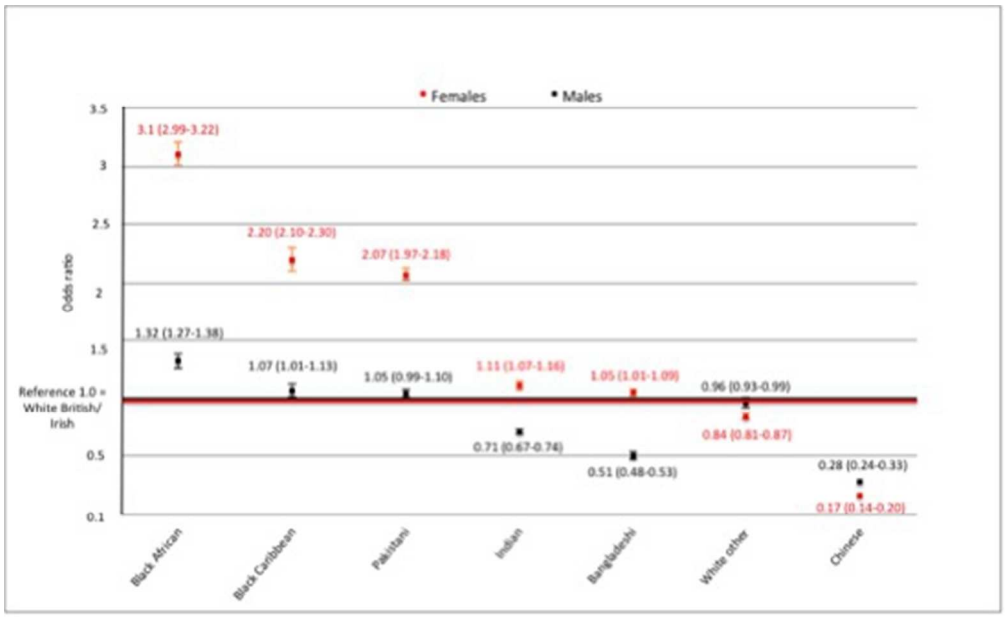
Ethnic group	Male		Female	
	OR (95%CI)	p-value	OR (95%CI)	p-value
Multi-level logistic regression of adjusted* odds ratio of 10% increase in area own-ethnic density and obesity or overweight prevalence by ethnic group				
Bangladeshi	0.99 (0.95-1.02)	0.43	0.99 (0.95-1.04)	0.74
Black African	1.21 (1.12-1.32)	<0.001	1.15 (1.06-1.26)	0.001
Indian	1.05 (0.98-1.12)	0.17	0.95 (0.91-0.99)	0.05
Pakistani	1.16 (1.05-1.27)	0.003	1.11 (1.00-1.22)	0.06
White British	1.02 (0.96-1.07)	0.56	1.04 (0.99-1.09)	0.13
Multi-level logistic regression of adjusted* odds ratio of 10% increase in area own-ethnic density and obesity or overweight prevalence by ethnic group, using primary care data for ethnic density				
Bangladeshi	1.01 (0.97-1.04)	0.68	1.00 (0.95-1.06)	0.89
Black African	1.14 (1.05-1.23)	<0.001	1.18 (1.08-1.30)	<0.001
Indian	1.02 (0.97-1.09)	0.40	0.95 (0.90-0.99)	0.04
Pakistani	1.08 (0.98-1.19)	0.13	1.06 (0.96-1.16)	0.24
White British	0.98 (0.92-1.04)	0.49	0.96 (0.91-1.02)	0.18
Multi-level logistic regression of adjusted odds ratio of 10% increase in area own-ethnic density and obesity prevalence by ethnic group, (obesity cut off 27.5 for Asian groups)				
Bangladeshi	1.00 (0.95-1.04)	0.926	1.04 (1.05-1.07)	0.024
Black African	1.18 (1.08-1.30)	<0.001	1.17 (1.08-1.27)	<0.001
Indian	0.94 (0.89-1.00)	0.064	1.05 (0.98-1.13)	0.171
Pakistani	1.09 (1.00-1.19)	0.044	1.06 (0.95-1.19)	0.287
White British	0.98 (0.93-1.04)	0.60	0.99 (0.94-1.05)	0.756
Multi-level logistic regression of adjusted* odds ratio of 10% increase in area own-ethnic density and obesity or overweight prevalence by broad ethnic group				
Asian (Bangladeshi, Indian, Pakistani)	1.02 (0.9-9-1.06)	0.20	0.97 (0.94-1.01)	0.15
Black (African and Caribbean)	1.03 (0.97-1.09)	0.30	1.04 (0.97-1.12)	0.29
White European (White British, Irish, European)	0.96 (0.93-0.99)	0.04	0.98 (0.94-1.02)	0.28

Figure 1. Multi-level logistic regression of adjusted odds* of obesity by ethnic group and sex, compared to White British/Irish

*Adjusted for age, deprivation, borough of residence, presence of serious mental illness or diabetes

Figure 2. Ethnic density distributions mapped across study area of East London for Bangladeshi, White, Black Caribbean, and Black African with south London comparator area.*

* Adapted from Mathur R, Schofield P, Smith D, et al. Is individual smoking behaviour influenced by area-level ethnic density? A cross-sectional electronic health database study of inner south-East London. *ERJ Open Research* 2017;3(1)



Multi-level logistic regression of adjusted odds of obesity by ethnic group and sex, compared to White British/Irish

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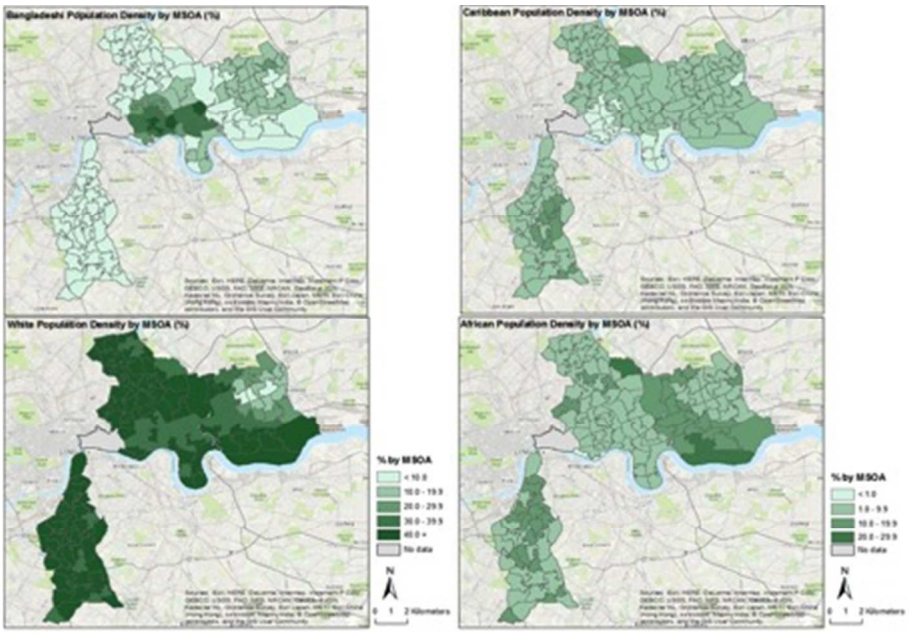

Ethnic density distributions mapped across study area of East London for Bangladeshi, White, Black Caribbean, and Black African with south London comparator area.

159x110mm (72 x 72 DPI)

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Does the ethnic density effect extend to obesity? A cross-sectional study of 415,166 adults in East London

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Does the ethnic density effect extend to obesity? A cross-sectional study of 415,166 adults in East London

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Appendix

Keywords: ethnic density; obesity; body mass index

SS is guarantor of the report. SS affirms that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned have been explained.

Abstract

Objective: To examine the association between increasing own group ethnic density and obesity prevalence, by sex and ethnic group.

Design and Setting: Cross-sectional study utilising electronic primary care records of 128 practices in a multi-ethnic population of East London.

Participants: Electronic primary care records of 415,166 adults.

Outcome measures:

1. Odds of obesity for different ethnic groups compared to White British.

2. Prevalence of obesity associated with each 10% increase in own-group ethnic density, by ethnic group.

Results: Compared to White British/Irish males, the odds of obesity was significantly higher among Black ethnic groups and significantly lower among Asian and White Other groups. Among females, all ethnic groups except Chinese and White Other were at increased odds of obesity compared to White British/Irish.

There was no association between increasing ethnic density and obesity prevalence, except among Black Africans and Indian females. A 10% increase in Black ethnic density was associated with a 15% increase in odds of obesity among Black African males (95% CI 1.07-1.24) and 18% among Black African females (95% CI 1.08-1.30). Among Indian females, a 10% increase in Indian ethnic density was associated with a 7% decrease in odds of obesity (95% CI 0.88-0.99).

Conclusion: Wider environmental factors play a greater role in determining obesity than the ethnic composition of the area for most ethnic groups. Further research is needed to understand the mechanism through which increasing ethnic density is associated with

increased odds of obesity among Black Africans and a decreased odds of obesity among Indian females.

Strengths and limitations of this study

- To date this is the largest study on ethnic density and obesity in the UK, including primary care data from over 400,000 individuals.
- Ethnicity recording was over 90% in the primary care records from this multiethnic area, hence allowing us to use a large routine dataset with multiple ethnic groups for the study.
- We were able to measure ethnic density at small, neighborhood level, rather than over large geographical areas.
- No data was available to adjust for potential confounders of the relationship between ethnic density and obesity such as proximity to fast food outlets and availability of green space.
- We used the Index of Multiple Deprivation, derived from census data, as a proxy measure of individual deprivation; this may inadequately measure individual deprivation.

Contributions

SH designed the study. SS extracted relevant data from electronic health records. SS and RM conducted statistical analysis and all authors contributed to, data interpretation and revising drafts produced by SS. All authors had full access to all the data collected, have checked for accuracy and have approved the final version of this manuscript.

Data Sharing

No additional data is available.

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Disclaimer: This article presents independent research. The views expressed in this

publication are those of the author(s) and not necessarily those of the NHS, the Health Foundation, or the University.

Ethical approval

Ethical approval was not required as patient-level data are anonymised and aggregated patient data are reported in this study. All GPs in the participating east London practices consented to the use of their anonymised patient data for research and development for patient benefit.

Provenance

Freely submitted; externally peer reviewed.

Competing interests

The authors have declared no competing interests.

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Does the ethnic density effect extend to obesity? A cross-sectional study of 415,166 adults in East London

Introduction

Tackling obesity is a major public health priority as worldwide prevalence continues to rise.[1] In England, 27% of men and women are obese and this is predicted to rise to over 40% by 2035.[2 3] Prevalence varies by ethnic group and gender; in England Bangladeshi and Chinese men have the lowest obesity rates, while Black Caribbean and Irish men have the highest. Among women, obesity prevalence is highest in the Black Caribbean, Black African and Pakistani groups, and lowest in the Chinese group.[4] Variation may be the result of differences between ethnic groups in socioeconomic status, diet, physical activity and cultural factors.[5] These in turn may be influenced by the ethnic composition of the area and the process of acculturation. Acculturation describes the tendency, over time, for minority groups to change their everyday behaviours and follow the cultural norms of the majority population. Studies exploring the effect of acculturation on weight find that as migrant populations move from low or medium-income countries to high-income countries, they adopt local dietary practices often resulting in weight gain.[6] Hence with increasing duration of residence and among subsequent generations, obesity increases to the level of the predominant ethnic group. [7 8] The association appears strongest among males. Among females the relationship appears more complex, with some studies finding no or an inverse relationship between acculturation and weight.[9 10] Ethnic density may modify this process of acculturation. Higher levels of own group ethnic density may encourage individuals to follow traditional eating habits,[11] provide greater social support and protect against stress;[12] and stress is strongly associated with weight gain.[13 14]

Most research on ethnic density has been conducted in the area of mental health where increasing own ethnic density has a protective effect on a range of mental health outcomes.[9,15 16 17-19] A recent systematic review and meta-analysis observed a 18% reduction in relative odds of psychotic experiences and 12% reduction in relative odds of suicidal ideation for each 10% increase in own-group ethnic density.[20] Beyond mental health, in the United Kingdom (UK) increasing ethnic density has been found protective against smoking, where a 10% increase in own-group ethnic density was associated with a 2–43% reduction in the odds of being a current smoker varying according to ethnic group.[17] The causal pathways through which the ethnic density effect operates have yet to be fully elucidated; the most researched hypothesis suggests that the buffering effect of increased own group ethnic density protects individuals against experiences of racism and discrimination alongside increased opportunity to build social capital.[12 15] While these mechanisms provide plausible hypotheses for protection against mental illness, it is less clear how this pathway affects health behaviour such as smoking and whether it extends to obesity. Current UK research on this topic is limited.[21] Studies from the United States (US), typically measuring ethnic density over large metropolitan areas, have found mixed effects. Kirby et al. found Hispanics living in areas of high Hispanic population density (over 25%) had a 21% increase in odds of obesity compared to those living in areas of lower Hispanic population density.[22] Maloney et al found increasing co-ethnic density was associated with increased odds of obesity among Black males, but not among Black females or Latinos.[23] A large Australian study, measuring ethnic density over small areas with an average population of 225 people found that among English and Irish, higher ethnic density was associated with lower BMI.[24]

Results in the UK are likely to differ from other countries due to different patterns of migration, duration of acculturation and population densities. There is an urgent need to understand the interplay between ethnicity, area-level ethnic density and risk of obesity, as

obesity rates continue to rise among ethnic minority groups whilst stabilising among White majority populations.[25 26] For the purposes of this study, we hypothesise that high own group ethnic density exerts a protective effect against acculturation. This in turn may reduce the risk of obesity for ethnic minority individuals living in areas of high own group ethnic density.

To date, no UK studies have explored whether the ethnic composition of an area may influence the risk of obesity. Using primary care data from three ethnically diverse, coterminous boroughs in East London, we report the prevalence of obesity among different ethnic groups and examine the association between own group ethnic density and obesity prevalence.

Methods

Study setting

The National Health Service (NHS) provides comprehensive health care, free at the point of delivery for residents in England, funded through taxation. The vast majority of the population are registered with a General Practice (GP) to access primary care services. We utilised anonymised, coded primary care data from the electronic health records held by the Clinical Effectiveness Group (CEG) for this cross-sectional observational study.

The adjoining east London boroughs of Tower Hamlets, Newham and Hackney are ethnically diverse, with a non-white British population of 52%, 61% and 49% respectively, compared to 30% in London and 14% in England.[27] The high proportion of minority ethnic groups makes east London an ideal area to study ethnic density effects.

We extracted demographic and clinical data for adults aged 18 and over currently registered at the 128 practices in these localities.

Obesity

Obesity measures were obtained by extracting data on body mass index (BMI) categorized into obese, overweight or normal/underweight based on a BMI above 30 kg/m^2, between 25 to 29.9 kg/m^2 or below 24.9 kg/m^2 respectively. We utilised BMI as it is routinely measured in primary care in contrast to other weight measures (e.g. waist circumference), which are poorly recorded. Uniform thresholds for obesity were used for all ethnic groups. We included a sensitivity analysis applying lower BMI thresholds to define obesity in South Asians, to reflect their increased risk of type 2 diabetes at lower levels of BMI.[28] Participants were included if they had at least one BMI measure in the previous three years (2014-2017), the most recent BMI was used. Women who were pregnant at the time of BMI measurement were excluded.

Ethnicity and ethnic density

Individual level ethnicity was extracted from primary care health records. Ethnicity is self-reported by the patient at registration or during consultation, and coded based on the UK Census categorization hierarchies. Reported ethnicity was collapsed into the 16 groups of the 2011 UK Census,[29] these were further collapsed into 9 groups: White British (White British, White Irish), White Other, Black African, Black Caribbean, Indian , Pakistani, Bangladeshi, Chinese, Mixed/other (White and Black Caribbean, White and Black African, White and Asian, Other mixed, Other Black, Other Asian, Other ethnic group). Recording of adult ethnicity in primary care health records is over 90% across the study area, following previous incentives to improve the quality of practice-based, self-reported ethnicity. [30 31]

Ethnic density was calculated as the percentage of people from each ethnic group living within each Middle Super Output Area, obtained from the 2011 census.[32] We used census data rather than primary care data for the calculation of ethnic density as the census data

includes the entire population, including individuals who may not be registered with a GP practice.

We chose Middle-layer Super Output Areas (MSOA), with average population size of 7,790, for the geographic area to calculate ethnic density as this has been used in other studies in England to identify the effect of ethnic density on health outcomes.[17] The study area of east London has a population density of 12,600 individuals per square kilometer, and we estimate an average MSOA covers 0.6 km^2 in this area, representing the walking environment for individuals. We found that ethnic density among White British, Black African, Indian, Pakistani and Bangladeshi varied sufficiently across our study area to be used for analysis of the ethnic density effect in our study (See figure 2).

We also undertook a sensitivity analysis using primary care data to calculate ethnic density.

Socio-economic deprivation

A proxy measure of individual socio-economic deprivation (Index of multiple deprivation, IMD) was obtained for each patient based on their LSOA of residence. IMD is a widely used measure of relative deprivation in England, combining information on seven domains of deprivation (income, employment, education, health and disability, housing and living environment) from census data.[33]

Demographic and clinical variables

Demographic and clinical data on current age, sex, borough of residence along with diagnostic data on chronic disease co-morbidity was extracted from the electronic record. All values were the latest recorded before the study date of March 2017.

Data analysis

All analyses were carried out using Stata version 14 (Statacorp, College Station, TX,

USA). Analyses were stratified by sex to account for established differences in rates of obesity between men and women.

To examine odds of obesity for different ethnic groups (White Other, Black Caribbean, Black African, Indian, Bangladeshi, Pakistani, Chinese) compared to the majority British/Irish White ethnic group, we used a two-level logistic regression model, with individuals nested in MSOA. Age, borough, deprivation (IMD score), and presence of serious mental illness or diabetes were included in the model as these were independently associated with both obesity and ethnicity.

To assess the relationship between ethnic density and obesity, a similar two-level logistic regression model was used. In common with previous studies on ethnic density effects, we choose 10% as the threshold interval above which an association with a change in the odds of being obese was sought,[17 19] A priori confounders included age, borough and deprivation (IMD score). Analysis was conducted separately for each ethnic group.

We hypothesized that younger adults may be more acculturated to the majority ethnic group and thus show a different relationship between obesity and ethnic density, hence we stratified the analysis by those aged 18–35 years and those aged >35 years. To examine the robustness of association, we performed several sensitivity analyses including: broadening ethnic grouping into Black, Asian and White, using different thresholds of BMI to include to individuals overweight (BMI>25) or obese (BMI>30) and using different ethnicity specific cut-offs for obesity status. We also repeated the analysis using ethnic density calculated from primary care records rather than census data.

Patient and Public Involvement

No patients or members of the public were involved in the design of this study.

Results

From a total of 792,395 GP registered adults aged 18 and over on 5th March 2017, 755,381 were resident within the study area. From this population 415,166 had a BMI measure within the last 3 years and were free of recorded pregnancy at the time of measurement. The mean age of the included population was 43.2 years and 48.3% were male. The largest ethnic group was White British/Irish, which represented 24.5% of the study population. Over half the population were either overweight (31.9%) or obese (23.1%). Same group ethnic density varied across different MSOA, the largest variation was seen among Bangladeshi population with an average ethnic density of 16%, ranging from a minimum of 1% to maximum of 53%, with similar ranges among Indian (average 7%, range 1%-40%) and White British (average 27%, range 4-53%). Pakistani (average 4%, range 0-21%) and Black African (average 9%, range 1-26%) both had smaller ranges. Chinese (average 2%, range 0-10%) and Black Caribbean (average 5%, range 1-13%) had the least variation (table 1).

The adjusted odds of obesity by ethnic group are reported in Figure 1 (and appendix table 1). In comparison with the White group those with the highest odds of obesity were Black African women (OR 3.10; [95% CI 2.99-3.22]), Caribbean (OR 2.20; [95% CI 2.10-2.30]), and Pakistani women (OR 2.07; [1.97-2.18]). In contrast, Chinese men (OR 0.28; [95% CI 0.24 - 0.33]), and women (OR 0.17; [95% CI 0.14-0.20]), had significantly lower odds of obesity compared to the White population.

The association between a 10% increase in own-group ethnic density and the prevalence of obesity is described in Table 2. We found no association between increasing ethnic density and obesity prevalence for any of the ethnic groups except for Black African men and women and

Indian women. A 10% increase in Black African ethnic density was associated with a 15% (95%CI 1.07-1.24) increased odds of obesity among Black African men and 18% increase among Black African women (95%CI 1.08-1.30). This association was present for both obese (BMI ≥30 kg/m^2) and overweight and obese (BMI≥25 kg/m^2) BMI categories; but was not present in those under 35 years of age (table 3). A 10% increase in Indian ethnic density was associated with a 6% (95%CI 0.88-0.99) decrease in odds of obesity among Indian women, there was no significant association among Indian men, and this association was not present for overweight Indian women or those under 35 years of age (table 3). Sensitivity analyses using different thresholds for ethnic density, different BMI cut offs, different age groups and clustering related ethnic groups did not significantly change the main results (Appendix Table 2).

Discussion

Main findings

Overall, 23.1% of our study population were recorded as obese with considerable variation by ethnic group. Prevalence of obesity among men and women was highest among Black Africans and Caribbean groups (both ~39%) and lowest among Chinese ethnic groups (5%). In men, odds of obesity were higher among Black ethnic groups compared to White British/Irish males and lower among Chinese, Indian, Bangladeshi, and White Other ethnic groups. Among women, all ethnic groups except Chinese and White Other had increased odds of obesity compared to White British/Irish women.

We found a 10% increase in Black African ethnic density was associated with a 15% and

18% increased odds of obesity among Black African men and women respectively. This association was present for both obesity and overweight BMI categories but was not present in those under 35 years of age. Among Indian women, a 10% increase in Indian ethnic density was associated with a 7% decrease in odds of obesity, but this association was not present at different cut offs for obesity or for Indian men.

Comparison with existing literature

The crude prevalence of obesity was lower in our study population (23%) compared to England (27%),[2] reflecting the younger age distribution of the east London population. Our findings of variation in prevalence of obesity among ethnic groups demonstrated similar trends to the 2004 Health Survey for England (HSE) study of adult obesity among ethnic groups in England.[4] However, among Indian and Bangladeshi females, we found the odds of obesity were higher compared to White British/Irish females which was not apparent in the 2004 HSE.[4]

Despite a growing number of studies examining the ethnic density effect, empirical evidence on the mechanism and underlying pathways remains scant. Among studies exploring ethnic density, protective associations have most commonly been identified for mental health outcomes compared to studies examining physical health measures.[15] Such studies have recently been extended to risk taking behaviour such as smoking, where Mathur et al. found increasing ethnic density was associated with a significant reduction in smoking prevalence among all ethnic groups except Black Caribbean females.[17]

Our data suggest such protective associations do not extend to the risk of obesity among White British/Irish and Bangladeshi ethnic groups. Among Indian females, increasing ethnic density may be protective against obesity, however this was not a robust finding in sensitivity analysis and was not strongly significant (95%CI 0.88-0.99). Among Black Africans, however, increasing ethnic density was found to be strongly associated as a risk factor for obesity. This is

consistent with findings from the US, which found ethnic density was a risk factor for obesity among certain ethnic groups.[22 34] However, there is little consistency between US studies in determining which ethnic groups are influenced by ethnic density,[23] and studies vary in their use of ethnic group categorization and in the size of geographical area used to calculate ethnic density, which typically tends to be much larger than we have used.

The lack of effect for most ethnic groups may reflect the complex and competing cultural influences on weight, as well as the overwhelming influence of other factors – in particular the "foodscape", which describes the exposure of individuals to food outlets in a geographical area.[35 36] Previous research on ethnic density and access to food outlets in England, found increasing ethnic density was associated with larger numbers of fast food outlets and supermarkets.[37] Such exposure may nullify any benefits of preserving traditional eating habits.

Research among Black ethnic groups living in America suggests that, compared to other ethnic groups, Black ethnic groups have a strong cultural preference for higher body weight.[38 39] Such cultural norms may be amplified in areas of increased ethnic density, where acculturation to the western preferences of body size may be weaker. For example, we found the association between Black Africans and increased same ethnic density only among older age groups (over 35 years); younger generations may be more acculturated to the western preferences of body size, preferring lower BMI.

The lack of variability in ethnic density among the Black Caribbean population meant we were unable to examine the association of ethnic density and obesity among this group. In a sensitivity analysis we clustered Black Africans and Black Caribbean together, finding no association between increasing Black ethnic density and prevalence of obesity among Black males or females (appendix table 2). This suggests the effects of ethnic density are not

generalizable to other Black ethnic groups and reflect distinct differences between the Black Africans and Caribbean populations particularly in terms of migration history and residency in the UK. [40] The longer period of residence among Black Caribbean groups may weaken any effect of ethnic density as the population has more time to acculturate to Western norms.

Strengths and limitations

To date, this is the largest study of adult obesity prevalence among ethnic groups in England, including over 400,000 individuals, of whom over 75% are from ethnic minority groups. It is among the first studies exploring the relationship between ethnic density and obesity in the UK.[21] The size of this study means that our findings are unlikely to have arisen by chance, reflected in our narrow confidence intervals for effect size. We explored the consistency of our results by performing a number of sensitivity analyses which confirmed no significant associations for different weight thresholds, different age groups and different clusters of related ethnic groups (appendix table 1).

The use of routine data introduces potential bias, with the risk of non random absence of data. In common with many variables in electronic health care records, BMI recording is incomplete, [41] as it is recorded opportunistically or when of clinical relevance. Completeness of BMI recording may also vary by ethnic group, as different ethnic groups vary in their use of primary care services.[42] This may lead to differential recording as a source of bias.

We were unable to adjust for other potential confounders of the relationship between ethnic density and obesity, such as availability of green space and density of fast food outlets, and we could not explore differences within ethnic groups in terms of migratory history and religion, which may influence diet and behavior. It is also possible that residual confounding occurred in our proxy measure of individual deprivation by using IMD. This may have inadequately

measured individual deprivation and potentially masked any ethnic density effect.

Implications for practice and policy

The obesity epidemic, and associated health effects, is structured by social deprivation and by ethnic group. Our data suggest that environmental factors such as food, exercise and cultural norms play a greater role in determining obesity than the ethnic composition of the area. Health policy should continue to focus on the known environmental factors that influence obesity such as the proximity of highly calorific food,[35] availability of green space[43] and encouraging active transport.[44]

Further understanding of the ethnic disparities in the UK obesity epidemic may best be served by learning from groups with the lowest prevalence of obesity such as the Chinese populations. Understanding the mechanisms through which Chinese immigrant populations in the UK maintain a healthy body weight may help formulate policy relevant to other ethnic groups. Further research is also needed to explore why among Black Africans, increasing own-group ethnic density is associated with obesity and how this can be tackled to reduce the burden of obesity experienced by Black Africans living in the UK.

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Table 1. Characteristics of the study population

Characteristic	Total	White		Black		Asian				Other	
		British/Irish	Other	African	Caribbean	Chinese	Bangladeshi	Indian	Pakistani	Mixed/ other[a]	Missing/not stated
N	415,166	101,710	87,157	30,761	18,239	6,584	51,575	29,250	16,884	52,650	20,356
Mean age, years (SD)	43.2 (16.3)	45.9 (18.5)	37.6 (13.4)	46.6 (14.1)	55.0 (17.3)	37.0 (15.1)	43.2 (14.6)	44.8 (16.0)	44.2 (15.2)	43.4 (15.6)	36.7 (13.8)
Sex:											
Male (%)	48.3	48.0	45.8	47.2	41.8	38.4	53.0	53.6	56.2	46.2	49.7
IMD score (SD)	42.0 (9.6)	41.3 (10.1)	41.7 (9.9)	45.0 (8.8)	43.5 (8.3)	39.2 (12.1)	43.5 (9.1)	39.7 (7.9)	40.9 (7.3)	42.4 (9.2)	40.7 (10.7)
Residence:											
Hackney (n)	127,256	38,744	32,693	11,286	8,667	1,360	2,312	3,874	1,047	19,753	7,520
Newham (n)	172,357	29,274	31,229	16,407	7,642	1,953	19,831	22,450	14,741	22,842	5,988
Tower Hamlets (n)	115,553	33,692	23,235	3,068	1,930	3,271	29,432	2,926	1,096	10,055	6,848
Weight status:											
BMI <20 (%)	8.2	8.9	10.9	3.3	3.8	23.1	5.9	6.9	5.3	7.5	12.0
BMI 20-25 (%)	36.8	40.3	44.8	21.2	23.0	52.8	34.1	34.7	26.3	33.7	42.8
BMI 25-30 (%)	31.9	28.4	27.0	36.3	34.5	19.2	41.1	37.4	38.6	32.9	27.3
BMI >30 (%)	23.1	22.5	17.4	39.3	38.8	4.9	18.9	21.0	29.8	25.8	18.0
Own group Ethnic density across different MSOA[b]											
Average (%)		27	13	9	5	2	16	7	4	-	-
Minimum (%)		4	4	1	1	0	1	1	0	-	-
Maximum (%)		53	28	26	13	10	53	40	21	-	-

[a] Mixed/other (=White and Black Caribbean, White and Black African, White and Asian, Other mixed, Other Black, Other Asian, Other ethnic group)
[b] MSOA = Middle super output area

Figure 1. Multi-level logistic regression of adjusted odds* of obesity by ethnic group and sex, compared to White British/Irish

*Adjusted for age, deprivation, borough of residence, presence of serious mental illness or diabetes

Table 2. Multi-level logistic regression of adjusted odds* of being obese given a 10% increase in own-group ethnic density for the study ethnic groups.

Ethnic group	Male		Female	
	OR (95%CI)	P-value	OR (95%CI)	P-value
Bangladeshi	1.00 (0.97-1.04)	0.72	1.00 (0.95-1.06)	0.89
Black African	1.15 (1.07-1.24)	<0.001	1.18 (1.08-1.30)	<0.001
Indian	1.03 (0.96-1.09)	0.44	0.93 (0.88-0.99)	0.02
Pakistani	1.06 (0.96-1.17)	0.22	1.05 (0.95-1.15)	0.32
White British/Irish	0.98 (0.93-1.04)	0.60	0.98 (0.93-1.04)	0.56

*Adjusted for age, deprivation and borough of residence

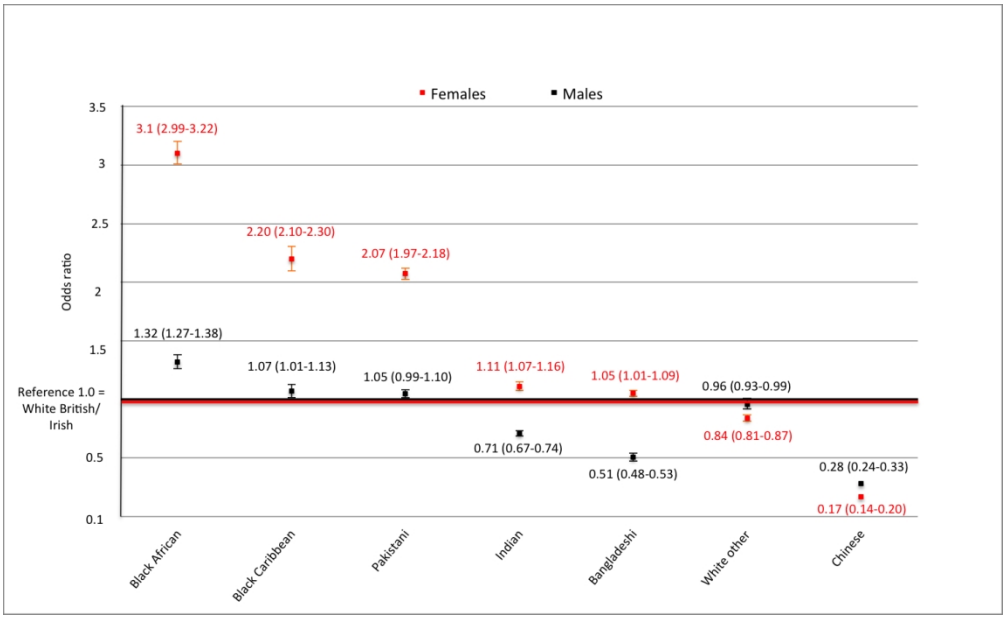
Table 3. Multi-level logistic regression of adjusted* odds ratio of 10% increase in area own-ethnic density and obesity prevalence by study ethnic group, stratified by sex and age group

	Male				Female			
	Under 35		Over 35		Under 35		Over 35	
Ethnic group	OR (95%CI)	p-value	OR (95%CI)	p-value	OR (95%CI)	p-value	OR (95%CI)	p-value
Bangladeshi	0.99 (0.94-1.05)	0.82	1.02 (0.98-1.07)	0.31	1.03 (0.96-1.13)	0.35	0.98 (0.93-1.04)	0.60
Black African	1.08 (0.96-1.28)	0.17	1.14 (1.06-1.23)	<0.001	1.13 (0.90-1.43)	0.29	1.19 (1.08-1.31)	<0.001
Indian	1.04 (0.95-1.14)	0.41	1.02 (0.95-1.10)	0.63	0.91 (0.82-1.00)	0.67	0.94 (0.89-0.99)	0.03
Pakistani	1.18 (0.97-1.43)	0.09	1.02 (0.92-1.13)	0.73	0.99 (0.83-1.18)	0.92	1.05 (0.94-1.17)	0.40
White British	0.99 (0.89-1.10)	0.84	0.96 (0.91-1.00)	0.09	1.05 (0.95-1.16)	0.37	0.96 (0.91-1.01)	0.13

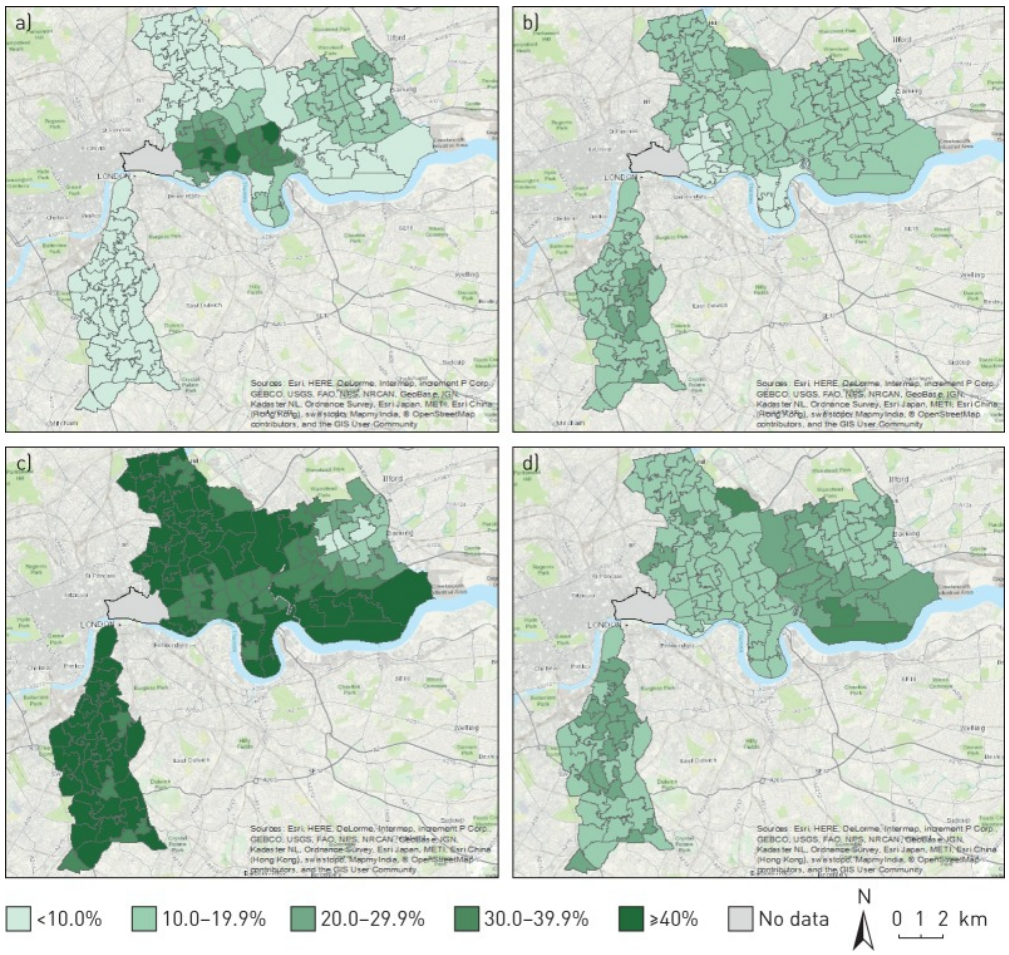
*Adjusted for age, deprivation and borough of residence

Figure 2.* Ethnic density distributions (%) by Middle Super Output Area mapped across east London: a) Bangladeshi, b) Caribbean, c) White and d) African with south London comparator area.

* Adapted from Mathur R, Schofield P, Smith D, et al. Is individual smoking behaviour influenced by area-level ethnic density? A cross-sectional electronic health database study of inner south-East London. *ERJ Open Research* 2017;3(1)



Multi-level logistic regression of adjusted odds* of obesity by ethnic group and sex, compared to White British/Irish



Ethnic density distributions (%) by Middle Super Output Area mapped across east London: a) Bangladeshi, b) Caribbean, c) White and d) African with south London comparator area.

67x63mm (300 x 300 DPI)

Appendix table 1

Multi-level logistic regression of adjusted odds* of obesity by ethnic group and sex, compared to White British/Irish

	Male		Female	
	OR (95%CI)	p-value	OR (95%CI)	p-value
White British/Irish (reference group)	1		1	
Black African	1.32 (1.38-1.27)	<0.01	3.10 (3.22-2.99)	<0.01
Black Caribbean	1.07 (1.13-1.01)	0.02	2.70 (2.30-2.20)	<0.01
Pakistani	1.05 (1.10-0.99)	0.11	2.07 (2.18-1.97)	<0.01
Indian	0.71 (0.74-0.67)	<0.01	1.11 (1.16-1.07)	<0.01
Bangladeshi	0.51 (0.53-0.48)	<0.01	1.05 (1.09-1.01)	0.01
White other	0.96 (0.99-0.93)	0.02	0.84 (0.87-0.81)	<0.01
Chinese	0.28 (0.33-0.24)	<0.01	0.17 (0.20-0.14)	<0.01

*Adjusted for age, deprivation, borough of residence, presence of serious mental illness and diabetes

Appendix Table 2

Sensitivity analysis

Ethnic group	Male		Female	
	OR (95%CI)	p-value	OR (95%CI)	p-value
Multi-level logistic regression of adjusted* odds ratio of 10% increase in area own-ethnic density and obesity or overweight prevalence by ethnic group				
Bangladeshi	0.99 (0.95-1.02)	0.43	0.99 (0.95-1.04)	0.74
Black African	1.21 (1.12-1.32)	<0.001	1.15 (1.06-1.26)	0.001
Indian	1.05 (0.98-1.12)	0.17	0.95 (0.91-0.99)	0.05
Pakistani	1.16 (1.05-1.27)	0.003	1.11 (1.00-1.22)	0.06
White British	1.02 (0.96-1.07)	0.56	1.04 (0.99-1.09)	0.13
Multi-level logistic regression of adjusted* odds ratio of 10% increase in area own-ethnic density and obesity or overweight prevalence by ethnic group, using primary care data for ethnic density				
Bangladeshi	1.01 (0.97-1.04)	0.68	1.00 (0.95-1.06)	0.89
Black African	1.14 (1.05-1.23)	<0.001	1.18 (1.08-1.30)	<0.001
Indian	1.02 (0.97-1.09)	0.40	0.95 (0.90-0.99)	0.04
Pakistani	1.08 (0.98-1.19)	0.13	1.06 (0.96-1.16)	0.24
White British	0.98 (0.92-1.04)	0.49	0.96 (0.91-1.02)	0.18
Multi-level logistic regression of adjusted odds ratio of 10% increase in area own-ethnic density and obesity prevalence by ethnic group, (obesity cut off 27.5 for Asian groups)				
Bangladeshi	1.00 (0.95-1.04)	0.926	1.04 (1.05-1.07)	0.024
Black African	1.18 (1.08-1.30)	<0.001	1.17 (1.08-1.27)	<0.001
Indian	0.94 (0.89-1.00)	0.064	1.05 (0.98-1.13)	0.171
Pakistani	1.09 (1.00-1.19)	0.044	1.06 (0.95-1.19)	0.287
White British	0.98 (0.93-1.04)	0.60	0.99 (0.94-1.05)	0.756
Multi-level logistic regression of adjusted* odds ratio of 10% increase in area own-ethnic density and obesity or overweight prevalence by broad ethnic group				
Asian (Bangladeshi, Indian, Pakistani)	1.02 (0.9-9-1.06)	0.20	0.97 (0.94-1.01)	0.15
Black (African and Caribbean)	1.03 (0.97-1.09)	0.30	1.04 (0.97-1.12)	0.29
White European (White British, Irish, European)	0.96 (0.93-0.99)	0.04	0.98 (0.94-1.02)	0.28

Appendix 2 - STROBE Statement

	Item No	Recommendation	Page/location
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Abstract
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Introduction
Objectives	3	State specific objectives, including any prespecified hypotheses	Introduction
Methods			
Study design	4	Present key elements of study design early in the paper	Abstract
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Methods (study setting)
Participants	6	(*a*) *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	Methods
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Methods
Data sources/ measurement	8	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*Methods*
Bias	9	Describe any efforts to address potential sources of bias	Discussion (limitations)
Study size	10	Explain how the study size was arrived at	Not applicable
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were	Methods

		chosen and why	
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Methods
		(*b*) Describe any methods used to examine subgroups and interactions	Methods
		(*c*) Explain how missing data were addressed	Discussion (limitations)
		(*d*) *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	Not relevant (no sampling)
		(*e*) Describe any sensitivity analyses	Methods
Results			
Participants	13	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Results (single stage study design)
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Results (Table 1)
		(b) Indicate number of participants with missing data for each variable of interest	Results
Outcome data	15	*Cross-sectional study*—Report numbers of outcome events or summary measures	*Results*
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Results – single model strategy
		(*b*) Report category boundaries when continuous variables	Methods

		were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Not applicable
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Results
Discussion			
Key results	18	Summarise key results with reference to study objectives	Discussion
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Discussion
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Discussion
Generalisability	21	Discuss the generalisability (external validity) of the study results	Not discussed. Exploratory concept.
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Title Page

BMJ Open

Does the ethnic density effect extend to obesity? A cross-sectional study of 415,166 adults in East London

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Does the ethnic density effect extend to obesity? A cross-sectional study of 415,166 adults in East London

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Figures: 2

Tables: 3

Appendix

Keywords: ethnic density; obesity; body mass index

SS is guarantor of the report. SS affirms that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned have been explained.

Abstract

Objective: To examine the association between increasing own group ethnic density and obesity prevalence, by sex and ethnic group.

Design and Setting: Cross-sectional study utilising electronic primary care records of 128 practices in a multi-ethnic population of East London.

Participants: Electronic primary care records of 415,166 adults with a body mass index (BMI) recorded in the previous three years.

Outcome measures:

1. Odds of obesity for different ethnic groups compared to White British.
2. Prevalence of obesity associated with each 10% increase in own-group ethnic density, by ethnic group.

Results: Using multi-level logistic regression models we find that compared to White British/Irish males, the odds of obesity was significantly higher among Black ethnic groups and significantly lower among Asian and White Other groups. Among females, all ethnic groups except Chinese and White Other were at increased odds of obesity compared to White British/Irish.

There was no association between increasing ethnic density and obesity prevalence, except among Black Africans and Indian females. A 10% increase in Black ethnic density was associated with a 15% increase in odds of obesity among Black African males (95% CI 1.07-1.24) and 18% among Black African females (95% CI 1.08-1.30). Among Indian females, a 10% increase in Indian ethnic density was associated with a 7% decrease in odds of obesity (95% CI 0.88-0.99).

Conclusion: Wider environmental factors play a greater role in determining obesity than the ethnic composition of the area for most ethnic groups. Further research is needed to

understand the mechanism through which increasing ethnic density is associated with increased odds of obesity among Black Africans and decreased odds of obesity among Indian females.

Strengths and limitations of this study

- To date this is the largest study on ethnic density and obesity in the UK, including primary care data from over 400,000 individuals.
- Ethnicity recording was over 90% in the primary care records from this multiethnic area, allowing us to use a large routine dataset with multiple ethnic groups for the study.
- We were able to measure ethnic density at small, neighborhood level, rather than over large geographical areas.
- No data was available to adjust for potential confounders of the relationship between ethnic density and obesity such as proximity to fast food outlets and availability of green space.
- We used the Index of Multiple Deprivation, derived from census data, as a proxy measure of individual deprivation; this may inadequately measure individual deprivation.

Contributions

SH designed the study. SS extracted relevant data from electronic health records. SS and RM conducted statistical analysis and all authors contributed to data interpretation and revising drafts produced by SS. All authors had full access to all the data collected, have checked for accuracy and have approved the final version of this manuscript.

Data Sharing

No additional data is available.

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Disclaimer: This article presents independent research. The views expressed in this publication are those of the author(s) and not necessarily those of the NHS, the Health Foundation, or the University.

Ethical approval

Ethical approval was not required as patient-level data are anonymised and aggregated patient data are reported in this study. All GPs in the participating east London practices consented to the use of their anonymised patient data for research and development for patient benefit.

Provenance

Freely submitted; externally peer reviewed.

Competing interests

The authors have declared no competing interests.

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Does the ethnic density effect extend to obesity? A cross-sectional study of 415,166 adults in East London

Introduction

Tackling obesity is a major public health priority as worldwide prevalence continues to rise.[1] In England, 27% of men and women are obese and this is predicted to rise to over 40% by 2035.[2 3] Prevalence varies by ethnic group and gender; this may be the result of differences between ethnic groups in socioeconomic status, diet, physical activity and cultural factors. [4 5] These in turn may be influenced by the ethnic composition of the area and the process of acculturation; whereby over time, minority groups change their everyday behaviours including dietary practices and follow the cultural norms of the majority population resulting in weight gain. [6 7 8] Hence with increasing duration of residence and among subsequent generations, obesity increases to the level of the predominant ethnic group.[9 10] Ethnic density may modify this process of acculturation. Higher levels of own group ethnic density may encourage individuals to follow traditional eating habits,[11] provide greater social support and protect against stress;[12] and stress is strongly associated with weight gain.[13 14]

Most research on ethnic density has been conducted in the area of mental health where increasing own ethnic density has a protective effect on a range of mental health outcomes. [9,15 16 17-19 20] Beyond mental health, increasing ethnic density has been found protective against smoking, where increasing own-group ethnic density was associated with reduced odds of smoking.[17] The causal pathways through which the ethnic density effect operates have yet to be fully elucidated; the most researched hypothesis suggests that the buffering effect of increased own group ethnic density protects individuals against experiences of racism and discrimination alongside increased opportunity to build social capital.[12 15] While these

mechanisms provide plausible hypotheses for protection against mental illness, it is less clear how this pathway affects health behaviour such as smoking and whether it extends to obesity. Current United Kingdom (UK) research on this topic is limited.[21] Studies from the United States (US), typically measuring ethnic density over large metropolitan areas have found mixed effects. [22 23 24]

Results in the UK are likely to differ from other countries due to different patterns of migration, duration of acculturation and population densities. We hypothesise that high own group ethnic density exerts a protective effect against acculturation. This in turn may reduce the risk of obesity for ethnic minority individuals living in areas of high own group ethnic density. Using primary care data from three ethnically diverse, coterminous boroughs in East London, we report the prevalence of obesity among different ethnic groups and examine the association between own group ethnic density and obesity prevalence.

Methods

Study setting

The National Health Service (NHS) provides comprehensive health care, free at the point of delivery for residents in England, funded through taxation. The vast majority of the population are registered with a General Practice (GP) to access primary care services. We utilised anonymised, coded primary care data from the electronic health records held by the Clinical Effectiveness Group (CEG) for this cross-sectional observational study.

The adjoining east London boroughs of Tower Hamlets, Newham and Hackney are ethnically diverse, with a non-white British population of 52%, 61% and 49% respectively, compared to 30% in London and 14% in England.[25] The high proportion of minority ethnic groups makes east London an ideal area to study ethnic density effects.

We extracted demographic and clinical data for adults aged 18 years and over currently registered at the 128 practices in these localities.

Obesity

Obesity measures were obtained by extracting data on body mass index (BMI) categorized into obese, overweight or normal/underweight based on a BMI above 30 kg/m^2, between 25 to 29.9 kg/m^2 or below 24.9 kg/m^2 respectively. We utilised BMI as it is routinely measured in primary care in contrast to other weight measures (e.g. waist circumference), which are poorly recorded. Uniform thresholds for obesity were used for all ethnic groups. We included a sensitivity analysis applying lower BMI thresholds to define obesity in South Asians, to reflect their increased risk of type 2 diabetes at lower levels of BMI.[26] Participants were included if they had at least one BMI measure in the previous three years (2014-2017), the most recent BMI was used. Women who were pregnant at the time of BMI measurement were excluded.

Ethnicity and ethnic density

Individual level ethnicity was extracted from primary care health records. Ethnicity is self-reported by the patient at registration or during consultation, and coded based on the UK Census categorization hierarchies. Reported ethnicity was collapsed into the 16 groups of the 2011 UK Census,[27] these were further collapsed into 9 groups: White British (White British, White Irish), White Other, Black African, Black Caribbean, Indian , Pakistani, Bangladeshi, Chinese, Mixed/other (White and Black Caribbean, White and Black African, White and Asian, Other mixed, Other Black, Other Asian, Other ethnic group). Recording of adult ethnicity in primary care health records is over 90% across the study area, following previous incentives to improve the quality of practice-based, self-reported ethnicity. [28 29]

Ethnic density was calculated as the percentage of people from each ethnic group living within each Middle Super Output Area (MSOA), obtained from the 2011 census. [30] MSOA has been used previously as the geographical area to calculate ethnic density and consists of an average population size of 7,790. In the study area of east London, with a population density of 12,600 individuals per square kilometer, we estimate an average MSOA covers 0.6 km^2 in this area. We found that ethnic density varied sufficiently across our study area to be used for analysis among White British, Black African, Indian, Pakistani and Bangladeshi groups only; there was insufficient variability in ethnic density among Black Caribbean and Chinese populations for further analysis in our study (See figure 1).

We also undertook a sensitivity analysis using primary care data to calculate ethnic density.

Socio-economic deprivation

A proxy measure of individual socio-economic deprivation (Index of multiple deprivation, IMD) was obtained for each patient based on their LSOA (Lower Super Output Area) of residence. IMD is a widely used measure of relative deprivation in England, combining information on seven domains of deprivation (income, employment, education, health and disability, housing and living environment) from census data.[31]

Demographic and clinical variables

Demographic and clinical data on current age, sex, borough of residence along with diagnostic data on chronic disease co-morbidity was extracted from the electronic record. All values were the latest recorded before the study date of March 2017.

Data analysis

All analyses were carried out using Stata version 14 (Statacorp, College Station, TX, USA). Analyses were stratified by sex to account for established differences in rates of obesity between men and women.

To examine odds of obesity for different ethnic groups (White Other, Black Caribbean,

Black African, Indian, Bangladeshi, Pakistani, Chinese) compared to the majority British/Irish White ethnic group, we used a two-level logistic regression model, with individuals nested in MSOA. Age, borough, deprivation (IMD score), and presence of serious mental illness or diabetes were included in the model as these were independently associated with both obesity and ethnicity.

To assess the relationship between ethnic density and obesity, a similar two-level logistic regression model was used. In common with previous studies on ethnic density effects, we choose 10% as the threshold interval above which an association with a change in the odds of being obese was sought.[17 19] A priori confounders included age, borough and deprivation (IMD score). Analysis was conducted separately for each ethnic group.

We hypothesized that younger adults may be more acculturated to the majority ethnic group and thus show a different relationship between obesity and ethnic density, hence we stratified the analysis by those aged 18–35 years and those aged >35 years. To examine the robustness of association, we performed several sensitivity analyses including: broadening ethnic grouping into Black, Asian and White, using different thresholds of BMI to include to individuals overweight (BMI>25) or obese (BMI>30) and using different ethnicity specific cut-offs for obesity status. We also repeated the analysis using ethnic density calculated from primary care records rather than census data.

Patient and Public Involvement

No patients or members of the public were involved in the design of this study.

Results

From a total of 792,395 GP registered adults aged 18 and over on 5th March 2017, 755,381 were resident within the study area. From this population 415,166 had a BMI measure within the last 3 years and were free of recorded pregnancy at the time of measurement. The mean age of the included population was 43.2 years and 48.3% were male. The largest ethnic group was White British/Irish, which represented 24.5% of the study population. Over half the population were either overweight (31.9%) or obese (23.1%). Same group ethnic density varied across different MSOA, the largest variation was seen among Bangladeshi population with an average ethnic density of 16%, ranging from a minimum of 1% to maximum of 53%, with similar ranges among Indian (average 7%, range 1%-40%) and White British (average 27%, range 4-53%). Pakistani (average 4%, range 0-21%) and Black African (average 9%, range 1-26%) both had smaller ranges. Chinese (average 2%, range 0-10%) and Black Caribbean (average 5%, range 1-13%) had the least variation (table 1).

The adjusted odds of obesity by ethnic group are reported in Figure 2 (and appendix table 1). In comparison with the White group those with the highest odds of obesity were Black African women (OR 3.10; [95% CI 2.99-3.22]), Caribbean (OR 2.20; [95% CI 2.10-2.30]), and Pakistani women (OR 2.07; [1.97-2.18]). In contrast, Chinese men (OR 0.28; [95% CI 0.24 - 0.33]), and women (OR 0.17; [95% CI 0.14-0.20]), had significantly lower odds of obesity compared to the White population.

The association between a 10% increase in own-group ethnic density and the prevalence of obesity is described in Table 2. We found no association between increasing ethnic density and obesity prevalence for any of the ethnic groups except for Black African men and women

and Indian women. A 10% increase in Black African ethnic density was associated with a 15% (95%CI 1.07-1.24) increased odds of obesity among Black African men and 18% increase among Black African women (95%CI 1.08-1.30). This association remained in our sensitivity analyses when changing the threshold of weight, from obese to overweight (BMI≥25 kg/m^2) (appendix table 2). Among Indian women, a 10% increase in Indian ethnic density was associated with a 6% (95%CI 0.88-0.99) decrease in odds of obesity. There was no significant association among Indian men, and in sensitivity analysis the association was not present for overweight Indian women (appendix table 2). In those under 35 years of age, there was no association between increasing ethnic density and obesity among any ethnic groups (table 3). Sensitivity analyses using different thresholds for ethnic density, different BMI cut offs, different age groups and clustering related ethnic groups did not significantly change the main results (Appendix Table 2).

Discussion

Main findings

Overall, 23.1% of our study population were recorded as obese with considerable variation by ethnic group. Prevalence of obesity among men and women was highest among Black Africans and Caribbean groups (both ~39%) and lowest among Chinese ethnic groups (5%). In men, odds of obesity were higher among Black ethnic groups compared to White British/Irish males and lower among Chinese, Indian, Bangladeshi, and White Other ethnic groups. Among women, all ethnic groups except Chinese and White Other had increased odds of obesity compared to White British/Irish women.

We found a 10% increase in Black African ethnic density was associated with a 15% and 18% increased odds of obesity among Black African men and women respectively. This association was present for both obesity and overweight BMI categories but was not present in those under 35 years of age. Among Indian women, a 10% increase in Indian ethnic density was associated with a 6% decrease in odds of obesity, but this association was not present at different cut offs for obesity or for Indian men.

Comparison with existing literature

The crude prevalence of obesity was lower in our study population (23%) compared to England (27%),[2] reflecting the younger age distribution of the east London population. Our findings of variation in prevalence of obesity among ethnic groups demonstrated similar trends to the 2004 Health Survey for England (HSE) study of adult obesity among ethnic groups in England.[4] However, among Indian and Bangladeshi females, we found the odds of obesity were higher compared to White British/Irish females which was not apparent in the 2004 HSE.[4]

Despite a growing number of studies examining the ethnic density effect, empirical evidence on the mechanism and underlying pathways remains scant. Among studies exploring ethnic density, protective associations have most commonly been identified for mental health

outcomes compared to studies examining physical health measures.[15] Such studies have recently been extended to risk taking behaviour such as smoking, where Mathur et al. found increasing ethnic density was associated with a significant reduction in smoking prevalence among all ethnic groups except Black Caribbean females.[17]

Our data suggest such protective associations do not extend to the risk of obesity among White British/Irish and Bangladeshi ethnic groups. Among Indian females, increasing ethnic density may be protective against obesity, however this was not a robust finding in sensitivity analysis and was not strongly significant (95%CI 0.88-0.99). Among Black Africans, however, increasing ethnic density was found to be strongly associated as a risk factor for obesity. This is consistent with findings from the US, which found ethnic density was a risk factor for obesity among certain ethnic groups.[22 32] However, there is little consistency between US studies in determining which ethnic groups are influenced by ethnic density,[23] and studies vary in their use of ethnic group categorization and in the size of geographical area used to calculate ethnic density, which typically tends to be much larger than we have used.

The lack of effect for most ethnic groups may reflect the complex and competing cultural influences on weight, as well as the overwhelming influence of other factors – in particular the "foodscape", which describes the exposure of individuals to food outlets in a geographical area.[33 34] Previous research on ethnic density and access to food outlets in England, found increasing ethnic density was associated with larger numbers of fast food outlets and supermarkets.[35] Such exposure may nullify any benefits of preserving traditional eating habits.

Research among Black ethnic groups living in America suggests that, compared to other ethnic groups, Black ethnic groups have a strong cultural preference for higher body weight.[36 37] Such cultural norms may be amplified in areas of increased ethnic density, where acculturation to the western preferences of body size may be weaker. For example, we found the association

between Black Africans and increased same ethnic density only among older age groups (over 35 years); younger generations may be more acculturated to the western preferences of body size, preferring lower BMI.

The lack of variability in ethnic density among the Black Caribbean population meant we were unable to examine the association of ethnic density and obesity among this group. In a sensitivity analysis we clustered Black Africans and Black Caribbean together, finding no association between increasing Black ethnic density and prevalence of obesity among Black males or females (appendix table 2). This suggests the effects of ethnic density are not generalizable to other Black ethnic groups and reflect distinct differences between the Black Africans and Caribbean populations particularly in terms of migration history and residency in the UK. [38] The longer period of residence among Black Caribbean groups may weaken any effect of ethnic density as the population has more time to acculturate to Western norms.

Strengths and limitations

To date, this is the largest study of adult obesity prevalence among ethnic groups in England, including over 400,000 individuals, of whom over 75% are from ethnic minority groups. It is among the first studies exploring the relationship between ethnic density and obesity in the UK.[21] The size of this study means that our findings are unlikely to have arisen by chance, reflected in our narrow confidence intervals for effect size. We explored the consistency of our results by performing a number of sensitivity analyses which confirmed no significant associations for different weight thresholds, different age groups and different clusters of related ethnic groups (appendix table 1).

The use of routine data introduces potential bias, with the risk of non random absence of data.

In common with many variables in electronic health care records, BMI recording is incomplete,[39] as it is recorded opportunistically or when of clinical relevance. We found differences in the proportions of individuals with a BMI recorded in the last 3 years by ethnic group. The highest completeness was among Black Caribbean, with 80.9% having a BMI taken in the last 3 years, and lowest among Bangladeshis with 61.6%. These differences may reflect variation by ethnic groups in their use of primary care services.[40] This may lead to differential recording as a source of bias. It is difficult to determine the direction of bias. Those individuals with no recent measure of BMI were younger and free of chronic diseases.

We were unable to adjust for other potential confounders of the relationship between ethnic density and obesity, such as availability of green space and density of fast food outlets, and we could not explore differences within ethnic groups in terms of migratory history and religion, which may influence diet and behavior. It is also possible that residual confounding occurred in our proxy measure of individual deprivation by using IMD. We were also unable to measure deprivation at the level at which ethnic density was recorded. Our proxy measure of individual deprivation, IMD, is measured at the LSOA level and likely to have captured deprivation at the level ethnic density was recorded. However, it is possible it did not fully capture deprivation thereby potentially masking any ethnic density effect.

Implications for practice and policy

The obesity epidemic, and associated health effects, is structured by social deprivation and by ethnic group. Our data suggest ethnic density does not play protective role in preventing obesity. It is possible that environmental factors such as food, exercise and cultural norms play a greater role in determining obesity than the ethnic composition of the area. Health policy should continue to focus on the known environmental factors that influence obesity such as the

proximity of highly calorific food,[33] availability of green space[41] and encouraging active transport.[42]

Further understanding of the ethnic disparities in the UK obesity epidemic may best be served by learning from groups with the lowest prevalence of obesity such as the Chinese populations. Understanding the mechanisms through which Chinese immigrant populations in the UK maintain a healthy body weight may help formulate policy relevant to other ethnic groups. Further research is also needed to explore why among Black Africans, increasing own-group ethnic density is associated with obesity and how this can be tackled to reduce the burden of obesity experienced by Black Africans living in the UK.

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Table 1. Characteristics of the study population

Characteristic	Total	White		Black		Asian				Other	
		British/Irish	Other	African	Caribbean	Chinese	Bangladeshi	Indian	Pakistani	Mixed/ other[a]	Missing/not stated
N	415,166	101,710	87,157	30,761	18,239	6,584	51,575	29,250	16,884	52,650	20,356
Mean age, years (SD)	43.2 (16.3)	45.9 (18.5)	37.6 (13.4)	46.6 (14.1)	55.0 (17.3)	37.0 (15.1)	43.2 (14.6)	44.8 (16.0)	44.2 (15.2)	43.4 (15.6)	36.7 (13.8)
Sex:											
Male (%)	48.3	48.0	45.8	47.2	41.8	38.4	53.0	53.6	56.2	46.2	49.7
IMD score (SD)	42.0 (9.6)	41.3 (10.1)	41.7 (9.9)	45.0 (8.8)	43.5 (8.3)	39.2 (12.1)	43.5 (9.1)	39.7 (7.9)	42.9 (7.3)	42.4 (9.2)	40.7 (10.7)
Residence:											
Hackney (n)	127,256	38,744	32,693	11,286	8,667	1,360	2,312	3,874	1,047	19,753	7,520
Newham (n)	172,357	29,274	31,229	16,407	7,642	1,953	19,831	22,450	4,741	22,842	5,988
Tower Hamlets (n)	115,553	33,692	23,235	3,068	1,930	3,271	29,432	2,926	1,096	10,055	6,848
Weight status:											
BMI <20 (%)	8.2	8.9	10.9	3.3	3.8	23.1	5.9	6.9	5.3	7.5	12.0
BMI 20-25 (%)	36.8	40.3	44.8	21.2	23.0	52.8	34.1	34.7	26.3	33.7	42.8
BMI 25-30 (%)	31.9	28.4	27.0	36.3	34.5	19.2	41.1	37.4	38.6	32.9	27.3
BMI >30 (%)	23.1	22.5	17.4	39.3	38.8	4.9	18.9	21.0	29.8	25.8	18.0
Own group Ethnic density across different MSOA[b]											
Average (%)		27	13	9	5	2	16	7	4	-	-
Minimum (%)		4	4	1	1	0	1	1	0	-	-
Maximum (%)		53	28	26	13	10	53	40	21	-	-

[a] Mixed/other (=White and Black Caribbean, White and Black African, White and Asian, Other mixed, Other Black, Other Asian, Other ethnic group)

[b] MSOA = Middle super output area

Figure 1.* Ethnic density distributions (%) by Middle Super Output Area mapped across east London: a) Bangladeshi, b) Caribbean, c) White and d) African with south London comparator area.

* Adapted from Mathur R, Schofield P, Smith D, et al. Is individual smoking behaviour influenced by area-level ethnic density? A cross-sectional electronic health database study of inner south-East London. *ERJ Open Research* 2017;3(1)

Figure 2. Multi-level logistic regression of adjusted odds* of obesity by ethnic group and sex, compared to White British/Irish

*Adjusted for age, deprivation, borough of residence, presence of serious mental illness or diabetes

Table 2. Multi-level logistic regression of adjusted odds* of being obese given a 10% increase in own-group ethnic density for the study ethnic groups.

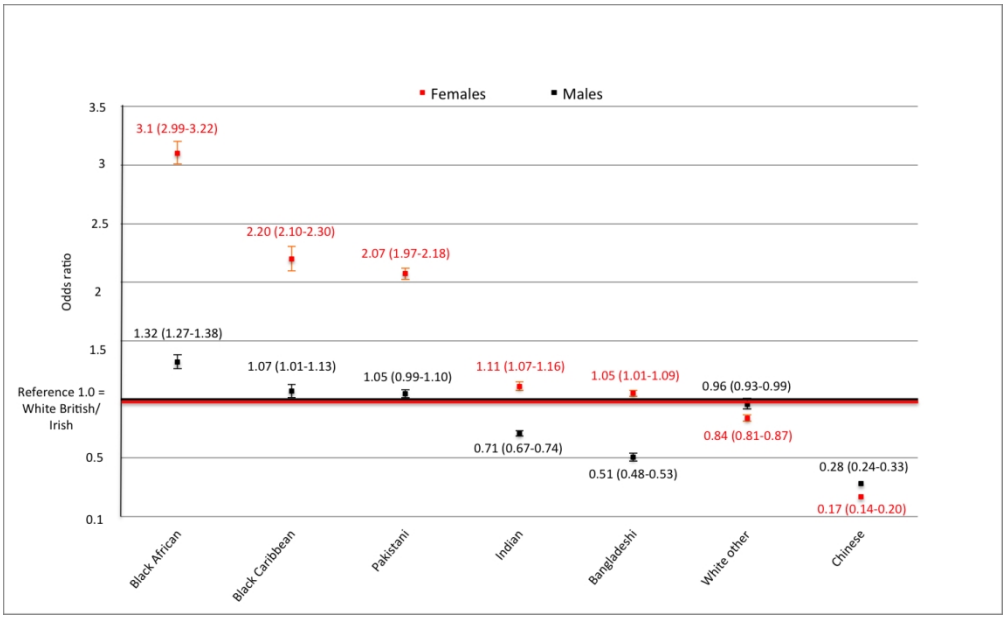
Ethnic group	Male		Female	
	OR (95%CI)	P-value	OR (95%CI)	P-value
Bangladeshi	1.00 (0.97-1.04)	0.72	1.00 (0.95-1.06)	0.89
Black African	1.15 (1.07-1.24)	<0.001	1.18 (1.08-1.30)	<0.001
Indian	1.03 (0.96-1.09)	0.44	0.93 (0.88-0.99)	0.02
Pakistani	1.06 (0.96-1.17)	0.22	1.05 (0.95-1.15)	0.32
White British/Irish	0.98 (0.93-1.04)	0.60	0.98 (0.93-1.04)	0.56

*Adjusted for age, deprivation and borough of residence

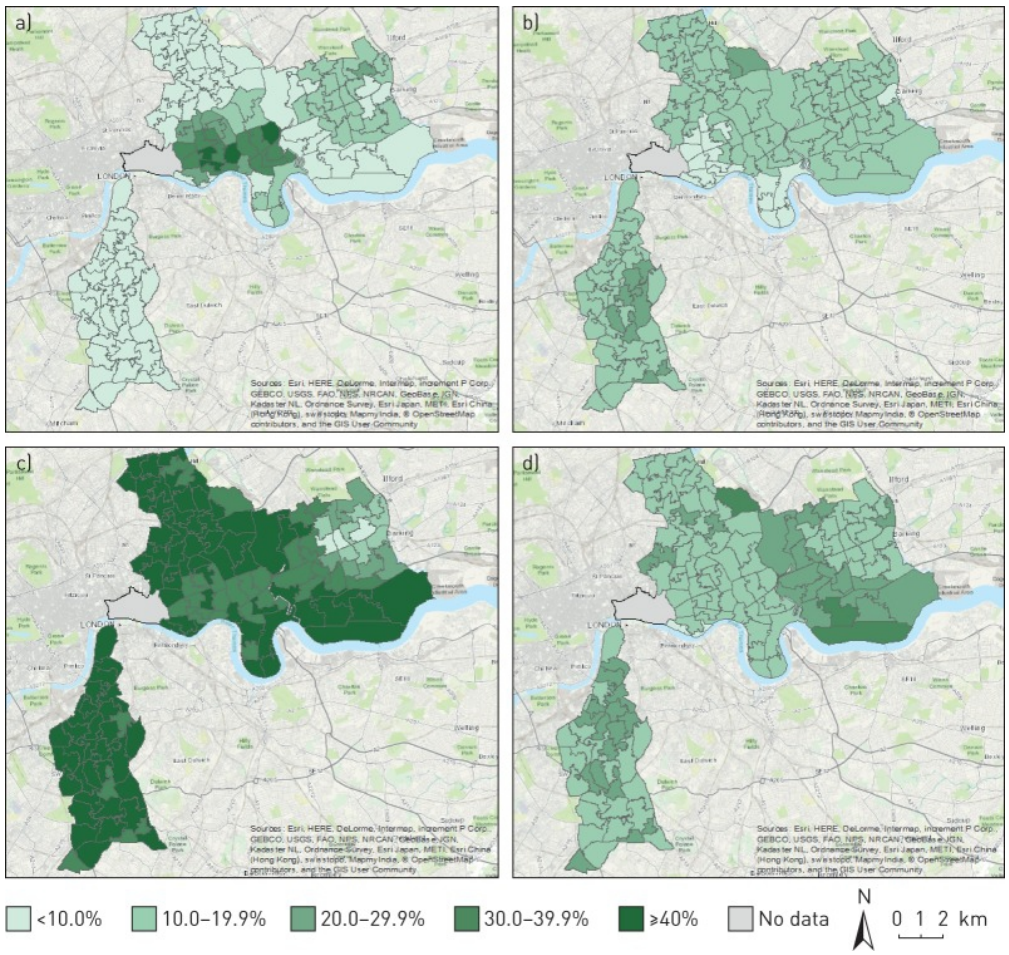
Table 3. Multi-level logistic regression of adjusted* odds ratio of 10% increase in area own-ethnic density and obesity prevalence by study ethnic group, stratified by sex and age group

	Male				Female			
	Under 35		Over 35		Under 35		Over 35	
Ethnic group	OR (95%CI)	p-value	OR (95%CI)	p-value	OR (95%CI)	p-value	OR (95%CI)	p-value
Bangladeshi	0.99 (0.94-1.05)	0.82	1.02 (0.98-1.07)	0.31	1.03 (0.96-1.13)	0.35	0.98 (0.93-1.04)	0.60
Black African	1.08 (0.96-1.28)	0.17	1.14 (1.06-1.23)	<0.001	1.13 (0.90-1.43)	0.29	1.19 (1.08-1.31)	<0.001
Indian	1.04 (0.95-1.14)	0.41	1.02 (0.95-1.10)	0.63	0.91 (0.82-1.00)	0.67	0.94 (0.89-0.99)	0.03
Pakistani	1.18 (0.97-1.43)	0.09	1.02 (0.92-1.13)	0.73	0.99 (0.83-1.18)	0.92	1.05 (0.94-1.17)	0.40
White British	0.99 (0.89-1.10)	0.84	0.96 (0.91-1.00)	0.09	1.05 (0.95-1.16)	0.37	0.96 (0.91-1.01)	0.13

*Adjusted for age, deprivation and borough of residence



Multi-level logistic regression of adjusted odds* of obesity by ethnic group and sex, compared to White British/Irish



Ethnic density distributions (%) by Middle Super Output Area mapped across east London: a) Bangladeshi, b) Caribbean, c) White and d) African with south London comparator area.

67x63mm (300 x 300 DPI)

Appendix table 1

Multi-level logistic regression of adjusted odds* of obesity by ethnic group and sex, compared to White British/Irish

	Male		Female	
	OR (95%CI)	p-value	OR (95%CI)	p-value
White British/Irish (reference group)	1		1	
Black African	1.32 (1.38-1.27)	<0.01	3.10 (3.22-2.99)	<0.01
Black Caribbean	1.07 (1.13-1.01)	0.02	2.70 (2.30-2.20)	<0.01
Pakistani	1.05 (1.10-0.99)	0.11	2.07 (2.18-1.97)	<0.01
Indian	0.71 (0.74-0.67)	<0.01	1.11 (1.16-1.07)	<0.01
Bangladeshi	0.51 (0.53-0.48)	<0.01	1.05 (1.09-1.01)	0.01
White other	0.96 (0.99-0.93)	0.02	0.84 (0.87-0.81)	<0.01
Chinese	0.28 (0.33-0.24)	<0.01	0.17 (0.20-0.14)	<0.01

*Adjusted for age, deprivation, borough of residence, presence of serious mental illness and diabetes

Appendix Table 2

Sensitivity analysis

Ethnic group	Male		Female	
	OR (95%CI)	p-value	OR (95%CI)	p-value
Multi-level logistic regression of adjusted* odds ratio of 10% increase in area own-ethnic density and obesity or overweight prevalence by ethnic group				
Bangladeshi	0.99 (0.95-1.02)	0.43	0.99 (0.95-1.04)	0.74
Black African	1.21 (1.12-1.32)	<0.001	1.15 (1.06-1.26)	0.001
Indian	1.05 (0.98-1.12)	0.17	0.95 (0.91-0.99)	0.05
Pakistani	1.16 (1.05-1.27)	0.003	1.11 (1.00-1.22)	0.06
White British	1.02 (0.96-1.07)	0.56	1.04 (0.99-1.09)	0.13
Multi-level logistic regression of adjusted* odds ratio of 10% increase in area own-ethnic density and obesity or overweight prevalence by ethnic group, using primary care data for ethnic density				
Bangladeshi	1.01 (0.97-1.04)	0.68	1.00 (0.95-1.06)	0.89
Black African	1.14 (1.05-1.23)	<0.001	1.18 (1.08-1.30)	<0.001
Indian	1.02 (0.97-1.09)	0.40	0.95 (0.90-0.99)	0.04
Pakistani	1.08 (0.98-1.19)	0.13	1.06 (0.96-1.16)	0.24
White British	0.98 (0.92-1.04)	0.49	0.96 (0.91-1.02)	0.18
Multi-level logistic regression of adjusted odds ratio of 10% increase in area own-ethnic density and obesity prevalence by ethnic group, (obesity cut off 27.5 for Asian groups)				
Bangladeshi	1.00 (0.95-1.04)	0.926	1.04 (1.05-1.07)	0.024
Black African	1.18 (1.08-1.30)	<0.001	1.17 (1.08-1.27)	<0.001
Indian	0.94 (0.89-1.00)	0.064	1.05 (0.98-1.13)	0.171
Pakistani	1.09 (1.00-1.19)	0.044	1.06 (0.95-1.19)	0.287
White British	0.98 (0.93-1.04)	0.60	0.99 (0.94-1.05)	0.756
Multi-level logistic regression of adjusted* odds ratio of 10% increase in area own-ethnic density and obesity or overweight prevalence by broad ethnic group				
Asian (Bangladeshi, Indian, Pakistani)	1.02 (0.9-9-1.06)	0.20	0.97 (0.94-1.01)	0.15
Black (African and Caribbean)	1.03 (0.97-1.09)	0.30	1.04 (0.97-1.12)	0.29
White European (White British, Irish, European)	0.96 (0.93-0.99)	0.04	0.98 (0.94-1.02)	0.28

Appendix 2 - STROBE Statement

	Item No	Recommendation	Page/location
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Abstract
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Introduction
Objectives	3	State specific objectives, including any prespecified hypotheses	Introduction
Methods			
Study design	4	Present key elements of study design early in the paper	Abstract
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Methods (study setting)
Participants	6	(*a*) *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	Methods
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Methods
Data sources/ measurement	8	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*Methods*
Bias	9	Describe any efforts to address potential sources of bias	Discussion (limitations)
Study size	10	Explain how the study size was arrived at	Not applicable
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were	Methods

		chosen and why	
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Methods
		(*b*) Describe any methods used to examine subgroups and interactions	Methods
		(*c*) Explain how missing data were addressed	Discussion (limitations)
		(*d*) *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	Not relevant (no sampling)
		(*e*) Describe any sensitivity analyses	Methods
Results			
Participants	13	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Results (single stage study design)
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Results (Table 1)
		(b) Indicate number of participants with missing data for each variable of interest	Results
Outcome data	15	*Cross-sectional study*—Report numbers of outcome events or summary measures	*Results*
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Results – single model strategy
		(*b*) Report category boundaries when continuous variables	Methods

		were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Not applicable
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Results
Discussion			
Key results	18	Summarise key results with reference to study objectives	Discussion
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Discussion
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Discussion
Generalisability	21	Discuss the generalisability (external validity) of the study results	Not discussed. Exploratory concept.
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Title Page

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Does the ethnic density effect extend to obesity? A cross-sectional study of 415,166 adults in East London

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Does the ethnic density effect extend to obesity? A cross-sectional study of 415,166 adults in East London

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Word count excluding abstract: 3,167

Figures: 2

Tables: 3

Appendix

Keywords: ethnic density; obesity; body mass index

SS is guarantor of the report. SS affirms that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned have been explained.

Abstract

Objectives: To examine the prevalence of obesity by ethnic group and to examine the association between ethnic density and obesity prevalence.

Design and Setting: Cross-sectional study utilising electronic primary care records of 128 practices in a multi-ethnic population of East London.

Participants: Electronic primary care records of 415,166 adults with a body mass index (BMI) recorded in the previous three years.

Outcome measures:

1. Odds of obesity for different ethnic groups compared to White British.
2. Prevalence of obesity associated with each 10% increase in own-group ethnic density, by ethnic group.

Results: Using multi-level logistic regression models we find that compared to White British/Irish males, the odds of obesity was significantly higher among Black ethnic groups and significantly lower among Asian and White Other groups. Among females, all ethnic groups except Chinese and White Other were at increased odds of obesity compared to White British/Irish.

There was no association between increasing ethnic density and obesity prevalence, except among Black Africans and Indian females. A 10% increase in Black ethnic density was associated with a 15% increase in odds of obesity among Black African males (95% CI 1.07-1.24) and 18% among Black African females (95% CI 1.08-1.30). Among Indian females, a 10% increase in Indian ethnic density was associated with a 7% decrease in odds of obesity (95% CI 0.88-0.99).

Conclusion: Wider environmental factors play a greater role in determining obesity than the ethnic composition of the area for most ethnic groups. Further research is needed to understand the mechanism through which increasing ethnic density is associated with

increased odds of obesity among Black Africans and decreased odds of obesity among Indian females.

Strengths and limitations of this study

- To date this is the largest study on ethnic density and obesity in the UK, including primary care data from over 400,000 individuals.
- Ethnicity recording was over 90% in the primary care records from this multiethnic area, allowing us to use a large routine dataset with multiple ethnic groups for the study.
- We were able to measure ethnic density at small, neighborhood level, rather than over large geographical areas.
- No data was available to adjust for potential confounders of the relationship between ethnic density and obesity such as proximity to fast food outlets and availability of green space.
- We used the Index of Multiple Deprivation, derived from census data, as a proxy measure of individual deprivation; this may inadequately measure individual deprivation.

Contributions

SH designed the study. SS extracted relevant data from electronic health records. SS and RM conducted statistical analysis and all authors contributed to data interpretation and revising drafts produced by SS. All authors had full access to all the data collected, have checked for accuracy and have approved the final version of this manuscript.

Data Sharing

No additional data is available.

Funding

This research received no specific grant from any funding agency.

Disclaimer: This article presents independent research. The views expressed in this

publication are those of the author(s) and not necessarily those of the NHS, the Health Foundation, or the University.

Ethical approval

Ethical approval was not required as patient-level data are anonymised and aggregated patient data are reported in this study. All GPs in the participating east London practices consented to the use of their anonymised patient data for research and development for patient benefit.

Provenance

Freely submitted; externally peer reviewed.

Competing interests

The authors have declared no competing interests.

Acknowledgements

The authors are grateful to the participating GPs for their cooperation, without which, such studies would be impossible.

The authors are grateful for advice and support on data extraction from Kate Homer.

Does the ethnic density effect extend to obesity? A cross-sectional study of 415,166 adults in East London

Introduction

Tackling obesity is a major public health priority as worldwide prevalence continues to rise.[1] In England, 27% of men and women are obese and this is predicted to rise to over 40% by 2035.[2 3] Prevalence varies by ethnic group and gender. Variation may be the result of differences in socioeconomic status, lifestyle and cultural factors. [4 5] Lifestyle factors, including diet, change over time as minority groups adopt the dietary norms of the majority population around them, by a process of acculturation, which often results in weight gain. [6 7 8 9 10] Ethnic density may modify this process of acculturation. Higher levels of own group ethnic density may encourage individuals to follow traditional eating habits,[11] provide greater social support and protect against stress;[12] and stress is strongly associated with weight gain.[13, 14]

Most research on ethnic density has been conducted in the area of mental health where increasing own ethnic density has a protective effect on a range of mental health outcomes. [9,15 16 17-19 20] Beyond mental health, increasing ethnic density has been found protective against smoking, where increasing own-group ethnic density was associated with reduced odds of smoking.[17] The causal pathways through which the ethnic density effect operates have yet to be fully elucidated; the most researched hypothesis suggests that the buffering effect of increased own group ethnic density protects individuals against experiences of racism and discrimination alongside increased opportunity to build social capital and reduce stress.[12 15] While these mechanisms provide plausible hypotheses for protection against mental illness, it is less clear how this pathway affects health behaviour such as smoking and whether it extends to obesity. Current United Kingdom (UK) research on this topic is limited.[21] Studies

from the United States (US), typically measuring ethnic density over large metropolitan areas have found mixed effects. [22 23 24]

Results in the UK are likely to differ from other countries due to different patterns of migration, duration of acculturation and population densities. We hypothesise that high own group ethnic density exerts a protective effect against acculturation. This in turn may reduce the risk of obesity for ethnic minority individuals living in areas of high own group ethnic density. Using primary care data from three ethnically diverse, coterminous boroughs in East London, we report the prevalence of obesity among different ethnic groups and examine the association between own group ethnic density and obesity prevalence.

Methods

Study setting

The National Health Service (NHS) provides comprehensive health care, free at the point of delivery for residents in England, funded through taxation. The vast majority of the population are registered with a General Practice (GP) to access primary care services. We utilised anonymised, coded primary care data from the electronic health records held by the Clinical Effectiveness Group (CEG) for this cross-sectional observational study.

The adjoining east London boroughs of Tower Hamlets, Newham and Hackney are ethnically diverse, with a non-white British population of 52%, 61% and 49% respectively, compared to 30% in London and 14% in England.[25] The high proportion of minority ethnic groups makes east London an ideal area to study ethnic density effects.

We extracted demographic and clinical data for adults aged 18 years and over currently registered at the 128 practices in these localities.

Obesity

Obesity measures were obtained by extracting data on body mass index (BMI) categorized into obese, overweight or normal/underweight based on a BMI above 30 kg/m^2, between 25 to 29.9 kg/m^2 or below 24.9 kg/m^2 respectively. We utilised BMI as it is routinely measured in primary care in contrast to other weight measures (e.g. waist circumference), which are poorly recorded. Uniform thresholds for obesity were used for all ethnic groups. We included a sensitivity analysis applying lower BMI thresholds to define obesity in South Asians, to reflect their increased risk of type 2 diabetes at lower levels of BMI.[26] Participants were included if they had at least one BMI measure in the previous three years (2014-2017), the most recent BMI was used. Women who were pregnant at the time of BMI measurement were excluded.

Ethnicity and ethnic density

Individual level ethnicity was extracted from primary care health records. Ethnicity is self-reported by the patient at registration or during consultation, and coded based on the UK Census categorization hierarchies. Reported ethnicity was collapsed into the 16 groups of the 2011 UK Census,[27] these were further collapsed into 9 groups: White British (White British, White Irish), White Other, Black African, Black Caribbean, Indian , Pakistani, Bangladeshi, Chinese, Mixed/other (White and Black Caribbean, White and Black African, White and Asian, Other mixed, Other Black, Other Asian, Other ethnic group). Recording of adult ethnicity in primary care health records is over 90% across the study area, following previous incentives to improve the quality of practice-based, self-reported ethnicity. [28 29]

Ethnic density was calculated as the percentage of people from each ethnic group living within each Middle Super Output Area (MSOA), obtained from the 2011 census. [30] MSOA has been used previously as the geographical area to calculate ethnic density and consists of an average population size of 7,790. In the study area of east London, with a population

density of 12,600 individuals per square kilometer, we estimate an average MSOA covers 0.6 km^2 in this area. We found that ethnic density varied sufficiently across our study area to be used for analysis among White British, Black African, Indian, Pakistani and Bangladeshi groups only; there was insufficient variability in ethnic density among Black Caribbean and Chinese populations for further analysis in our study (See figure 1).

We also undertook a sensitivity analysis using primary care data to calculate ethnic density.

Socio-economic deprivation

A proxy measure of individual socio-economic deprivation (Index of multiple deprivation, IMD) was obtained for each patient based on their LSOA (Lower Super Output Area) of residence. IMD is a widely used measure of relative deprivation in England, combining information on seven domains of deprivation (income, employment, education, health and disability, housing and living environment) from census data.[31]

Demographic and clinical variables

Demographic and clinical data on current age, sex, borough of residence along with diagnostic data on chronic disease co-morbidity was extracted from the electronic record. All values were the latest recorded before the study date of March 2017.

Data analysis

All analyses were carried out using Stata version 14 (Statacorp, College Station, TX, USA). Analyses were stratified by sex to account for established differences in rates of obesity between men and women.

To examine odds of obesity for different ethnic groups (White Other, Black Caribbean, Black African, Indian, Bangladeshi, Pakistani, Chinese) compared to the majority British/Irish White ethnic group, we used a two-level logistic regression model, with

individuals nested in MSOA. Age, borough, deprivation (IMD score), and presence of serious mental illness or diabetes were included in the model as these were independently associated with both obesity and ethnicity.

To assess the relationship between ethnic density and obesity, a similar two-level logistic regression model was used. In common with previous studies on ethnic density effects, we choose 10% as the threshold interval above which an association with a change in the odds of being obese was sought.[17 19] A priori confounders included age, borough and deprivation (IMD score). Analysis was conducted separately for each ethnic group.

We hypothesized that younger adults may be more acculturated to the majority ethnic group and thus show a different relationship between obesity and ethnic density, hence we stratified the analysis by those aged 18–35 years and those aged >35 years. To examine the robustness of association, we performed several sensitivity analyses including: broadening ethnic grouping into Black, Asian and White, using different thresholds of BMI to include to individuals overweight (BMI>25) or obese (BMI>30) and using different ethnicity specific cut-offs for obesity status. We also repeated the analysis using ethnic density calculated from primary care records rather than census data.

Patient and Public Involvement

No patients or members of the public were involved in the design of this study.

Results

From a total of 792,395 GP registered adults aged 18 and over on 5th March 2017, 755,381 were resident within the study area. From this population 415,166 had a BMI measure within the last 3 years and were free of recorded pregnancy at the time of measurement. The mean age of the included population was 43.2 years and 48.3% were male. The largest ethnic group was White British/Irish, which represented 24.5% of the study population. Over half the population were either overweight (31.9%) or obese (23.1%). Same group ethnic density varied across different MSOA, the largest variation was seen among Bangladeshi population with an average ethnic density of 16%, ranging from a minimum of 1% to maximum of 53%, with similar ranges among Indian (average 7%, range 1%-40%) and White British (average 27%, range 4-53%). Pakistani (average 4%, range 0-21%) and Black African (average 9%, range 1-26%) both had smaller ranges. Chinese (average 2%, range 0-10%) and Black Caribbean (average 5%, range 1-13%) had the least variation (table 1).

The adjusted odds of obesity by ethnic group are reported in Figure 2. In comparison with the White group those with the highest odds of obesity were Black African women (OR 3.10; [95% CI 2.99-3.22]), Caribbean (OR 2.20; [95% CI 2.10-2.30]), and Pakistani women (OR 2.07; [1.97-2.18]). In contrast, Chinese men (OR 0.28; [95% CI 0.24 -0.33]), and women (OR 0.17; [95% CI 0.14-0.20]), had significantly lower odds of obesity compared to the White population.

The association between a 10% increase in own-group ethnic density and the prevalence of obesity is described in Table 2. We found no association between increasing ethnic density and obesity prevalence for any of the ethnic groups except for Black African men and women

and Indian women. A 10% increase in Black African ethnic density was associated with a 15% (95%CI 1.07-1.24) increased odds of obesity among Black African men and 18% increase among Black African women (95%CI 1.08-1.30). This association remained in our sensitivity analyses when changing the threshold of weight, from obese to overweight (BMI≥25 kg/m^2) (appendix table 1). Among Indian women, a 10% increase in Indian ethnic density was associated with a 7% (95%CI 0.88-0.99) decrease in odds of obesity. There was no significant association among Indian men, and in sensitivity analysis the association was not present for overweight Indian women (appendix table 1). In those under 35 years of age, there was no association between increasing ethnic density and obesity among any ethnic groups (table 3). Sensitivity analyses using different thresholds for ethnic density, different BMI cut offs, different age groups and clustering related ethnic groups did not significantly change the main results (appendix table 1).

Discussion

Main findings

Overall, 23.1% of our study population were recorded as obese with considerable variation by ethnic group. Prevalence of obesity among men and women was highest among Black Africans and Caribbean groups (both ~39%) and lowest among Chinese ethnic groups (5%). In men, odds of obesity were higher among Black ethnic groups compared to White British/Irish males and lower among Chinese, Indian, Bangladeshi, and White Other ethnic groups. Among women, all ethnic groups except Chinese and White Other had increased odds of obesity compared to White British/Irish women.

We found a 10% increase in Black African ethnic density was associated with a 15% and 18% increased odds of obesity among Black African men and women respectively. This association was present for both obesity and overweight BMI categories but was not present in those under 35 years of age. Among Indian women, a 10% increase in Indian ethnic density was associated with a 7% decrease in odds of obesity, but this association was not present at different cut offs for obesity or for Indian men.

Comparison with existing literature

The crude prevalence of obesity was lower in our study population (23%) compared to England (27%),[2] reflecting the younger age distribution of the east London population. Our findings of variation in prevalence of obesity among ethnic groups demonstrated similar trends to the 2004 Health Survey for England (HSE) study of adult obesity among ethnic groups in England.[4] However, among Indian and Bangladeshi females, we found the odds of obesity were higher compared to White British/Irish females which was not apparent in the 2004 HSE.[4]

Despite a growing number of studies examining the ethnic density effect, empirical evidence on the mechanism and underlying pathways remains scant. Among studies exploring ethnic density, protective associations have most commonly been identified for mental health outcomes compared to studies examining physical health measures.[15] Such studies have recently been extended to risk taking behaviour such as smoking, where Mathur et al. found increasing ethnic density was associated with a significant reduction in smoking prevalence among all ethnic groups except Black Caribbean females.[17]

Our data suggest such protective associations do not extend to the risk of obesity among White British/Irish and Bangladeshi ethnic groups. Among Indian females, increasing ethnic density may be protective against obesity, however this was not a robust finding in sensitivity analysis and was not strongly significant (95%CI 0.88-0.99). Among Black Africans, however, increasing ethnic density was found to be strongly associated as a risk factor for obesity. This is consistent with findings from the US, which found ethnic density was a risk factor for obesity among certain ethnic groups.[22 32] However, there is little consistency between US studies in determining which ethnic groups are influenced by ethnic density,[23] and studies vary in their use of ethnic group categorization and in the size of geographical area used to calculate ethnic density, which typically tends to be much larger than we have used.

The lack of effect for most ethnic groups may reflect the complex and competing cultural influences on weight, as well as the overwhelming influence of other factors – in particular the "foodscape", which describes the exposure of individuals to food outlets in a geographical area.[33 34] Previous research on ethnic density and access to food outlets in England, found increasing ethnic density was associated with larger numbers of fast food outlets and supermarkets.[35] Such exposure may nullify any benefits of preserving traditional eating habits.

Research among Black ethnic groups living in America suggests that, compared to other ethnic groups, Black ethnic groups have a strong cultural preference for higher body weight.[36 37] Such cultural norms may be amplified in areas of increased ethnic density, where acculturation to the western preferences of body size may be weaker. For example, we found the association between Black Africans and increased same ethnic density only among older age groups (over 35 years); younger generations may be more acculturated to the western preferences of body size, preferring lower BMI.

The lack of variability in ethnic density among the Black Caribbean population meant we were unable to examine the association of ethnic density and obesity among this group. In a sensitivity analysis we clustered Black Africans and Black Caribbean together, finding no association between increasing Black ethnic density and prevalence of obesity among Black males or females (appendix table 1). This suggests the effects of ethnic density are not generalizable to other Black ethnic groups and reflect distinct differences between the Black Africans and Caribbean populations particularly in terms of migration history and residency in the UK. [38] The longer period of residence among Black Caribbean groups may weaken any effect of ethnic density as the population has more time to acculturate to Western norms.

Strengths and limitations

To date, this is the largest study of adult obesity prevalence among ethnic groups in England, including over 400,000 individuals, of whom over 75% are from ethnic minority groups. It is among the first studies exploring the relationship between ethnic density and obesity in the UK.[21] The size of this study means that our findings are unlikely to have arisen by chance, reflected in our narrow confidence intervals for effect size. We explored the consistency of our results by performing a number of sensitivity analyses which confirmed no significant associations for different weight thresholds,

different age groups and different clusters of related ethnic groups (appendix table 1).

The use of routine data introduces potential bias, with the risk of non random absence of data. In common with many variables in electronic health care records, BMI recording is incomplete,[39] as it is recorded opportunistically or when of clinical relevance. We found differences in the proportions of individuals with a BMI recorded in the last 3 years by ethnic group. The highest completeness was among Black Caribbean, with 80.9% having a BMI taken in the last 3 years, and lowest among Bangladeshis with 61.6%. These differences may reflect variation by ethnic groups in their use of primary care services.[40] This may lead to differential recording as a source of bias. It is difficult to determine the direction of bias. Those individuals with no recent measure of BMI were younger and free of chronic diseases and therefore less likely to be obese, resulting in an overestimate of obesity prevalence in those ethnic groups with higher proportions of missing BMI data. However, while this may impact our estimates for obesity prevalence between ethnic groups, it is unlikely to have effected the examination of ethnic density and obesity prevalence within ethnic groups.

We were unable to adjust for other potential confounders of the relationship between ethnic density and obesity, such as availability of green space and density of fast food outlets, and we could not explore differences within ethnic groups in terms of migratory history and religion, which may influence diet and behavior. It is also possible that residual confounding occurred in our proxy measure of individual deprivation by using IMD. We were also unable to measure deprivation at the level at which ethnic density was recorded. Our proxy measure of individual deprivation, IMD, is measured at the LSOA level and likely to have captured deprivation at the level ethnic density was recorded. However, it is possible it did not fully capture deprivation thereby potentially masking any ethnic density effect.

Implications for practice and policy

The obesity epidemic, and associated health effects, is structured by social deprivation and by ethnic group. Our data suggest ethnic density does not play protective role in preventing obesity. It is possible that environmental factors such as food, exercise and cultural norms play a greater role in determining obesity than the ethnic composition of the area. Health policy should continue to focus on the known environmental factors that influence obesity such as the proximity of highly calorific food,[33] availability of green space[41] and encouraging active transport.[42]

Further understanding of the ethnic disparities in the UK obesity epidemic may best be served by learning from groups with the lowest prevalence of obesity such as the Chinese populations. Understanding the mechanisms through which Chinese immigrant populations in the UK maintain a healthy body weight may help formulate policy relevant to other ethnic groups. Further research is also needed to explore why among Black Africans, increasing own-group ethnic density is associated with obesity and how this can be tackled to reduce the burden of obesity experienced by Black Africans living in the UK.

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Table 1. Characteristics of the study population

Characteristic	Total	White		Black		Asian				Other	
		British/Irish	Other	African	Caribbean	Chinese	Bangladeshi	Indian	Pakistani	Mixed/ other[a]	Missing/not stated
N	415,166	101,710	87,157	30,761	18,239	6,584	51,575	29,250	16,884	52,650	20,356
Mean age, years (SD)	43.2 (16.3)	45.9 (18.5)	37.6 (13.4)	46.6 (14.1)	55.0 (17.3)	37.0 (15.1)	43.2 (14.6)	44.8 (16.0)	44.2 (15.2)	43.4 (15.6)	36.7 (13.8)
Sex:											
Male (%)	48.3	48.0	45.8	47.2	41.8	38.4	53.0	53.6	56.2	46.2	49.7
IMD score (SD)	42.0 (9.6)	41.3 (10.1)	41.7 (9.9)	45.0 (8.8)	43.5 (8.3)	39.2 (12.1)	43.5 (9.1)	39.7 (7.9)	42.9 (7.3)	42.4 (9.2)	40.7 (10.7)
Residence:											
Hackney (n)	127,256	38,744	32,693	11,286	8,667	1,360	2,312	3,874	1,047	19,753	7,520
Newham (n)	172,357	29,274	31,229	16,407	7,642	1,953	19,831	22,450	4,741	22,842	5,988
Tower Hamlets (n)	115,553	33,692	23,235	3,068	1,930	3,271	29,432	2,926	1,096	10,055	6,848
Weight status:											
BMI <20 (%)	8.2	8.9	10.9	3.3	3.8	23.1	5.9	6.9	5.3	7.5	12.0
BMI 20-25 (%)	36.8	40.3	44.8	21.2	23.0	52.8	34.1	34.7	26.3	33.7	42.8
BMI 25-30 (%)	31.9	28.4	27.0	36.3	34.5	19.2	41.1	37.4	38.6	32.9	27.3
BMI >30 (%)	23.1	22.5	17.4	39.3	38.8	4.9	18.9	21.0	29.8	25.8	18.0
Own group Ethnic density across different MSOA[b]											
Average (%)		27	13	9	5	2	16	7	4	-	-
Minimum (%)		4	4	1	1	0	1	1	0	-	-
Maximum (%)		53	28	26	13	10	53	40	21	-	-

[a] Mixed/other (=White and Black Caribbean, White and Black African, White and Asian, Other mixed, Other Black, Other Asian, Other ethnic group)

[b] MSOA = Middle super output area

Figure 1.* Ethnic density distributions (%) by Middle Super Output Area mapped across east London: a) Bangladeshi, b) Caribbean, c) White and d) African with south London comparator area.

* Adapted from Mathur R, Schofield P, Smith D, et al. Is individual smoking behaviour influenced by area-level ethnic density? A cross-sectional electronic health database study of inner south-East London. *ERJ Open Research* 2017;3(1)

Figure 2. Multi-level logistic regression of adjusted odds* of obesity by ethnic group and sex, compared to White British/Irish

*Adjusted for age, deprivation, borough of residence, presence of serious mental illness or diabetes

Table 2. Multi-level logistic regression of adjusted odds* of being obese given a 10% increase in own-group ethnic density for the study ethnic groups.

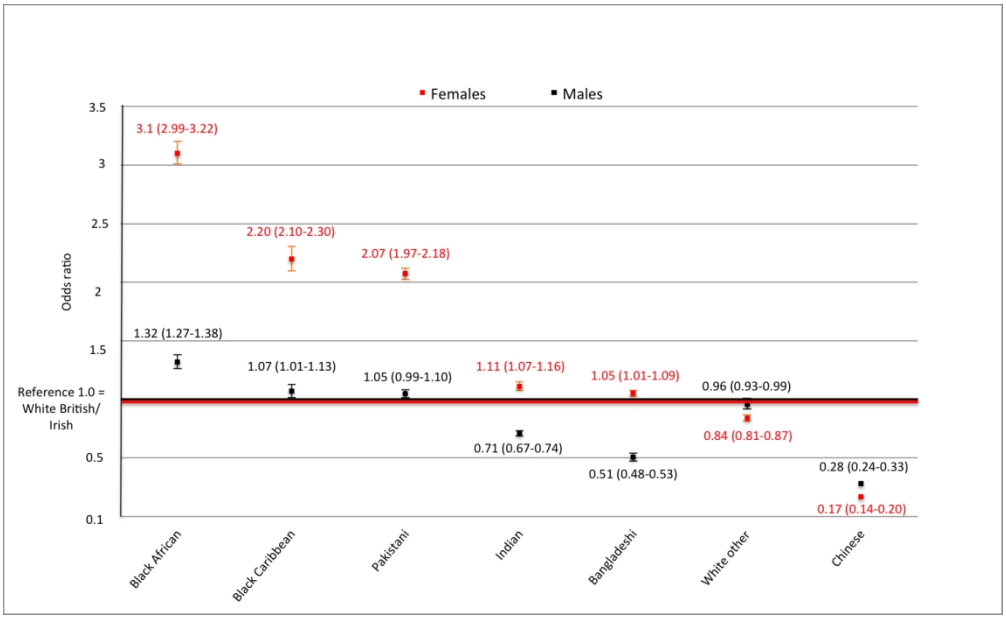
Ethnic group	Male		Female	
	OR (95%CI)	P-value	OR (95%CI)	P-value
Bangladeshi	1.00 (0.97-1.04)	0.72	1.00 (0.95-1.06)	0.89
Black African	1.15 (1.07-1.24)	<0.001	1.18 (1.08-1.30)	<0.001
Indian	1.03 (0.96-1.09)	0.44	0.93 (0.88-0.99)	0.02
Pakistani	1.06 (0.96-1.17)	0.22	1.05 (0.95-1.15)	0.32
White British/Irish	0.98 (0.93-1.04)	0.60	0.98 (0.93-1.04)	0.56

*Adjusted for age, deprivation and borough of residence

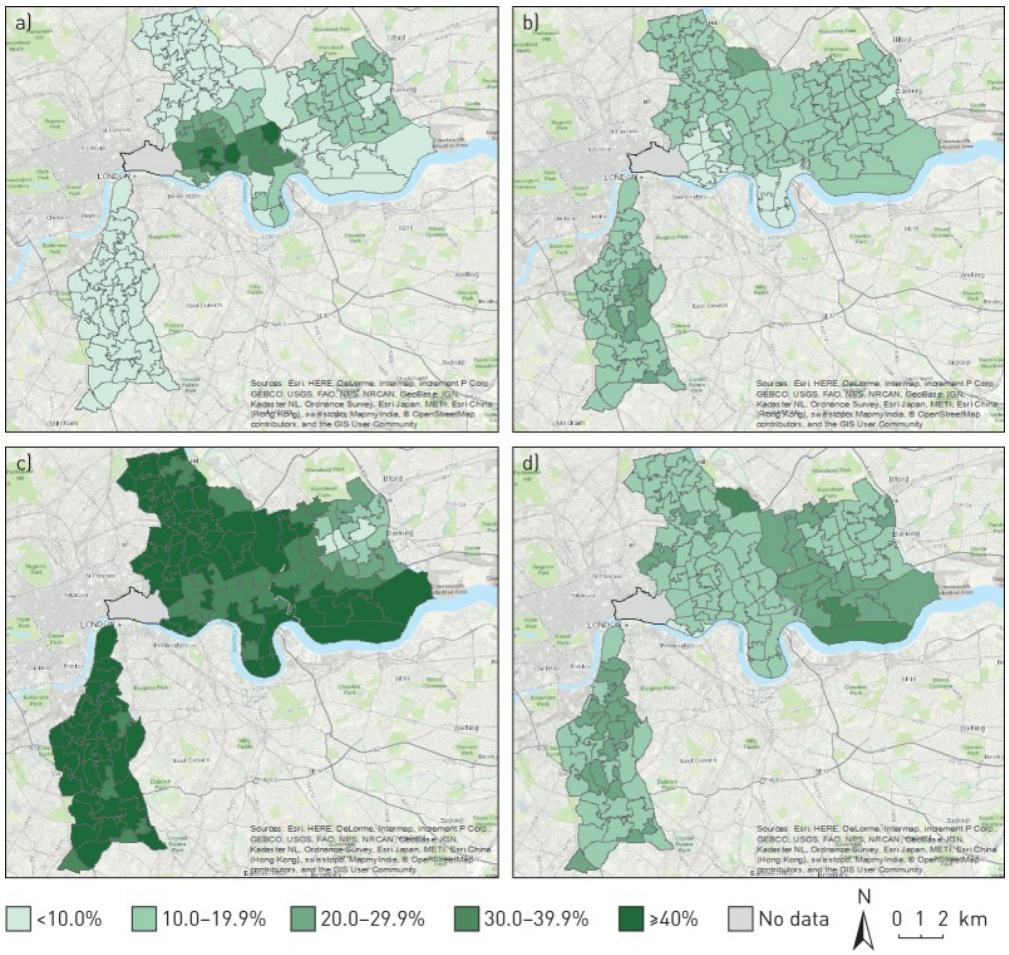
Table 3. Multi-level logistic regression of adjusted* odds ratio of 10% increase in area own-ethnic density and obesity prevalence by study ethnic group, stratified by sex and age group

	Male				Female			
	Under 35		Over 35		Under 35		Over 35	
Ethnic group	OR (95%CI)	p-value	OR (95%CI)	p-value	OR (95%CI)	p-value	OR (95%CI)	p-value
Bangladeshi	0.99 (0.94-1.05)	0.82	1.02 (0.98-1.07)	0.31	1.03 (0.96-1.13)	0.35	0.98 (0.93-1.04)	0.60
Black African	1.08 (0.96-1.28)	0.17	1.14 (1.06-1.23)	<0.001	1.13 (0.90-1.43)	0.29	1.19 (1.08-1.31)	<0.001
Indian	1.04 (0.95-1.14)	0.41	1.02 (0.95-1.10)	0.63	0.91 (0.82-1.00)	0.67	0.94 (0.89-0.99)	0.03
Pakistani	1.18 (0.97-1.43)	0.09	1.02 (0.92-1.13)	0.73	0.99 (0.83-1.18)	0.92	1.05 (0.94-1.17)	0.40
White British	0.99 (0.89-1.10)	0.84	0.96 (0.91-1.00)	0.09	1.05 (0.95-1.16)	0.37	0.96 (0.91-1.01)	0.13

*Adjusted for age, deprivation and borough of residence



Multi-level logistic regression of adjusted odds* of obesity by ethnic group and sex, compared to White British/Irish



Ethnic density distributions (%) by Middle Super Output Area mapped across east London: a) Bangladeshi, b) Caribbean, c) White and d) African with south London comparator area.

67x63mm (300 x 300 DPI)

Appendix table 1

Sensitivity analysis

Ethnic group	Male		Female	
	OR (95%CI)	p-value	OR (95%CI)	p-value
Multi-level logistic regression of adjusted* odds ratio of 10% increase in area own-ethnic density and obesity or overweight prevalence by ethnic group				
Bangladeshi	0.99 (0.95-1.02)	0.43	0.99 (0.95-1.04)	0.74
Black African	1.21 (1.12-1.32)	<0.001	1.15 (1.06-1.26)	0.001
Indian	1.05 (0.98-1.12)	0.17	0.95 (0.91-0.99)	0.05
Pakistani	1.16 (1.05-1.27)	0.003	1.11 (1.00-1.22)	0.06
White British	1.02 (0.96-1.07)	0.56	1.04 (0.99-1.09)	0.13
Multi-level logistic regression of adjusted* odds ratio of 10% increase in area own-ethnic density and obesity or overweight prevalence by ethnic group, using primary care data for ethnic density				
Bangladeshi	1.01 (0.97-1.04)	0.68	1.00 (0.95-1.06)	0.89
Black African	1.14 (1.05-1.23)	<0.001	1.18 (1.08-1.30)	<0.001
Indian	1.02 (0.97-1.09)	0.40	0.95 (0.90-0.99)	0.04
Pakistani	1.08 (0.98-1.19)	0.13	1.06 (0.96-1.16)	0.24
White British	0.98 (0.92-1.04)	0.49	0.96 (0.91-1.02)	0.18
Multi-level logistic regression of adjusted odds ratio of 10% increase in area own-ethnic density and obesity prevalence by ethnic group, (obesity cut off 27.5 for Asian groups)				
Bangladeshi	1.00 (0.95-1.04)	0.926	1.04 (1.05-1.07)	0.024
Black African	1.18 (1.08-1.30)	<0.001	1.17 (1.08-1.27)	<0.001
Indian	0.94 (0.89-1.00)	0.064	1.05 (0.98-1.13)	0.171
Pakistani	1.09 (1.00-1.19)	0.044	1.06 (0.95-1.19)	0.287
White British	0.98 (0.93-1.04)	0.60	0.99 (0.94-1.05)	0.756
Multi-level logistic regression of adjusted* odds ratio of 10% increase in area own-ethnic density and obesity or overweight prevalence by broad ethnic group				
Asian (Bangladeshi, Indian, Pakistani)	1.02 (0.9-9-1.06)	0.20	0.97 (0.94-1.01)	0.15
Black (African and Caribbean)	1.03 (0.97-1.09)	0.30	1.04 (0.97-1.12)	0.29
White European (White British, Irish, European)	0.96 (0.93-0.99)	0.04	0.98 (0.94-1.02)	0.28

Appendix 2 - STROBE Statement

	Item No	Recommendation	Page/location
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Abstract
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Introduction
Objectives	3	State specific objectives, including any prespecified hypotheses	Introduction
Methods			
Study design	4	Present key elements of study design early in the paper	Abstract
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Methods (study setting)
Participants	6	(*a*) *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	Methods
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Methods
Data sources/ measurement	8	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*Methods*
Bias	9	Describe any efforts to address potential sources of bias	Discussion (limitations)
Study size	10	Explain how the study size was arrived at	Not applicable
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were	Methods

		chosen and why	
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Methods
		(*b*) Describe any methods used to examine subgroups and interactions	Methods
		(*c*) Explain how missing data were addressed	Discussion (limitations)
		(*d*) *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	Not relevant (no sampling)
		(*e*) Describe any sensitivity analyses	Methods
Results			
Participants	13	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Results (single stage study design)
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Results (Table 1)
		(b) Indicate number of participants with missing data for each variable of interest	Results
Outcome data	15	*Cross-sectional study*—Report numbers of outcome events or summary measures	*Results*
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Results – single model strategy
		(*b*) Report category boundaries when continuous variables	Methods

		were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Not applicable
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Results
Discussion			
Key results	18	Summarise key results with reference to study objectives	Discussion
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Discussion
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Discussion
Generalisability	21	Discuss the generalisability (external validity) of the study results	Not discussed. Exploratory concept.
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Title Page