SSM - Population Health 7 (2019) 100394

Contents lists available at ScienceDirect

SSM - Population Health

journal homepage: www.elsevier.com/locate/ssmph

Article

Pathways to ethnic differences in obesity: The role of migration, culture and socio-economic position in the UK

Vanessa Higgins*, James Nazroo, Mark Brown

Cathie Marsh Institute for Social Research, University of Manchester, UK

ARTICLE INFO

Keywords:
Obesity
Waist circumference
Ethnicity
Migration
Culture
Socio-economic position
Neighbourhoods
Multi-level modelling

ABSTRACT

Previous research has identified ethnic differences in abdominal obesity but has not fully explored the pathways that explain these ethnic differences, which may relate to individual and contextual characteristics. This research identifies ethnic differences in waist circumference for eight ethnic groups in England, before and after accounting for a range of individual-level and area-level factors. Three key pathways to obesity are explored: migration status, cultural characteristics, and socio-economic characteristics.

Data come from four years of the Health Survey for England (1998, 1999, 2003 and 2004) and linked area-level data from the 2001 Census. The total sample size is 27,946. Multi-level modelling methods are used to account for individual-level and area-level factors.

The results show that migration status has a strong association with ethnic differences in waist circumference – in particular, waist circumference increases with length of time since migration to the UK. Cultural characteristics and socio-economic characteristics are also associated with ethnic differences in waist circumference, but not to the same extent as migration status. The strong association between migration status and waist circumference is partly attenuated by cultural characteristics and partly by socio-economic inequality. However, there is still a strong association between migrant status and waist circumference that remains unexplained.

1. Introduction

1.1. Ethnic differences in obesity

The prevalence of adult obesity in England has risen over the last few decades and is now one of the most important public health concerns in the country (Fuller, Mindell, & Prior, 2016). Abdominal obesity (which relates to fat distributed mainly in the abdominal area) is recognised as a risk of coronary heart disease, insulin resistance, and adult-onset (Type 2) diabetes (NICE, 2006). Previous research shows that Bangladeshi women, Pakistani men and women, Black African women and Black Caribbean women in England have a higher risk of abdominal obesity than the general population in England (Sproston & Mindell, 2006a). The World Health Organisation recommends that measures of abdominal obesity are particularly important for members of those ethnic groups (namely those of South Asian origin) with an increased risk of developing the metabolic syndrome which is a group of risk factors for heart disease and other health problems such as diabetes (WHO, 2004).

A small number of previous studies have explored ethnic differences in obesity using multi-variate analysis to control for potential explanatory factors (Higgins & Dale, 2010, Agyemang et al., 2011; Wardle, Waller, & Jarvis, 2002). However, most of these studies use Body Mass Index (a measure of generalised obesity) rather than abdominal obesity. One of the studies (Agyemang et al., 2011) explored abdominal obesity in the White, Indian and Caribbean groups in England and found that, after adjusting for a small number of explanatory variables, Indian men and women and Caribbean women had a higher prevalence ratio of abdominal obesity (1.07, 1.36 and 1.27 respectively) than White men and women (1.00). Caribbean men had a lower prevalence ratio of abdominal obesity than White men (0.85 compared with 1.00 respectively). The study did not look at other ethnic minority groups, such as Pakistani, Bangladeshi or Chinese populations, nor did it fully explore the pathways that underlie the ethnic differences.

1.2. Pathways to ethnic differences in obesity

Previous research reports that the health of migrants is better than that of those who do not migrate and that this is largely attributable to selection effects – most notably the 'healthy migrant' effect where migrants are healthier and have higher socio-economic position than those who do not migrate (Boyle & Norman, 2010; Marmot, Adelstein,

* Corresponding author.
E-mail address: vanessa.higgins@manchester.ac.uk (V. Higgins).

https://doi.org/10.1016/j.ssmph.2019.100394
Received 18 December 2018; Received in revised form 4 March 2019; Accepted 26 March 2019

Bulusu, & OPCS, 1984). However, Nazroo, Jackson, Karlsen & Torres (2007) note that selection into and experiences of migration change according to the context (social, economic and historical). Indeed, experiences post-migration are also relevant to the health of migrants. This is recognised by authors such as Misra and Ganda (2007) in their approach to understanding ethnic differences in obesity, which centres on theories of acculturation and convergence, i.e. ethnic minority groups modify their behaviour and converge towards that of the majority within the new country of settlement. Thus, migration can lead to changes in lifestyle behaviours, attitudes or socio-economic position, which can subsequently lead to changes in body weight (Mellin-Olsen & Wandel, 2005). An international literature review of the influence of migration on obesity and diabetes in different ethnic groups found evidence of higher obesity levels in migrant groups compared with those living in their original country of birth. The review concluded that environmental factors (for instance diet and lifestyle behaviours and urbanization) have a major role in the association between migration and increased obesity (Misra & Ganda, 2007). However, Smith, Kelly & Nazroo (2011) also found that improvements in socio-economic position between first and second generation ethnic minorities are protective against obesity.

Cultural practices or beliefs are often offered as an explanation for ethnic differences in health outcomes – although this is often assumed rather than measured objectively (Karlsen, 2004). Cultural background may influence obesity via the influence on health behaviours and related attitudes. Research suggests that this is particularly the case for women from Indian, Pakistani and Bangladeshi cultural backgrounds in relation to diet (Cross-Bardell et al., 2015) and physical activity (Koshoedo, Paul-Ebhohimhen, Jepson, & Watson, 2015) and for Black African and Black Caribbean women in relation to body size ideals, although this is contested (Shoneye, Johnson, Steptoe, & Wardle, 2011; Swami, 2015; Tovee, Swami, Furnham, & Mangalparsad, 2006). Eating habits (Higgins & Dale, 2010; Sproston & Mindell, 2006a), levels of smoking, drinking (Sproston & Mindell, 2006a), and breastfeeding (Leung & Stanner, 2011) differ by ethnic group and are each associated with obesity. However, ethnic groups are not homogenous; health behaviours are affected by factors such as age, gender, socio-economic position, religion and migration status, among other things.

The areas that ethnic groups settle and live within may also influence ethnic differences in obesity. Bangladeshi, Pakistani, Black Caribbean and Black African groups are over represented in the most deprived neighbourhoods in England and Wales (Jivraj & Simpson, 2015). Area-level residential deprivation is associated with increased levels of obesity for women in the UK and, therefore, may disproportionately increase the level of obesity among women from these ethnic groups (Stafford, Brunner, Head, & Ross, 2010b). In addition, a large body of work has focused on the protective effect of area-level co-ethnic density on ethnic inequalities in health, i.e. that people from ethnic minority groups who live in areas with higher concentrations of people from the same ethnic group have more positive health outcomes than those living in areas with lower levels of co-ethnics once the effects of associated area deprivation are taken into account (Pickett & Wilkinson, 2008; Stafford, Bécares & Nazroo, 2010a; Bécares, Nazroo, Albor, Chandola. & Stafford, 2012). Research from the USA has examined the association between co-ethnic density and weight status, but these studies have produced contradictory results; some reporting protective effects, some reporting obesity-promoting effects and others reporting no association (Chang, 2006; Kirby, Liang, Chen, & Wang, 2012; Moloney & South, 2015; Park, Neckerman, Quinn, Weiss, & Rundle, 2008). The different results from the different USA studies are likely to be related to differences in research design. Within the UK, only one published study on this topic has been conducted and this found no association between co-ethnic density and BMI - but the study uses data from the 1980s and is focussed on one small population (Asian people in Glasgow) (Ecob & Williams, 1991).

Socio-economic position may also contribute to ethnic differences in obesity, given its strong association with both obesity (Sobal & Stunkard, 1989) and with ethnicity (Jivraj & Simpson, 2015). Within the UK, the Black Caribbean, Black African, Pakistani and Bangladeshi groups in particular have a lower socio-economic position than the White majority population (Jivraj & Simpson, 2015).

As the ethnic groups within the UK vary in terms of their demographic and socio-economic profiles, migration histories and cultural practices and beliefs, it is important, to examine the effects of each of these potential pathways on ethnic differences in obesity. It is also important to consider the interplay between the potential pathways. For example, migration is strongly linked to cultural pathways to obesity (e.g. first generation migrants may adhere more to the cultural traditions of their country of birth than second generation migrants) and to socio-economic pathways (e.g. recent migrants may have lower incomes which might lead to increased obesity). In addition, the operation of these pathways might be strongly shaped by area context, with both area deprivation and co-ethnic density being important in this. This paper, therefore, adopts a multi-dimensional exploration of the pathways to ethnic differences in abdominal obesity with the following research questions:

- *How far does migration status explain ethnic differences in abdominal obesity?*
- *How far do socioeconomic characteristics explain ethnic differences in abdominal obesity?*
- *How far do cultural characteristics explain ethnic differences in abdominal obesity?*
- *How far do socioeconomic characteristics and cultural characteristics explain the migration status effect upon abdominal obesity?*
- *How far are these pathways influenced by area context?*

In summary, there are three potential pathways to ethnic differences in abdominal obesity in England that are measured within this paper – socio-economic characteristics, cultural characteristics and migration to the UK. Culture characteristics are measured indirectly in this paper through a set of health behaviour characteristics and a measure of co-ethnic density which are used together as a proxy marker of cultural practice. A more adequate measure of culture would include questions on cultural opinions and behaviours, similar to those used in the Fourth National Survey of Ethnic Minorities (1993–1994). The migration pathway used in this paper reflects international migration to the UK and length of time since immigration but does not include movements in and out of the UK. As noted, the migration pathway is strongly linked to the cultural pathway to ethnic differences in obesity – for example, first generation migrants may adhere more than second generation migrants to the health behaviours and other cultural markers of the majority within their country of birth.

There are many other hypothesised pathways that are not included in this study because they cannot be measured or operationalised with the data – these include local access to food outlets, local access to indoor and outdoor facilities providing opportunity for physical activity, the influence of early life exposures, epi-genetics, experiences of racism/discrimination, the influence of social networks, and perceptions of body image and stigma (National Obesity Observatory, 2011).

2. Methods

2.1. Data

Data from the Health Survey for England (HSE) (1998, 1999, 2003 and 2004) and the 2001 Census are used (National Centre for Social Research, University College London, Department of Epidemiology and Public Health, 2010). The HSE is an annual cross-sectional survey which is designed to provide regular information on a wide variety of aspects of the nation's health. It provides a nationally representative sample of the population living in private households in England via a

multi-stage, stratified, probability sample. Data were obtained via a face-to-face interview with a trained interviewer, followed by a nurse visit to take measurements and blood samples. The 1999 and 2004 surveys focus on the health of ethnic minority groups and over-sample Black Caribbean, Indian, Pakistani, Bangladeshi, Irish, Chinese and (in 2004 only) Black African participants (Sproston & Mindell, 2006a). The White sample was drawn from the 1998 and 2003 HSE. More detailed information on the methodology of the HSE is available elsewhere (Sproston & Mindell, 2006b). Data from the 2001 Census on the area where the HSE participants lived were linked to the HSE data.

2.2. Outcome variable

There are two widely used measures of abdominal obesity – waist circumference and waist-hip ratio. Waist-to-height-ratio is another measure but this is less widely used in epidemiological studies and more research is needed to assess the appropriateness of the boundary levels proposed to indicate obesity (Ashwell, Cole, & Dixon, 1996; Molarius & Seidell, 1998). The WHO recommended thresholds for 'increased' waist circumference and waist-hip ratio are intended for diagnostic purposes, including the monitoring of population health. For investigations of aetiology, the use of continuous waist circumference/waist-hip ratio obesity is preferable to a categorical outcome (Alberti et al., 2009; NICE, 2013; WHO, 2004). However, it should be noted that the use of a continuous outcome for obesity does not measure obesity per se.

The results of ratios, such as waist-hip, are difficult to interpret, so this research uses continuous waist circumference as the outcome variable, with continuous hip circumference measurement used as a control variable to account for body size. Preliminary linear regression analysis (not shown) compared the use of continuous waist circumference, with hip as a control variable, with the use of categorical waist-hip ratio using the WHO recommended thresholds for obesity; the results were very similar in terms of the ethnic groups highlighted, the direction of the coefficients and the statistical significance of the results. The measurement of waist and hip circumference took place during the nurse visit to the household using a tape measure. More detailed information on these measurements is available elsewhere (Sproston & Mindell, 2006b).

2.3. Ethnicity

Ethnicity is a multi-dimensional concept that reflects an expression of belonging based on one of more shared characteristics such as common ancestry, country-of birth, nationality, religion, culture, colour or language (Bhopal, 2004; Burton, Nandi, & Platt, 2010; Modood, 1997).

The ethnicity variable within the Health Survey for England data was based on the respondent's perceived ethnic identity and perceived family origins, with slight variation in the questions asked across the four waves of data collection. All minority ethnic groups, apart from the Irish, were as defined in the 2001 Census. The Irish group often identify as White British so respondents were asked for their mother and father's origins; people were included as being of Irish origin if they were born in Ireland, or their father or mother were born there. This produced a sample of: Black Caribbean (n = 1331); Black African (n = 376); Indian (n = 1550); Pakistani (n = 1204); Bangladeshi (n = 874); Chinese (n = 804); Irish (n = 1546); and White (n = 20261). The White category includes White British and White Other.

2.4. Theorised explanatory pathways

Migration status is derived from two variables which determine (1) whether an individual is UK born or born outside the UK and (2) for those born outside the UK, the length of time that they have lived in the UK. This gives six categories:

- UK born;
- Child migrant
- Adult migrant – lived in UK < 5 years
- Adult migrant – lived in UK 5–9 years
- Adult migrant – lived in UK 10–19 years
- Adult migrant – lived in UK 20 years or more

Those aged 16 or over when they migrated to the UK are defined as adult migrants and those aged under 16 when they migrated to the UK are defined as child migrants.

Cultural characteristics are measured using three proxy measures:

- English language proficiency.
- Health behaviour - measured with four variables (1) fat intake (2) physical activity level (3) smoking status (4) alcohol consumption frequency.
- Co-ethnic density - measured using a continuous variable of the percentage of co-ethnics in an area (Middle Super Output Area). This variable was available from the Census data matched onto the HSE dataset and was calculated by dividing the number of residents within the area from an individual's own ethnic group by the total number of residents in that area.

Socio-economic characteristics are measured using four variables:

- Registrar General Social Class based on self-reported occupation
- Highest educational qualification
- Equivalised Household income quintiles (a measure of income that takes account for the number of people living in the household).
- Area level deprivation - measured using the Index of Multiple Deprivation 2004 variable (IMD 2004). IMD2004 scores of all Super Output Areas in England were grouped into quintiles - the first quintile contains the least deprived areas and the fifth quintile contains the most deprived areas. Households within the HSE datasets were then allocated to an IMD2004 quintile according to their postcode. Each individual in a household is assigned to the deprivation quintile of their household.

2.5. Control variables

Age is included as a continuous variable in the models (defined as age at last birthday). This ensures that the models are corrected for differences in age distributions between ethnic groups. All respondents aged 16–74 years are included in the analysis.

Health Status is measured by three variables (1) Self-reported general health (2) Limiting long standing illness (3) Psychological health measured using GHQ12. These are included because there is evidence that physical and mental health status influence both levels of obesity and health behaviours (Luppino et al., 2010; Marmot, 2010).

A variable for marital status/children in household is included because there is evidence that married or cohabiting partners influence each other's obesity-related health behaviours and obesity levels (The & Gordon-Larsen, 2009; Falba & Sindelar, 2008; Monden, van Lenthe, De Graaf, & Kraaykamp, 2003). Research also suggests that the presence of children within households has a detrimental effect upon women's diet (Laroche, Hofer, & Davis, 2007).

2.6. Data analyses

The combined Health Survey for England and Census data have a hierarchical structure, i.e. individuals (level 1) live within areas (level 2). Individuals living in the same area may have more similar obesity levels and other characteristics to each other than people living in different areas. The use of simple linear regression modelling techniques ignores the clustering of people within areas and therefore runs the risk of over-estimating the size of correlation coefficients. Multilevel

modelling techniques account for the hierarchical structure of data and enable the simultaneous modelling of individual-level effects and area effects (Dale, Fieldhouse, Holdsworth, & Boyle, 2000). Random intercept multilevel modelling techniques were, therefore, used to model the data. Analyses were conducted using Stata MP, Version 13. Multi-level linear regression models were run using the Runmlwin command in Stata, which uses the MLwiN software package (Leckie & Charlton, 2012). Survey weights were used to account for the sampling design of the survey and for non-response. Models were run for men and women separately. The White ethnic group was used as the reference group in the models because it has the largest sample and because this approach enables an exploration of the causal pathways that are relevant to the ethnic minority groups. The analyses were conducted in five steps:

1. Unadjusted models (accounting for hip circumference and the three control variables only) were run to explore ethnic differences in waist circumference before accounting for other factors (Model 1)

Theorised blocks of variables (based on the three theorised pathways to ethnic differences in obesity) were then added to Model 1 in the following stages:

2. Migration status (Model 2)
3. Migration status + cultural characteristics (Model 3)
4. Migration status + socio-economic characteristics (Model 4)
5. Migration status + cultural characteristics + socio-economic characteristics (Model 5)

This approach enables an examination of the effect of the three theorised blocks of variables on the waist circumference of each ethnic group (relative to the White group), as well as the effect of cultural characteristics and socio-economic characteristics, respectively, on the migrant status effect.

The Akaike Information Criterion (AIC) is calculated to explore the goodness-of-fit of the multi-level models. The AIC uses the log-likelihood measure of goodness-of-fit and adjusts it for the number of variables within the model. The best model is the one with the lowest AIC (Dedrick et al., 2009).

3. Results

3.1. Results from descriptive statistics

Descriptive statistics explored each explanatory variable by ethnic group and sex. Tables are not shown but key results are described.

3.1.1. Migration status

Among the ethnic minority groups, high proportions of Irish (76.9%) and Black Caribbean men (51.8%) and women (73.9% and 53.1% respectively) were born in the UK when compared with other ethnic groups (excluding the White group). The Bangladeshi group have the highest proportion of people who migrated as children, compared with other ethnic minority groups. The Chinese, Indian and Black Caribbean groups have the highest proportion of people who migrated as adults more than 20 years ago.

3.1.2. Cultural characteristics

High proportions of Bangladeshi men (19.2%) and women (38.0%) do not speak or read English with high rates also found for Pakistani women (21.7%) and Chinese men (15.4%) and women (15.7%).

A very high proportion of Bangladeshi women (80.9%) and Pakistani women (78.3%) have low levels of physical activity. Among men, the Bangladeshi (59.2%), Chinese (51.5%) and Pakistani (50.7%) groups have the highest proportions doing low levels of physical activity.

Among men, the White men (17.6%) have the highest proportion of high fat intake, compared with, for example, Indian men (6.0%). Among women, the Bangladeshi women have the highest proportion of fat intake (13.7%), compared with, for example, Indian women (3.2%).

The majority of Bangladeshi men (96.3%) and women (98.8%) and Pakistani men (90.4%) and women (96.9%) do not drink alcohol.

Very high proportions of Bangladeshi (97.8%), Pakistani (93.8%), Indian (92.5%) and Chinese (87.9%) women have never regularly smoked. Among men, Black African men have the highest proportions who have never regularly smoked (70.3%), followed by the Chinese, Indian and Pakistani men (approximately 66% each). Bangladeshi men are quite different to Bangladeshi women in terms of smoking prevalence, with only 46.2% who have never regularly smoked.

Among ethnic minority groups, the Pakistani and Bangladeshi groups have the highest levels of co-ethnic density. For example, Pakistani women's co-ethnic density ranges from 0 to 73.8%, with a mean of 19.4%. The Chinese and the Irish groups have, by far, the lowest levels of co-ethnic density (mean of 1.4% and 2.0% respectively).

3.1.3. Socio-economic characteristics

Pakistani and Bangladeshi men and women generally have the lowest socio-economic position of all the ethnic groups. For example, high levels of Pakistani (44.3%) and Bangladeshi (54.5%) women have no qualifications compared with, for example, White women (26.4%). Black Caribbean men and women also have a fairly low socio-economic position – for example low proportions of Black Caribbean men (3.3%) and women (1.6%) are in the Professional social class compared with, for example, Indian men (9.6%) and women (3.8%).

Bangladeshi men (82.7%) and (84.4%) women are far more likely to live in the most deprived areas of the country than other ethnic groups. This is followed by Pakistani (57.7% men; 58.6% women), Black Caribbean (48.1% men; 51.6% women) and Black African (47.0% men; 50.8% women).

3.2. Results from the multi-level models (Tables 1 and 2)

3.2.1. Ethnic differences in waist circumference

The unadjusted models (Model 1) show that all seven of the ethnic minority women's groups have a greater waist circumference, on average, than White women. Bangladeshi women have by far, the largest waist circumference (5.54 cm larger than White women) on average (Table 1).

Among men, the unadjusted model shows that Indian, Pakistani, Bangladeshi (and Irish men to a lesser extent) have a greater waist circumference than White men, with Indian the largest (1.98 cm larger than White men, on average). In contrast, Black Caribbean and Black African men have a smaller waist circumference than White men on average (-2.34 and -2.22 cm respectively) (Table 2).

Model 5 shows the results for the fully-adjusted models. Between Models 1 and 5 there is a large reduction in the waist circumference coefficients for all ethnic groups, for both men and women. The reductions to the coefficients are so large that many of the results become statistically non-significant. Among women, only the Bangladeshi, Pakistani, Black Caribbean and Chinese group's coefficients remain statistically significantly greater than White women in the fully adjusted model. Among men, only Indian men have a statistically significantly larger waist circumference than White men (1.75 cm larger than White men, on average) in the fully adjusted model. Additionally, Pakistani, Bangladeshi and Irish men no longer have a statistically significantly larger waist circumference, compared with White Men, on average.

3.2.2. Migration status

When migration status is added to the model (Model 2) there is a large reduction in the waist circumference coefficient for each ethnic minority group and for both men and women. For example,

Table 1
Ethnic differences in waist circumference (women) – Models 1-5.

	Model 1 (adjusted for age, hip circumference, health status, marital status and children in the household)		Model 2 (Model 1 + migration status)		Model 3 (Model 2 + cultural characteristics)		Model 4 (Model 2 + socio-economic characteristics)		Model 5 (Model 2 + cultural characteristics + socio-economic characteristics)	
	B	CI	B	CI	B	CI	B	CI	B	CI
Ethnic group (ref: White)										
Black Caribbean	2.06**	1.51, 2.61	1.39**	0.81, 1.97	1.66**	0.61, 2.72	1.16**	0.57, 1.75	1.52*	0.46, 2.57
Black African	1.33*	0.10, 2.56	0.13	−1.19, 1.44	0.77	−0.80, 2.33	−0.06	−1.39, 1.27	0.63	−0.95, 2.21
Indian	1.24**	0.70, 1.79	0.23	−0.42, 0.87	0.61	−0.44, 1.65	0.22	−0.43, 0.87	0.68	−0.38, 1.73
Pakistani	3.11**	2.41, 3.81	2.23**	1.47, 2.98	2.43**	1.33, 3.54	1.46**	0.67, 2.26	2.11**	0.98, 3.23
Bangladeshi	5.54**	4.71, 6.37	4.36**	3.44, 5.27	4.38**	3.19, 5.56	3.22**	2.25, 4.19	3.83**	2.62, 5.04
Chinese	2.34**	1.71, 2.98	1.10*	0.33, 1.87	1.50*	0.31, 2.69	1.21**	0.43, 1.99	1.67*	0.46, 2.88
Irish	1.18**	0.64, 1.72	0.81*	0.24, 1.37	0.82	−0.23, 1.87	0.78*	0.22, 1.35	0.88	−0.17, 1.94
Migration status (Ref: UK Born)										
Child migrant			0.80*	0.18, 1.42	0.73	0.09, 1.37	0.77*	0.14, 1.39	0.74*	0.09, 1.38
Adult migrant (< 5 years)			0.95	−0.09, 1.99	0.54	−0.52, 1.60	0.37	−0.66, 1.39	0.27	−0.78, 1.33
Adult migrant (5–9 years)			1.40**	0.47, 2.33	0.74	−0.24, 1.71	0.97*	0.04, 1.90	0.62	−0.36, 1.59
Adult migrant (10–19 years)			2.03**	1.19, 2.87	1.45**	0.60, 2.30	1.55**	0.71, 2.40	1.31**	0.46, 2.17
Adult migrant (20 + years)			1.56**	0.88, 2.25	1.38**	0.66, 2.11	1.35**	0.67, 2.04	1.33**	0.60, 2.06
Cultural characteristics										
Speak/read English (ref: does not read and speak English)										
Reads or speaks English					−1.45*	−2.85, −0.06			−1.22	−2.62, 0.17
Both reads and speaks English					−2.10**	−3.08, −1.13			−1.49*	−2.54, −0.44
Fat in diet (ref: low fat)										
Medium fat					−0.53**	−0.81, −0.25			−0.58**	−0.86, −0.29
High fat					−0.66*	−1.13, −0.19			−0.77**	−1.24, −0.30
No fat data					−0.43*	−0.76, −0.10			−0.46*	−0.79, −0.13
Physical activity (ref: high level)										
Low level					0.54**	0.25, 0.82			0.51**	0.22, 0.80
Medium level					0.04	−0.25, 0.34			0.08	−0.21, 0.38
Smoking status (ref: heavy smoker)										
Moderate smoker					−1.24**	−1.77, −0.71			−1.18**	−1.71, −0.64
Light smoker					−1.85**	−2.40, −1.29			−1.71**	−2.27, −1.15
Ex-smoker					−1.64**	−2.13, −1.14			−1.46**	−1.96, −0.96
Never smoked					−2.73**	−3.17, −2.29			−2.47**	−2.93, −2.02
Alcohol (ref: none in last 12 months/non-drinker)										
Almost every day/5–6 days week/ 3–4 days week					−0.37	−0.83, 0.08			−0.08	−0.54, 0.39
Once or twice a week					−0.50*	−0.95, −0.05			−0.30	−0.75, 0.15
Once or twice month/once every couple months					−0.21	−0.66, 0.24			−0.05	−0.50, 0.41
Once or twice a year					0.22	−0.33, 0.77			0.26	−0.29, 0.81
Co-ethnic density (continuous variable)					0.00	−0.01, 0.01			0.00	−0.01, 0.01
Socio-economic characteristics										
Social Class (ref: professional)										
Managerial/technical/skilled non-manual							−0.02	−0.76, 0.71	0.01	−0.73, 0.74
Manual							0.54	−0.23, 1.32	0.51	−0.26, 1.29

(*continued on next page*)

Table 1 (*continued*)

	Model 1 (adjusted for age, hip circumference, health status, marital status and children in the household)		Model 2 (Model 1 + migration status)		Model 3 (Model 2 + cultural characteristics)		Model 4 (Model 2 + socio-economic characteristics)		Model 5 (Model 2 + cultural characteristics + socio-economic characteristics)	
	B	CI	B	CI	B	CI	B	CI	B	CI
Armed forces/sufficient info/ fulltime student if never worked							0.14	−0.91, 1.20	0.50	−0.59, 1.58
Never worked							1.37*	0.37, 2.37	1.13*	0.10, 2.16
Qualifications (ref: degree level or above)										
Higher education below degree							0.30	−0.16, 0.76	0.22	−0.24, 0.69
NVQ level 3 or equivalent							−0.15	−0.59, 0.30	−0.19	−0.64, 0.26
NVQ level 1 or 2 equivalent/ foreign/other							0.27	−0.10, 0.65	0.07	−0.31, 0.44
No qualifications							0.55*	0.11, 0.99	0.19	−0.26, 0.64
Full-time student							0.35	−0.14, 0.84	0.36	−0.14, 0.85
Equivalised household income (ref: quintile 1, lowest quintile)										
Quintile 2							−0.15	−0.57, 0.28	−0.11	−0.53, 0.32
Quintile 3							−0.39	−0.80, 0.02	−0.24	−0.66, 0.17
Quintile 4							−0.29	−0.72, 0.13	−0.15	−0.58, 0.28
Highest quintile							−0.35	−0.82, 0.12	−0.20	−0.67, 0.27
Missing income data							−0.28	−0.72, 0.16	−0.21	−0.66, 0.24
Area-deprivation (ref: IMD 1: least deprived)										
IMD 2							0.04	−0.31, 0.40	−0.01	−0.36, 0.34
IMD 3							0.34	−0.02, 0.71	0.26	−0.10, 0.63
IMD 4							0.68**	0.31, 1.06	0.55**	0.18, 0.93
IMD 5 – most deprived							1.07**	0.65, 1.48	0.82**	0.39, 1.24
AIC	93527		92122		89639		91828		89425	
N	14222		14011		13673		13982		13645	

* = P < 0.05; ** = P < 0.01.

Table 2
Ethnic differences in waist circumference (men) – Models 1-5.

	Model 1 (adjusted for age, hip circumference, health status, marital status and children in the household)		Model 2 (Model 1 + migration status)		Model 3 (Model 2 + cultural characteristics)		Model 4 (Model 2 + socio-economic characteristics)		Model 5 (Model 2 + cultural characteristics + socio-economic characteristics)	
	B	CI	B	CI	B	CI	B	CI	B	CI
Ethnic group (ref: White)										
Black Caribbean	−2.34**	−2.88, −1.80	−2.99**	−3.56, −2.42	−2.63**	−3.61, −1.65	−3.20**	−3.78, −2.63	−2.90**	−3.89, −1.92
Black African	−2.22**	−3.24, −1.20	−3.13**	−4.18, −2.07	−2.71**	−4.02, −1.41	−2.97**	−4.06, −1.88	−2.64**	−3.96, −1.31
Indian	1.98**	1.52, 2.44	1.07**	0.50, 1.64	1.40**	0.51, 2.28	1.56**	0.97, 2.14	1.75**	0.85, 2.65
Pakistani	1.69**	1.14, 2.25	0.80**	0.14, 1.47	0.79	−0.20, 1.78	0.93*	0.24, 1.62	0.93	−0.08, 1.94
Bangladeshi	1.88**	1.19, 2.57	0.90**	0.12, 1.69	0.63	−0.43, 1.68	0.76	−0.05, 1.57	0.66	−0.41, 1.72
Chinese	−0.35**	−0.93, 0.24	−1.25**	−1.92, −0.58	−0.84	−1.89, 0.21	−0.73*	−1.41, −0.06	−0.44	−1.49, 0.62
Irish	0.74**	0.26,1.22	0.42**	−0.07, 0.92	0.88	−0.03, 1.80	0.40	−0.10, 0.89	0.77	−0.15, 1.70
Migration status (Ref: UK Born)										
Child migrant			1.04**	0.46, 1.62	0.84*	0.23, 1.45	0.76*	0.18, 1.34	0.58	−0.03, 1.19
Adult migrant (< 5 years)			−0.04	−0.86, 0.78	−0.19	−1.02, 0.64	−0.29	−1.13, 0.55	−0.35	−1.20 0.49
Adult migrant (5–9 years)			1.35*	0.34, 2.36	1.24*	0.20, 2.28	1.02*	0.01, 2.04	1.03*	−0.01, 2.07
Adult migrant (10–19 years)			1.60**	0.80, 2.39	1.44**	0.63, 2.25	1.22**	0.42, 2.02	1.17*	0.36, 1.98
Adult migrant (20 + years)			1.46**	0.86, 2.05	1.43**	0.81, 2.05	1.16**	0.56, 1.76	1.21**	0.59, 1.84
Cultural characteristics										
Speak/read English (ref: does not read and speak English)										
Reads or speaks English					−0.42	−1.84, 1.00			−0.36	−1.80, 1.07
Both reads and speaks English					−0.43	−1.48, 0.62			0.15	−0.93, 1.22
Fat in diet (ref: low fat)										
Medium fat					−0.39**	−0.65, −0.12			−0.39**	−0.65, −0.13
High fat					−0.49**	−0.81, −0.17			−0.61**	−0.93, −0.29
No fat data					−0.12	−0.47, 0.23			−0.16	−0.50, 0.19
Physical activity (ref: high level)										
Low level					1.00**	0.74, 1.27			1.15**	0.88, 1.41
Medium level					0.00	−0.26, 0.26			0.30*	0.04, 0.56
Smoking status (ref: heavy smoker)										
Moderate smoker					−0.71**	−1.18, −0.24			−0.68*	−1.16, −0.21
Light smoker					−1.28**	−1.80, −0.77			−1.07**	−1.58, −0.55
Ex-smoker					−0.60*	−1.02, −0.18			−0.32	−0.74, 0.10
Never smoked					−1.53**	−1.93, −1.13			−1.09**	−1.50, −0.69
Alcohol (ref: none in last 12 months/non-drinker)										
Almost every day/5–6 days week/ 3–4 days week					−0.65*	−1.12, −0.18			−0.44	−0.91, 0.03
Once or twice a week					−0.41	−0.88, 0.06			−0.35	−0.82, 0.12
Once or twice month/once every couple months					−0.68*	−1.18, −0.18			−0.64*	−1.14, −0.14
Once or twice a year					−0.86*	−1.59, −0.13			−0.87*	−1.60, −0.14
Co-ethnic density (continuous variable)					0.01	0.00, 0.01			0.00	0.00, 0.01
Socio-economic characteristics										
Social Class (ref: professional)										
Managerial/technical/skilled non-manual							0.48*	0.05, 0.90	0.43*	0.01, 0.86
Manual							1.09**	0.63, 1.55	1.15**	0.68, 1.61

(*continued on next page*)

Table 2 (*continued*)

	Model 1 (adjusted for age, hip circumference, health status, marital status and children in the household)		Model 2 (Model 1 + migration status)		Model 3 (Model 2 + cultural characteristics)		Model 4 (Model 2 + socio-economic characteristics)		Model 5 (Model 2 + cultural characteristics + socio-economic characteristics)	
	B	CI	B	CI	B	CI	B	CI	B	CI
Armed forces/sufficient info/ fulltime student if never worked							0.58	−0.15, 1.30	0.50	−0.24, 1.24
Never worked							0.45	−0.84, 1.75	0.33	−0.96, 1.62
Qualifications (ref: degree level or above)										
Higher education below degree							0.62**	0.24, 1.00	0.56*	0.17 0.94
NVQ level 3 or equivalent							0.52*	0.12, 0.92	0.45*	0.04, 0.86
NVQ level 1 or 2 equivalent/ foreign/other							0.83**	0.49, 1.18	0.74**	0.39, 1.09
No qualifications							1.28**	0.87, 1.70	1.14**	0.72, 1.56
Full-time student							−0.19	−0.68, 0.30	−0.17	−0.67, 0.33
Equivalised household income (ref: quintile 1, lowest quintile)										
Quintile 2							−0.04	−0.46, 0.38	0.01	−0.41, 0.44
Quintile 3							0.06	−0.37, 0.48	0.15	−0.27, 0.58
Quintile 4							0.18	−0.25, 0.62	0.27	−0.17, 0.71
Highest quintile							0.42	−0.03, 0.87	0.52*	0.06, 0.98
Missing income data							−0.09	−0.54, 0.35	0.02	−0.43, 0.47
Area-deprivation (ref: IMD 1: least deprived)										
IMD 2							0.30	−0.04, 0.65	0.32	−0.02, 0.66
IMD 3							0.50*	0.14, 0.86	0.52*	0.16, 0.88
IMD 4							0.76**	0.41, 1.12	0.76**	0.41, 1.12
IMD 5 – most deprived							0.97**	0.57, 1.37	0.90**	0.49, 1.31
AIC	77058		75934		74489		75697		74292	
N	12141		11972		11771		11961		11762	

* = P < 0.05; ** = P < 0.01.

Bangladeshi women's waist circumference coefficient reduces from 5.54 cm to 4.36 cm and Indian men's waist circumference reduces from 1.98 cm to 1.07 cm. For women, Black African and Indian women's waist circumference is no longer statistically significantly different to White women's.

Model 2 shows that those who arrived in the UK as a child had a larger waist circumference than those born in the UK. For those who migrated as adults there was an increasingly greater waist circumference, relative to those born in the UK, as time since migration increased. There is a particularly strong association with migration status for adult women; those who arrived in the UK as adults 5–9 and 10–19 years ago had a waist circumference 1.40 cm and 2.03 cm greater, respectively, than the UK born.

3.2.3. Cultural characteristics

The introduction of the cultural characteristic variables to the migration status model (Model 3) *increases* the waist circumference of each ethnic group, relative to the White group (Model 2 compared with model 3). This is with the exception of Pakistani and Bangladeshi men for whom the coefficients reduce and become statistically non-significant. This means that once adjusting for markers of culture, the difference between the waist circumference of most ethnic minority groups and the White group becomes greater, with the exception of Pakistani and Bangladeshi men. However, for Pakistani men the difference in the coefficients between Models 2 and 3 is only very small (0.80 cm and 0.79 cm respectively) so this could be interpreted as a null effect rather than a reduction in the coefficients.

The results for fat intake show an unexpected inverse association between fat intake and weight/waist for both genders. For example men with a high dietary fat intake have a 0.49 cm smaller waist circumference, on average, than men with a low dietary fat intake. This suggests that the variable is not capturing dietary behaviour correctly/adequately in relation to obesity. A leaner multilevel model which excluded the dietary fat variable did not change the overall results (table not shown).

Co-ethnic density was included in the cultural characteristic block. The results suggest that co-ethnic density does not have a statistically significant association with waist circumference.

3.2.4. Socio-economic characteristics

For women, the addition of socio-economic characteristics results in notable further reductions to the waist circumference of those ethnic groups with the lowest socio-economic status (the Pakistani and Bangladeshi groups, followed by the Black Caribbean and Black African groups), relative to White women (Model 2 compared with Model 4). For example, the coefficient for Bangladeshi women reduces from 4.36 cm to 3.22 cm, relative to White women. Similarly for men, the addition of the socio-economic characteristics block of variables results in notable further reductions to the waist circumference of those ethnic groups with lower socio-economic position (Black Caribbean and Bangladeshi men), relative to White men, but also increases the coefficients of those with a higher socio-economic position (Indian, Chinese and Black African men). Unexpectedly, for Pakistani men (who have a low socio-economic position) the waist circumference coefficient *increases,* relative to White men, when socio-economic characteristics are added to the model.

Area deprivation was included in the socio-economic status block. There is a strong association between area deprivation and waist circumference for both men and women; waist circumference increases as area deprivation increases. The association is particularly strong for men – for example men who live in the most derived areas have a waist circumference 0.90 cm greater than those who live in the least deprived areas.

3.2.5. The association of cultural and socio-economic characteristics with the migrant effect

For men and women in each ethnic minority group, the migrant status coefficients reduce, relative to White men and women, when the cultural characteristics block of variables is entered into the model. For example, in Model 2, female adult migrants who have lived in the UK for twenty years or more have a waist circumference 1.56 cm greater than the UK born, on average, but this reduces to 1.38 cm in Model 3. Similarly, for men in Model 2, child migrants have a waist circumference 1.04 cm greater than the UK born, on average, but this reduces to 0.84 cm in Model 3.

The migrant status coefficients also reduce, relative to the White group, when the socio-economic block of variables is entered into the model (for both men and women). For example, among women, the coefficient for adult migrants who have lived in the UK for twenty years or more reduces from 1.57 cm in Model 3 to 1.35 cm, on average, in Model 4.

In terms of the association of the socio-economic and cultural characteristics blocks of variables with the migration status coefficients, the results vary by ethnic group and by gender. Cultural characteristics have a greater association with the migration status effect than do socio-economic characteristics for Black Caribbean and Black African men and women, Indian women, Chinese women, Bangladeshi men and Irish men. Whereas, socio-economic characteristics have a greater association with the migration status effect than do cultural characteristics for Pakistani men and women, Bangladeshi women, Irish women, Indian and Chinese men. The AIC for Models 3 and 4 show that, overall, the cultural block of variables (Model 3, AIC = 89639 women and 74489 men) has a better fit to the data than the socio-economic block of variables (Model 4, AIC = 91828 women and 75697 men).

4. Discussion

4.1. Ethnic differences in waist circumference

The basic models identify clear ethnic differences in waist circumference and gender differences within some ethnic groups. Bangladeshi and Pakistani men and women and Indian men are highlighted as having the largest waist circumferences of all the ethnic groups studied. There are notable gender differences within the Black Caribbean, Black African and Chinese groups – the women have a greater waist circumference than White women but the men have a smaller waist circumference than White men, on average.

However, the picture changes when migration status, culture and socio-economic position are accounted for. Only Bangladeshi, Pakistani, Black Caribbean and Chinese women and Indian men have a statistically significant greater waist than the White group. Only Black Caribbean and Black African men's waist circumference is statistically significantly lower than White men's.

The results support the results of Agyemang et al. (2011) that, after adjusting for some explanatory factors, Indian men and Caribbean women have higher levels of abdominal obesity than White men and women and Caribbean men have lower levels of abdominal obesity than White men. However the results for Indian women are slightly different in this study - they are not statistically significantly higher than White women. The difference in the results is likely to be due to the inclusion of the migration status variable in this research, which attenuates the ethnic group effect and makes many of the results statistically non-significant (Agyemang et al., 2011).

4.2. Migration, cultural and socio-economic pathways

Migration, culture and socio-economic inequality are three potential theorised pathways to ethnic differences in waist circumference. The study finds that each of these pathways has an association with ethnic

differences in waist circumference. However, it is clear that for men and women in all ethnic minority groups, migration to the UK has a greater association (than socio-economic or cultural characteristics) with increased waist circumference. The study also shows that adult migrants', waist circumference increases, relative to those born in the UK, with length of time since migration. These findings are consistent with two possibilities, that risk of obesity is increased by early life pre-migration environment and also by the negative consequences of the UK environment for adults and children (with a greater exposure the longer the time since migration). These results support the findings of previous research that shows the prevalence of a range of health conditions increases with length of residence in the UK (Harding, 2003, 2004; Williams, 1993).

The study shows that cultural characteristics also have an association with ethnic differences in waist circumference – but a smaller association than that between length of time since migration and waist circumference. For most ethnic minority groups, with the exception of Pakistani and Bangladeshi men, the waist circumference becomes larger, indicating that differentials in these cultural characteristics do not explain the observed disparities in waist circumference. For Bangladeshi men, the difference with White men is attenuated by cultural characteristics and for Pakistani men, cultural characteristics have little association with waist circumference. When compared with men from other ethnic groups, Pakistani and Bangladeshi men are the most likely, of all ethnic groups, to have low English language proficiency, report low levels of physical activity and to not drink alcohol (all of which are associated with increased obesity). In addition, Bangladeshi men are far more likely to be smokers (which is associated with increased obesity) than Pakistani men. It is clear, therefore, why cultural characteristics may have a different association with the waist circumference of Pakistani and Bangladeshi men (and particularly for the latter group) when compared to other ethnic groups.

Pakistani and Bangladeshi women have similar cultural 'profiles' to Pakistani and Bangladeshi men low levels of English language proficiency, low levels of physical activity and high levels of non-drinking and (similar to Pakistani men) have high levels of 'never smoked'. Therefore, one might expect cultural characteristics to have the same association with Pakistani and Bangladeshi women as they do for their male counterparts. These issues are certainly highlighted extensively in the related literature in particular around cultural barriers to physical activity. However, this study finds that cultural characteristics do not attenuate the difference between Pakistani or Bangladeshi women's waist circumference and White women's waist circumference. For these women, the differences in waist circumference persist, and in fact become larger, indicating that differentials in these cultural characteristics do not explain the observed disparities in waist circumference. The association of cultural characteristics with waist circumference for other ethnic minority groups is less clear and this may be related to the way in which culture is operationalised within the study. Socio economic characteristics are also associated with ethnic differences in waist circumference. Socio-economic characteristics may change upon migration, with upward or downward social mobility depending on the circumstances of migration. Socio-economic circumstances and social mobility play an important part in obesity (Smith et al., 2011; Sobal & Stunkard, 1989). The removal of barriers to upwards social mobility among migrant populations (such as barriers to educational attainment and employment) would go some way to reducing their higher risk of abdominal obesity. It is also clear that the areas that ethnic groups settle and live within have an association with ethnic differences in obesity, particularly in relation to the levels of deprivation within the areas.

The strong association between migration status and waist circumference may be driven by two underlying mechanisms related to post-migration experiences - changes in lifestyle or cultural norms and social mobility. Migration can lead to changes in lifestyle behaviours, attitudes or socio-economic position which can subsequently lead to changes in body weight (Mellin-Olsen & Wandel, 2005). The results from this study show that the strong association between migration status and waist circumference is partly attenuated by cultural characteristics and partly by socio-economic inequality. However, there is still a strong association between migrant status and waist circumference that remains unexplained. This may be a consequence of unmeasured cultural and socioeconomic effects, or other unobserved factors (such as diet) and requires further exploration. In particular, the measurement of dietary intake within the data set used here is poor (see limitations section), and, so, it is plausible that the strong association between migration status and waist circumference partly reflects dietary change among migrants.

The strong association between migration status and waist circumference and the small effect of culture and socio-economic inequality upon the association between migration status and waist circumference, suggests that policy makers should focus on obesity prevention among child and adult migrants and particularly focus on the length of time since migration (with an association between obesity and less recent adult migrants). However, the results also illustrate the importance of acknowledging the multi-dimensional nature of ethnic inequalities in obesity and the complex interplay between the potential pathways of migration, culture and socio-economic inequality. Policy should also focus on the removal of barriers to educational attainment and employment among migrant populations and consider the effect of the areas that migrants live, particularly in relation to area deprivation.

5. Limitations

The cross-sectional design of the HSE limits the degree to which causal pathways can be determined. However, a longitudinal dataset with a large enough sample size of adult ethnic minorities and an adequate array of variables to track over time the pathways leading to ethnic inequalities in obesity does not exist in the UK.

The cross-sectional data used are now quite old which means that the levels of obesity within ethnic groups may have changed due to, for example, changes in the age and generation profiles of ethnic groups and increased social mobility among some ethnic groups, among other things. However, the theorised pathways to obesity are considered unlikely to have changed substantially and this research is largely an exploration of the pathways to ethnic differences in obesity.

It is not possible to determine whether the results are partially due to selection effects. There may be 'healthy migrant' selection effects associated with the migration status results and there may be area-level selection effects – an individual may select to live in (or stay in) an area rather than being randomly distributed into an area (Boyle & Norman, 2010). Also, migration status is based on country of birth and initial age of immigration to the UK, so migration status is not calculated for those who moved in and out of the country. The datasets do not contain data on movements in and out of the country. Additionally, it is not possible to completely disentangle the potential correlation between length of time since migration and age.

Health behaviour variables are based on self-reported data rather than objectively measured data so respondents may under-report or over-report. The measurement of dietary behaviour does not adequately capture diet as a construct (in the way required to explore obesity). Fat intake is used as a proxy for diet but the results show an unexpected inverse association between fat intake and obesity. More complete data on dietary behaviour are required in order to precisely capture all food consumption (food types and amounts), which in turn would determine calorific intake.

Middle-Super Output Area (MSOA) data are the lowest level of geography that the data owners would release due to concerns over confidentiality. The use of MSOA (or any other artificial geographical boundary) limits the exploration of area effects because it does not take into consideration exposure to neighbourhoods outside of the residential MSOA (via activities such as employment, social activities or shopping).

Finally, there are a number of unmeasured elements within this research (due to lack of data) that could be the result of migration, cultural and socio-economic pathways to ethnic differences in obesity. For instance, experiences of racism/discrimination, stress, allostatic load, local access to food outlets or green space, the influence of early life exposures and perceptions of body image and stigma (National Obesity Observatory, 2011).

6. Conclusions

This research makes an important contribution to the study of ethnic differences in waist circumference in England. It is the first UK study to explore the associations of migration, cultural and socio-economic pathways with ethnic differences in waist circumference for a wide range of ethnic groups, using both individual and contextual data. The study finds that migration status has a strong association with ethnic differences in waist circumference – in particular length of time since migration to the UK.

The strong association between migration status and waist circumference is partly attenuated by cultural characteristics and partly by socio-economic inequality. However, there is still a strong association between migrant status and waist circumference that remains unexplained.

The results illustrate the multi-dimensional nature of ethnic inequalities in obesity and the complex interplay between migration status, culture and socio-economic inequality. Policy makers should focus on:

- obesity prevention among child and adult migrants, particularly focussing on length of time since migration.
- removal of barriers to educational attainment and employment among migrant populations
- the effect of the areas that migrants live, particularly in relation to area deprivation.

Obesity is an important factor in many health-related outcomes so the regular tracking of ethnic inequalities in obesity and a clear understanding of the pathways behind these differences is fundamental for improving the health of ethnic minority people.

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