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Ethnic Differences in overweight and obese children in England

CCSR Working Paper 2010-07
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The 1999 and 2004 Health Surveys for England are used to examine ethnic differences in overweight and obese boys and girls aged 2-15. Separate logistic regression models are run for 6 different ethnic groups. Having overweight or obese parents is a stronger predictor of childhood BMI than ethnic origin. Mothers' and fathers' BMI are predictors of childhood BMI across the ethnic groups studied but there are differences between boys and girls with the same ethnic origin. Interventions aimed at reducing childhood overweight/obesity should focus on parental characteristics, but they also need to be sensitive to gender and ethnic differences.

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Abstract

Objective:

(1) To determine ethnic differences[1] in child overweight/obesity after controlling for a range of mothers' socio-economic characteristics and parental Body Mass Index (BMI)

(2) To determine the importance of parental BMI and mothers' socio-economic status in attenuating overweight/obesity for boys and girls from different ethnic groups

Design:

The 1999 and 2004 Health Surveys for England are used to examine ethnic differences in overweight and obese boys and girls aged 2-15. The total number of children in the analyses is 7047. Child overweight (including obesity) is defined using the International Obesity Task Force (IOTF) age-specific thresholds for children. Logistic regression models are used to establish the relative importance of the explanatory variables for boys and girls, separately. Separate logistic regression models are run for 6 different ethnic groups (Black Caribbean, Indian, Pakistani, Bangladeshi, Irish and White) for boys and girls separately.

Results:

There are no statistically significant ($p<0.05$) ethnic differences in childhood BMI after controlling for a range of parental characteristics. Mothers' BMI is a predictor of overweight/obesity for boys and girls – and for all ethnic groups except Bangladeshi and Irish boys. Fathers' overweight/obesity is associated with overweight/obesity in sons and fathers' obesity with overweight/obesity in daughters. Fathers' BMI, mothers' social class and mothers' qualifications are not consistent predictors of children's BMI across different ethnic groups for boys or girls.

Conclusion:

Having overweight or obese parents is a stronger predictor of childhood BMI than ethnic origin. Mothers' and fathers' BMI are predictors of childhood BMI across the ethnic groups studied but there are differences between

[1] Ethnic differences refers to the difference between minority ethnic groups (such as Black Caribbean) and the majority 'white' population

boys and girls with the same ethnic origin. Interventions aimed at reducing childhood overweight/obesity should focus on parental characteristics, but they also need to be sensitive to gender and ethnic differences.

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Introduction

Obesity is an established risk factor in many health problems, including arthritis, stroke, heart disease, cancer and diabetes (Kopelman, 2000, Jonsson et al. 2002). Childhood obesity is a worldwide concern (Lobstein, 2004; Popkin et al, 2006); high levels of BMI in childhood are associated with being overweight in adulthood (Guo & Chumlea, 1999) and there is evidence to suggest that childhood obesity and overweight is linked to type 2 diabetes in childhood and also adult mortality and morbidity (Ehtisham et al. 2004, Rhoads and Kagan 1983, Gunnell et al. 1998). Obesity and overweight among children aged 2-15 years within England has increased in the last decade: the percentage of boys who were overweight or obese rose from 24 percent in 1995 to 31 percent in 2008 and for girls from 26 percent to 29 percent (Craig et al. 2009).

A number of London studies have consistently found differences in the levels of overweight/obesity in adolescents from different ethnic groups, with Black African and Black Caribbean adolescent girls more vulnerable to overweight and obesity than their white peers (Taylor et al 2005, Wardle et al 2006, Harding et al 2008). A nationally representative study of English children and young adults (aged 2 to 20) found that British Afro-Caribbean and Pakistani girls have an increased risk of being obese and Indian and Pakistani boys have an increased risk of being overweight than the general population (Saxena et al. 2004). The study suggested that ethnicity is a stronger predictor of childhood obesity than social class but it did not control for the effects of other socio-economic measures such as household income, parental education or parental employment status. A range of socio-economic characteristics – particularly related to

mothers - are associated with child obesity. Studies of preschool and school-age children suggest that mothers' employment status, working hours, educational qualifications and partnership status are each related to childhood overweight and obesity (Hawkins et al. 2008, Anderson et al. 2003; Phipps et al. 2006). For example, children whose mothers work long hours may spend longer watching television and have more access to snacks (Anderson et al, 2003; and we may expect better educated mothers to be better able to access information about the nutritional value of different foods than less educated mothers.

In addition, parental obesity is also a strong risk factor for child obesity, with child obesity more likely in households where both parents are either overweight or obese than in households with only one parent overweight/obese or with neither parent overweight/obese (Hunt et al, 2002; Abu-Rmeileh et al, 2008; Craig and Shelton, 2008, Jotangia et al. 2006). Daughters' obesity has been associated with mothers' obesity while sons' obesity has been associated with fathers' obesity (Perez-Pastor et al, 2009). In contrast, another study found that mothers who are overweight are more likely to have overweight daughters *and* sons (and more likely to have obese daughters) than mothers who are not overweight. The study also found that fathers who are overweight are more likely to have obese (but not overweight) daughters than fathers who are not overweight but there is no association with sons (Harding et al, 2008). However, little is known about whether these associations are consistent across different ethnic groups; the effect of mothers' and/or fathers' obesity may not have the same impact across all ethnic groups. We know of only one study in the United Kingdom that has examined this - Harding et al (2008) studied adolescents (aged 11-13) in London and found that the effects of mothers' and fathers' overweight status are not consistent across ethnic groups. However, this study is specific to 11-

13 year olds in London and parental overweight was based on the child's assessment rather than an objective measurement such as BMI.

Children whose mothers smoke during pregnancy are more likely to be obese than those whose mothers do not (Koupil & Toivanen, 2008; Oken et al, 2008). Few studies have examined mothers' current smoking status but Harding et al, (2008) found that mothers' current smoking status was positively associated with overweight and obesity for girls and obesity for boys; maternal smoking may be associated with material disadvantage.

Migration to a more affluent society may result in a change of lifestyle which may lead to increased body weight (Goel et al, 2004; Mellin-Olsen & Wandel, 2005). UK children who are born overseas are less likely to be obese than those born in the UK (Harding et al. 2008). A number of studies note the adoption of unhealthy diets among Pakistani, Bangladeshi and African people who migrate to Britain (Lawrence et al. 2007, Landman and Cruickshank, 2001).

This study adds to the literature by using nationally representative data from England for children aged 2-15 and their parents to examine:

(1) ethnic differences[2] in child overweight/obesity after controlling for a range of mothers' socio-economic characteristics and parental Body Mass Index (BMI)

(2) the importance of parental BMI and mothers' socio-economic status in attenuating overweight/obesity for boys and girls from different ethnic groups

[2] Ethnic differences refers to the difference between minority ethnic groups (such as Black Caribbean) and the majority 'white' population

The analyses uses an objective measures of overweight/obesity (BMI) for both mothers and fathers and their children and is able to distinguish key ethnic groups. All analyses use a combined measure of overweight and obesity for children. This provides much more robust estimates than restricting the analyses to obesity alone. In order to address the question of same sex parent-child relationships with overweight/obesity all analyses have been run for boys and girls separately. Details of the data and variables are given in the next section.

Methods

Data and definitions

The research uses the combined 1999 and 2004 Health Surveys for England (HSE) to examine ethnic differences in overweight (including obesity) in children. The HSE is an annual large-scale nationally representative cross-sectional survey. The 1999 and 2004 surveys cover adults and children living in private households and focus on the health of ethnic minority groups. In both years data is collected from a "general population" sample to represent the general population of England and also an "ethnic boost" sample to increase the number of ethnic minority participants. We merged individual data from the general population sample and the ethnic boost samples in both years in order to increase the overall sample size.

The 1999 and 2004 survey questionnaires collected information on cardio-vascular disease and related risk factors such as smoking and physical activity. Height and weight were measured in order to calculate BMI to measure obesity. A range of socio-economic variables were also collected from respondents, for instance educational qualifications and employment status. All

materials and questionnaires were translated into seven languages: Urdu, Punjabi, Gujarati, Hindi, Bengali, Mandarin and Cantonese. Informants who could not carry out an interview in English were provided with an interviewer who could speak the appropriate language (Erens et al. 2001, Sproston and Mindell, 2006).

The definition of what constitutes an ethnic group is widely debated (Coleman and Salt 1996, Bulmer 1996, Ballard 1996, Solomos and Back 1996). The HSE defines ethnic minority groups as in the 2001 UK Census, except for the Irish who are defined as Irish if either the respondent, or their mother or father had been born in the Republic of Ireland or Northern Ireland. The 1999 HSE sampling scheme was designed to give adequate numbers for analyses of the following minority ethnic groups: Black Caribbean, Indian, Pakistani, Bangladeshi, Chinese and Irish (Erens et al. 2001, Sproston and Mindell, 2006). The 2004 survey also boosted Black Africans. Although the non-boost sample contains a representative spread of all ethnic groups, only the minority groups listed here have a boosted sample size and they therefore form the focus of this analyses. Where informants were of mixed origin which included one of the minority ethnic groups listed above the HSE assigned them to that minority ethnic group. For example a person self-identifying as White and Black Caribbean would be defined as Black Caribbean. The White group is self-defined and is therefore a heterogeneous group that can be defined as 'White, not of Irish ancestory'. Table 1 gives a breakdown by ethnic group for boys and girls in the combined 1999 & 2004 dataset; the total number of children included in the analyses is 7047. The HSE defines children as those aged under 16 years and this age cut-off determines the questions that are asked to respondents so this analyses uses the same definition of a child. Children under 2

years are excluded from the analyses because the 1999 survey only covered those aged 2 and over.

Table 1: Number of persons aged 2-15 per ethnic group by sex (unweighted)

Ethnic group	Boys	Girls	Total
Black Caribbean	348	362	710
Black African *	157	144	301
Indian	391	326	717
Pakistani	522	523	1,045
Bangladeshi	454	399	853
Chinese	205	196	401
Irish	385	384	769
White	1,184	1,067	2,251
Total	3,646	3,401	7,047

* A boost sample for Black Africans was only taken in 2004

We use the Body Mass Index (BMI) measurement as an indicator of adiposity. BMI is widely used in epidemiological studies and clinical settings. Children are classified using the International Obesity Task Force (IOTF) age-specific thresholds for obesity and overweight[3] (Cole et al. 2000). There is some questioning over the suitability of childhood BMI thresholds for some ethnic groups but an expert group has recently concluded that the IOTF definitions are the most appropriate for all ethnic groups in the UK (Viner et el, 2010). Measures of abdominal

[3] The dataset includes age as an integer (for confidentiality reasons) so the analyses does not include the mid-year cut-offs in the IOTF definition. However, child's age rounded to the nearest integer is used to determine the age-specific BMI cut-off appropriate for the integer closest to the child's age.

fat (for instance waist circumference and waist-hip-ratio) may be better measures of body fat for Indians, Pakistanis and Bangladeshis because they have a more centralised distribution of body fat without developing generalised obesity (Yusuf et al, 2005; International Diabetes Institute, 2000; Mellin-Olsen & Wandel, 2005), however abdominal measurements are not available for children in the HSE dataset, therefore the analyses uses BMI. Mothers obesity/overweight is measured using the World Health Organisation definition of Body Mass Index for adults (weight / height²) (Cole et al. 2000). Overweight/obese for adults is defined as a BMI of more than 25kg/m.

Survey questions ask about the relationship between each member of the household, thus enabling linkage between parents and children. Data from both parents were linked to each child in the dataset. Parental status was defined as the person(s) who have legal responsibility (self-defined) for the child in question.

The HSE uses the Postcode Address File (PAF) as its sampling frame with up to three households interviewed at each address. In the 1999 survey the primary sampling unit (PSU) was the postcode sector and in the 2004 survey it was census wards. The 2004 minority ethnic boost sample selected an additional 408 PSUs stratified on the basis of 2001 Census estimates of the proportion of residents in the wards who were Black Caribbean, Black African, Indian, Pakistani, Bangladeshi, Chinese or Irish. The 1999 minority ethnic boost sample was drawn from an additional 340 PSUs.

The general population sample collects data from each adult member of the household (aged 16 and over) and data from up to two children in the household. The ethnic minority boost samples

up to four adults and three children from each household. An indicator of PSU for both 1999 and 2004 was available from the dataset and used in all analyses to take into account the sampling design (see later discussion).

The cross-sectional nature of the HSE means that we do not have access to the repeated measures and early-life information that make longitudinal surveys such as the British Cohort Studies so valuable for analyzing health outcomes. The HSE cannot, for example, allow one to establish the causal direction of an association between socio-economic characteristics and overweight/obesity. However, we are able to benefit from the hierarchical structure of the survey to establish generational differences that allow us to examine the relationships between parental characteristics and children's overweight/obesity

Modelling strategy

Combined models for all children aged 2-15

The purpose of these models is to identify ethnic differences in overweight (including obesity) after controlling for a range of parental characteristics and also to identify the strongest predictors of childhood obesity/overweight for use in the separate ethnic models outlined later in this paper. We use logistic regression models to predict the propensity of being overweight/obese. The response variable is thus binary where y=1 indicates 'overweight including obesity' and y=0 indicates 'not overweight or obese'. In order to allow gender differences in the relationship with mothers' and fathers' BMI, separate models are run for girls and boys. Each ethnic group is included as a dummy variable and other explanatory variables are

included based on the literature. Although only the full model is shown here, variables were added in successive stages and model fit examined after each addition.[4]

Age is included in the models to control for the fact that BMI varies with age and because children within different ethnic groups may have different age profiles. We also include year in the models to control for differences between 1999 and 2004.

The literature suggests that the characteristics of mothers are of importance in predicting child overweight/obesity outcomes. Based on the evidence discussed above, we have included:

- Mothers' BMI, categorized as obese, overweight and neither overweight nor obese.
- Mothers' employment, categorized as part-time, full-time, unemployed or other economically inactive. We use the HSE definition of part-time, which is less than 30 hours per week.
- Mothers' social class (based on Registrar General's Class) categorized as professional, managerial, skilled non-manual, skilled manual, semi-skilled, unskilled or no class. Class was based on responses to current or last occupation and employment status for all adults who had ever worked. Those with no recorded class information were allocated to a 'no class' category.
- Mothers' highest educational qualification categorised as degree-level; higher qualifications below degree; National Vocational Qualifiaction (NVQ)[5] level 3 equivalent;

[4] Standard measures of goodness of fit are not reported in STATA when using 'svy' commands for complex samples with the logit function. We therefore used an algorithm specifically devised for measuring goodness of fit in this situation (svylogitgof).

[5] NVQs are qualifications in England, Wales and Northern Ireland that are achieved through assessment and training. They are based on National Occupational Standards that describe the 'competencies' required for a particular job role.

NVQ level 1 or 2 equivalent; and no qualifications. Overseas and 'other' qualifications are grouped with NVQ 1 or 2 equivalent[6]

- Mothers' migration status divided into GB born and not born in GB
- Mothers' smoking status divided into current smoker and not a current smoker

The only fathers' characteristic included in the models is fathers' BMI. However, 23 percent of children in the analyses had no father in the household (i.e. in lone-mother families) and 13 percent had a father in the household but no data recorded for him. These two groups are combined. Fathers' BMI is categorized as:

- father obese; father overweight; father neither obese nor overweight; father in household but with no data or no father in the household.

Lone parent family is included in the model as a binary variable. Household income is also included in the models as follows:

- equivalised household income[7] per annum, grouped into three tertiles (top, middle and bottom) based on total household income from all sources.

The 2004 survey provides information on fruit and vegetable intake but the 1999 survey does not provide comparable data. The survey does not provide information on calorific intake. Initial analyses of the 2004 data showed that fruit and vegetable intake had no explanatory value in

[6] In the 2004 survey less than one percent of men and only two percent of women had overseas or 'other' qualifications.

[7] Equivalised household income adjusts household income to take account of the number of persons in the household. Equivalised annual income scores are calculated, and the equivalised annual household income attributed to each adult and child in the household. The variable is based on gross income and is constructed before household costs.

predicting children's obesity/overweight and therefore it has not been used in the analyses. Children's physical activity in the 1999 survey was only asked to ethnic minority groups; because of the lack of a white comparator we have not included physical activity in the models.

Models for separate ethnic groups

In order to examine whether the parental factors introduced in the combined model have the same effects across all ethnic groups we need to analyse each ethnic group separately. We have run separate logistic models for each of the six largest ethnic groups: Black Caribbean, Indian, Pakistani, Bangladeshi, Irish and White and for girls and boys within each group. We have excluded the two smallest groups, Black Africans and Chinese, because numbers for boys and girls in these groups fall below 200. We have limited the explanatory variables to those which were significant in the combined models: age, year, mothers' and fathers' BMI, mothers' social class and mothers' highest educational qualification and have collapsed social class and qualification categories as below:

- professional or managerial; skilled non-manual or skilled manual; semi-skilled or unskilled; and no class
- degree-level or higher qualifications below degree or National Vocational Qualifiaction (NVQ) level 3 equivalent; NVQ level 1 or 2 or equivalent; and no qualifications

All our analyses are carried out in STATA using the survey command (SVY) which accounts for the complex design features of the HSE and, in particular, allows clustering within PSUs to be

incorporated[8]. All analyses are also weighted to account for unequal probabilities of selection and non-response.

Results

Exploratory analyses

Table 2 shows the level of boys and girls in the sample who are overweight/obese by each of the explanatory variables used in the models. Black Caribbean and Black African girls have the highest levels of being overweight/obese followed by Pakistani boys, Bangladeshi girls and Indian girls. Chinese boys are lowest with only 15 percent overweight or obese. Over forty percent of girls and around one-third of boys with obese mothers are overweight or obese themselves. Similarly over one-third of boys and girls with obese fathers are overweight or obese themselves. For girls and boys there appears to be a relationship between mothers' social class and being overweight/obese. For girls only there is a clear gradient with mothers' highest level of qualification, with levels of obesity/overweight 16% for girls whose mother has a degree compared with about 29% for girls whose mothers have low or no qualifications. This suggests that the children of elite mothers in higher occupations and/or with high levels of qualification are less likely to be overweight/obese - but that the effect may vary for girls and boys. The results from the logistic regression models, discussed below, provide a formal assessment of the statistical significance of the predictor variables.

[8] Standard commands in statistical software typically treat data as simple random samples which can result in an underestimation (or in some cases, overestimation) of the standard errors and incorrect identification of statistically significant results

Table 2: Levels of overweight (including obesity) for boys and girls (aged 2-15) by key variables

	% overweight/obese, CI (95%)	
Descriptive	**Boys**	**Girls**
Age group		
2-3	27.3 (21.0,34.7)	20.4 (15.4,26.5)
4-6	21.4 (17.4,26.1)	24.2 (19.8,29.1)
7-9	21.0 (16.8,25.8)	24.2 (19.9,29.1)
10-12	25.7 (21.2,30.8)	27.7 (22.6,33.4)
13-15	23.7 (19.2,29.0)	29.7 (24.2,36.0)
Total number of persons	3646	3401
Ethnic group		
White	23.4 (20.9,26.2)	25.3 (22.6,28.3)
Black Caribbean	24.4 (18.7,31.3)	36.3 (30.1,43.0)
Black African	26.3 (17.0,38.4)	36.1 (21.9,53.3)
Indian	21.9 (17.4,27.2)	27.9 (22.1,34.5)
Pakistani	28.6 (23.6,34.1)	23.8 (19.6,28.6)
Bangladeshi	20.8 (16.8,25.5)	28.1 (21.6,35.8)
Chinese	15.2 (10.9,20.8)	21.8 (16.0,29.1)
Irish	21.8 (17.0,27.5)	24.1 (18.4,31.0)
Total number of persons	3646	3401
Mothers' Body Mass Index		
Neither overweight or obese	17.4 (14.4,20.7)	14.8 (12.2,17.8)
Obese	33.6 (27.8,39.8)	43.7 (37.7,49.8)
Overweight	25.3 (21.1,30.0)	29.4 (25.1,34.1)
Total number of persons	3093	2960
Mothers' employment status		
Employed full-time	23.4 (18.9,28.7)	29.7 (24.7,35.2)
Employed part-time	22.6 (19.0,26.7)	21.6 (18.1,25.6)
Unemployed	24.0 (14..5,36.9)	14.9 (7.8,26.8)
Not economically active	24.7 (20.7,29.2)	27.7 (23.7,32.1)

Total number of persons	3308	3120
Mothers' social class		
Professional	14.8 (6.4,30.6)	16.0 (6.4,34.5)
Managerial	22.5 (18.16,27.5)	22.5 (18.2,27.4)
Skilled non-manual	24.4 (20.4,28.9)	26.4 (22.3,31.0)
Skilled manual	31.7 (23.7,40.9)	32.9 (24.0,43.2)
Semi-skilled	21.7 (16.9,27.3)	21.9 (17.0,27.6)
Unskilled	23.6 (15.0,35.1)	34.8 (24.3,47.0)
No class	20.6 (16.0,26.0)	30.3 (23.5,38.2)
Total number of persons	3464	3401
Mothers' highest educational qualification		
Degree or higher	24.0 (18.2,30.9)	16.4 (12.2,21.7)
Higher education	20.8 (14.8,28.3)	20.4 (15.0,27.1)
NVQ level 3 or equivalent	32.7 (25.3,41.1)	29.0 (22.8,36.2)
NVQ level 1 or 2 or equivalent	22.2 (19.1,.25.8)	27.1 (23.6,30.8)
No qualifications	21.8 (17.0,27.6)	28.9 (23.0,35.5)
Total number of persons	3311	3124
Mothers' migration status		
Born overseas	26.9 (22.0,32.5)	25.3 (20.9,30.3)
GB born	23.1 (20.6,25.8)	25.4 (22.8,28.2)
Total number of persons	3301	3119
Mothers' smoking status		
Current smoker	22.4 (18.6,26.9)	26.6 (22.2,31.7)
Not a current smoker	24.1 (21.3,27.1)	24.9 (22.2,27.8)
Total number of persons	3313	3121
Fathers' Body Mass Index		
Obese	34.0 (27.8,40.8)	34.9 (28.0,42.5)

Overweight	21.7 (18.1,25.9)	24.9 (20.7,29.5)
Neither overweight or obese	12.6 (9.0,17.3)	17.8 (13.3,23.3)
Father in household but no data or no father in household	24.8 (21.0,29.0)	26.5 (22.7,30.6)
Total number of persons	3646	3401
Lone-parent family		
Yes	23.1 (19.0,27.8)	27.1 (22.6,32.1)
No	23.5 (20.9,26.3)	25.1 (22.4,28.1)
Total number of persons	3646	3401
Equivalised household income tertiles		
Highest income tertile	25.9 (21.4,31.0)	22.9 (18.5,27.9)
Middle income tertile	22.3 (18.5,26.7)	24.0 (20.2,28.2)
Lowest income tertile	21.4 (18.0,25.2)	28.8 (24.6,33.3)
Total number of persons	3186	2974

Combined models

Table 3 presents the logistic regression model for all children aged 2-15 with ethnic group entered as a dummy variable. The beta coefficients and standard errors are reported – a positive beta coefficient indicates that the category is more likely than the reference category to be overweight/obese and a negative coefficient indicates the opposite, with larger coefficients indicating stronger relationships. The statistically significant variables are highlighted with asterixes as follows: * $p<0.05$; ** $p<0.01$; ***$p<0.001$.

Table 3: Logistic regression for overweight/obesity, children aged 2-15

Variables	Boys (aged 2-15)			Girls (aged 2-15)		
	Beta	Std error	CI (95%)	Beta	Std error	CI (95%)
Age (single years)	-0.01	0.02	-0.05, 0.03	0.02	0.02	-0.1, 0.06
Year (ref: 1999)						
2004	0.12	0.16	-0.19, 0.43	0.35*	0.14	0.07, 0.63
Ethnic group (ref: white)						
Black Caribbean	-0.03	0.24	-0.51, 0.45	0.42	0.23	-0.03, 0.87
Black African	0.19	0.41	-0.62, 0.99	0.42	0.59	-0.73,1.57
Indian	-0.14	0.28	-0.68, 0.41	-0.04	0.31	-0.64, 0.57
Pakistani	0.30	0.31	-0.31, 0.90	-0.41	0.39	-1.19, 0.36
Bangladeshi	0.18	0.35	-0.51, 0.86	0.16	0.45	-0.72, 1.03
Chinese	-0.15	0.34	-0.82, 0.51	0.12	0.39	-0.64, 0.88
Irish	-0.15	0.25	-0.62, 0.33	-0.08	0.25	-0.56, 0.40
Mothers' Body Mass Index (ref: neither obese or overweight)						
Overweight	0.51**	0.20	0.14, 0.88	0.73***	0.17	0.39, 1.06
Obese	0.91***	0.19	0.53, 1.29	1.28***	0.18	0.92, 1.64
Mothers' employment status (ref: in full-time employment)						
In employment – part-time	0.06	0.20	-0.33, 0.46	-0.23	0.20	-0.63, 0.16
Unemployed	0.13	0.39	-0.64, 0.90	-0.81	0.42	-1.64, 0.25
Other economically inactive	0.11	0.25	-0.39, 0.60	-0.04	0.22	-0.46, 0.38
Mothers' social class (ref: professional)						
Managerial	0.83	0.48	-0.11, 1.78	0.00	0.56	-1.10, 1.10
Skilled non-manual	1.11*	0.51	0.11, 2.12	-0.04	0.58	-1.19, 1.11
Skilled manual	1.42*	0.57	0.30, 2.55	0.06	0.64	-1.19, 1.31
Semi-skilled	1.00	0.52	-0.03, 2.02	-0.29	0.61	-1.48, 0.90
Unskilled	1.24*	0.59	0.08, 2.42	0.53	0.66	-0.77, 1.82
No class	0.76	0.58	-0.37, 1.89	-0.14	0.72	-1.55, 1.27
Mothers' highest qualification (ref: degree)						
Higher education below Degree	-0.39	0.31	-1.00, 0.22	0.22	0.29	-0.34, 0.78
NVQ level 3 equiv	0.27	0.32	-0.35, 0.90	0.77**	0.30	0.19, 1.36

NVQ level 1 or 2 equiv/Foreign/Other	-0.24	0.28	-0.79, 0.32	0.58*	0.26	0.07, 1.10
No Qualifications	-0.33	0.34	-1.01, 0.34	0.54	0.34	-0.12, 1.20
Mothers' migration status (ref: GB born)						
Born overseas	0.26	0.25	-0.24, 0.76	0.14	0.30	-0.45, 0.73
Mothers' smoking status (ref: not a current smoker)						
Current smoker	0.10	0.18	-0.25, 0.45	0.10	0.18	-0.25, 0.45
Fathers' Body Mass Index (ref: neither obese or overweight)						
Overweight	0.54*	0.23	0.09, 0.99	0.20	0.24	-0.26, 0.67
Obese	1.05***	0.25	0.56, 1.55	0.68*	0.27	0.16, 1.21
Father in household but no data or no father in household	0.62*	0.30	0.04, 1.21	0.49	0.28	-0.05, 1.03
Lone Parent household (ref: not a lone parent household)						
Yes	0.08	0.28	-0.48, 0.63	-0.30	0.27	-0.83, 0.23
Equivalised household income tertiles (ref: highest income tertile)						
Middle income tertile	-0.34	0.20	-0.74, 0.05	-0.04	0.21	-0.46, 0.37
Lowest income tertile	-0.48*	0.23	-0.94, 0.02	-0.01	0.24	-0.49, 0.46
Unweighted number of persons[9]	*2695*			*2573*		

* p<0.05; ** p<0.01; ***p<0.001

While the exploratory analyses (Table 2) highlighted a number of ethnic differences in overweight/obesity for boys and girls, the logistic regression models introduce explanatory variables, informed by the literature, which attenuate these observed ethnic differences. The model shows that for children aged 2-15, after including all controls, there are no statistically significant ethnic differences in being overweight/obese.

[9] The total number of males and females is smaller than those shown in Table 1 because of item non-response

The exploratory analyses suggested that childhood overweight/obesity for boys and girls is strongly influenced by the BMI status of their mother and the logistic regression supports this. After controlling for other factors boys and girls with obese or overweight mothers are more likely to be overweight/obese than those whose mothers are not overweight or obese. The effect of mothers' obesity and overweight status is stronger for girls than for boys, although it is highly significant for both sexes.

Mothers' social class and mothers' qualifications are significant indicators of childhood BMI but not for both sexes. Mothers' social class has a significant effect on boys only. Boys with mothers who are skilled-non-manual, skilled manual or unskilled are more likely to be overweight/obese than those with professional mothers, after controlling for other factors. In contrast, girls but not boys have a significantly raised likelihood of being overweight/obese if their mother has low qualifications (NVQ level 1-3 or equivalent) by comparison with girls whose mother has a degree level qualification. For boys there are no significant associations with mothers' level of qualifications.

Although the literature suggests that mothers' smoking status, mothers' employment and work hours, mothers' migration status and lone parenthood are all important predictors of obesity for girls and boys our models do not find that any of these factors are significant. However, boys with an overweight or obese father are more likely to be overweight/obese themselves by comparison with boys with a father who is neither overweight nor obese. Having no father in the household or a father in the household but with no data is also associated with being overweight/obese for boys. Fathers' obesity also influences girls; girls with an obese father are

more likely to be overweight/obese than those with a father who is not overweight or obese. Although having a father who is overweight is positively associated with being overweight/obese, for girls it did not reach significance level. Having no father in the household or a father in the household but with no data is positively associated with being overweight/obese for girls but not statistically significant.

Boys living in households in the lowest household income tertile are less likely to be overweight or obese than those in households in the highest income tertile. Household income is not significant for girls.

Models for separate ethnic groups

The combined models make the assumption that the effect of the explanatory variables is the same irrespective of the child's ethnic group. In reality, though, having a mother with no qualifications may have a different relationship with the outcome variable for a White child than for a Bangladeshi child. Similarly the effect of mothers' or fathers' obesity may not have the same uniform impact across all ethnic groups. The separate models for the six different ethnic groups aim to establish this. We have limited the explanatory variables to those which were significant in the combined models: mothers' and fathers' BMI, mothers' social class and mothers' highest educational qualification. Tables 4 and 5 show the results for boys and girls respectively.

Table 4: Logistic regression: overweight (including obese) for separate ethnic groups, boys aged 2-15 (model also controlled for age and year) * p<0.05; ** p<0.01; ***p<0.001

BOYS (aged 2-15)	ETHNIC GROUP					
Variables	Black Caribbean	Indian	Pakistani	Bangladeshi	Irish	White
	Beta (95% CI)					
Mothers' BMI (ref: not overweight/obese)						
Overweight	0.97 (-0.02, 1.96)	0.43 (-0.30, 1.16)	0.34 (-0.61, 1.29)	-0.07 (-0.72, 0.58)	0.54 (-0.32, 1.41)	0.48* (0.09, 0.87)
Obese	2.30*** (1.25, 3.34)	0.85* (0.09, 1.62)	1.16* (0.14, 2.17)	0.09 (0.79, 0.97)	0.16 (-0.85, 1.18)	0.86*** (0.45, 1.26)
Fathers' BMI (ref: not overweight/obese)						
Overweight	2.61* (0.41, 4.81)	1.00 ** (0.24, 1.77)	0.17 (-0.69, 1.02)	0.64 (-0.28, 1.55)	1.32 (-0.10, 2.73)	0.52* (0.03, 1.00)
Obese	0.41 (-1.92, 2.74)	0.79 (-0.25, 1.83)	0.62 (-0.46, 1.71)	1.77** (0.60, 2.95)	1.70* (0.10, 3.30)	0.95** (0.40, 1.50)
Father in household but no data or no father in household	1.15 (-0.86, 3.17)	1.30** (0.43, 2.16)	-0.15 (-0.90, 0.60)	0.56 (-0.32, 1.44)	0.97 (-0.27, 2.20)	0.63* (0.14, 1.12)
Mothers' social class (ref: Professional/managerial)						
Skilled	0.01 (-0.85, 0.86)	0.15 (-0.73, 1.03)	0.10 (-1.05, 1.26)	0.81 (-1.36, 2.98)	0.43 (-0.65, 1.52)	0.28 (0.16, 0.72)
Semi-skilled or unskilled	-0.75 (-1.90, 0.40)	-0.67 (-1.64, 0.31)	0.96 (-0.23, 2.14)	0.48 (-1.86, 2.81)	0.64 (-0.50, 1.78)	0.16 (-0.32, 0.63)
No class	-1.01 (-2.44, 0.42)	-0.85 (-2.10, 0.41)	0.21 (-0.94, 1.35)	0.47 (-1.74, 2.68)	1.05 (-0.85, 2.95)	-0.40 (-1.47, 0.68)
Mothers' qualifications (ref: degree/higher education below degree/NVQ level 3 equiv)						
NVQ level 1 or 2 equiv/Foreign/Other	0.04 (-0.70, 0.78)	-0.19 (-0.87, 0.49)	0.45 (-0.50, 1.41)	0.08 (-1.03, 1.20)	0.27 (-0.63, 1.16)	-0.37 (-0.74, -0.01)
No Qualifications	-0.50 (-1.57, 0.57)	0.06 (0.78, 0.90)	0.31 (-0.66, 1.27)	0.14 (-0.96, 1.24)	-0.18 (-1.30, 0.95)	-0.36 (-0.89, 0.18)
Unweighted number of Cases	*269*	354	445	374	280	1076

Table 5: Logistic regression: overweight (including obese) for separate ethnic groups, girls aged 2-15 (model also controlled for age and year) * p<0.05; ** p<0.01; ***p<0.001

GIRLS (aged 2-15)	ETHNIC GROUP					
Variables	Black Caribbean	Indian	Pakistani	Bangladeshi	Irish	White
	Beta (95% CI)					
Mothers' BMI (ref: not overweight/obese)						
Overweight	0.80 (-0.02,1.62)	0.53 (-0.27,1.33)	0.53 (-0.30,1.36)	0.38 (-0.27,1.03)	-0.36 (-1.29,0.57)	0.91*** (0.54,1.27)
Obese	1.65*** (0.78,2.53)	1.65*** (0.75,2.55)	1.14** (0.40,1.87)	1.47** (0.65,2.29)	1.34** (0.45,2.22)	1.42*** (1.02,1.82)
Fathers' BMI (ref: not overweight/obese)						
Overweight	2.39* (0.34,4.43)	0.55 (-0.33,1.44)	0.91* (0.22,1.60)	0.40 (-0.27,1.07)	2.08* (0.19,3.98)	0.00 (-0.50,0.50)
Obese	3.34* (0.82,5.86)	1.37** (0.39,2.35)	0.64 (-0.28,1.57)	0.57 (-0.64,1.79)	2.30* (0.39,4.21)	0.39 (-0.14,0.92)
Father in household but no data or no father in household	2.19* (-0.35,4.02)	0.26 (-0.69,1.20)	0.82* (0.09,1.55)	-0.01 (-0.82,0.79)	1.84* (0.23, 3.46)	0.03 (-0.44,0.49)
Mothers' social class (ref: Professional/managerial)						
Skilled	1.33** (0.46,2.20)	0.17 (-0.70,1.03)	1.42* (0.15,2.70)	-0.48 (-2.60,1.64)	1.19* (0.21,2.16)	-0.07 (-0.49,0.34)
Semi-skilled or unskilled	1.36** (0.38, 2.34)	0.08 (-0.88,1.04)	1.40* (0.08,2.72)	0.25 (-1.85,2.34)	0.49 (-0.52,1.50)	-0.23 (-0.72,0.26)
No class	1.65 (-0.51,3.82)	0.45 (-0.69,1.60)	0.64 (-0.50,1.77)	-1.07 (-3.15,1.00)	-0.59 (-2.74,1.56)	0.33 (-0.72,1.38)
Mothers' qualifications (ref: degree/higher education below degree/NVQ level 3 equiv)						
NVQ level 1 or 2 equiv/Foreign/Other	-0.24 (-1.03,0.55)	-0.52 (-1.39,0.34)	0.16 (-0.68,0.99)	0.03 (-1.02,1.08)	-0.70 (-1.71,0.32)	0.37* (0.00,0.73)
No Qualifications	-0.63 (-1.80,0.55)	0.31 (-0.46,1.09)	0.06 (-0.70,0.82)	0.34 (-0.88,1.56)	0.39 (-0.86,1.65)	0.38 (-0.19,0.96)
Unweighted number of cases	280	302	446	349	302	1000

Boys

Mothers overweight or obesity (or both) is significantly related to boys' overweight/obesity for all groups except Bangladeshi and Irish boys. Fathers' overweight or obesity is similarly predictive of boys' overweight/obesity (but not statistically significant for Pakistani boys). There is no statistically significant relationship between mothers' social class or mothers' level of education for boys in any of the 6 ethnic groups.

Girls

Across ethnic groups, girls with obese mothers are more likely to be overweight/obese compared with those whose mother is neither overweight nor obese. Fathers' overweight/obese status is associated with girls' overweight or obesity for all groups except White and Bangladeshi girls. Mothers' social class and educational qualifications are not consistently significant predictors of childhood obesity for girls across the different ethnic groups. For example, Black Caribbean and Pakistani girls with mothers in skilled, semi or unskilled jobs are significantly more likely to be overweight/obese than girls with mothers in professional or managerial jobs. While there was a relationship between mothers' qualifications and the probability of overweight/obesity for girls in the combined model, this relationship is not apparent for the separate ethnic groups. In part this may be because the small number of mothers with degree level qualifications meant that categories had to be collapsed and thus this distinction was lost.

Discussion

While the exploratory analyses highlight a number of ethnic differences in overweight/obese status for boys and girls, the combined regression models in Table 3 introduce explanatory variables which attenuate these observed differences. There were no statistically significant

ethnic differences in the probability of being overweight/obese. This findings contrast with other nationally representative studies of ethnicity and childhood obesity (Saxena et al, 2004; Sproston and Mindell, 2006) - these differences are likely to be due to the larger set of controls used in this study and, in particular, the inclusion of parental BMI.

Parental BMI is the major predictor of a child's BMI, regardless of ethnicity and other factors. Contrary to the Earlybird study by Perez-Pastor et al (2009) which found that childhood obesity is most importantly associated with the BMI of the same-sex parent, the combined models (table 3) indicate that mothers' overweight and obesity are strongly associated with overweight/obesity among sons. Mothers' overweight and obesity is also strongly associated with overweight/obesity in daughters but the association between fathers and daughters is only present for obese fathers and not for overweight fathers. Although these results are not entirely consistent with those of Perez-Pastor et al, they lend weight to their overall conclusion – that interventions need to be directed at the overweight or obese parent. However, these associations are not carried over in a straightforward manner for separate ethnic groups. The results suggest that mothers' BMI status has a stronger effect than fathers' across most groups but the variation between ethnic groups suggests the need to look more carefully at cultural and dietary explanations for these differences. It also suggests that any inherited tendency towards obesity is far from deterministic.

By contrast with other studies (Hawkins et al, 2008; Harding, 2008) our combined models (Table 3) show no association between mothers' employment status, work hours, current smoking status, migration status or partnership status and children's overweight/obesity. However,

Anderson et al (2003) in the US and Hawkins et al (2008) in the UK found that the relationship between child obesity and mothers' increased work hours was specific to high earning mothers and we have not been able to test this interaction.

Mothers' social class was significantly associated with boys' overweight/obesity. This result contrasts with Saxena's results using the 1999 HSE which found no significant relationships with childhood overweight/obesity and social class. However, Saxena's model did not include other controls and did not test for interactions with specific ethnic groups. Our combined models also found that mothers' educational level was significantly associated with girls' overweight/obesity. These results suggest that the children of elite mothers in higher occupations and/or with high levels of qualification are less likely to be overweight/obese – with the effect varying for girls and boys. Mothers' qualification level and mothers' social class were therefore included in the models for separate ethnic groups. With separate models for each ethnic group we find that Black Caribbean and Pakistani girls have a significantly higher likelihood of overweight/obesity if their mother is in a skilled, semi- or unskilled class by comparison with a professional or managerial class – but there is no significant relationship for other ethnic groups.

Limitations of the study

- The HSE is a nationally representative cross-sectional survey and therefore causal relationships cannot be established. However, by making inter-generational linkages we are able to identify associations between parental characteristics and child outcomes.

- The 1999 and 2004 HSE ethnic boost enables detailed analyses for separate ethnic and gender groups but the number of persons in each analysis group is small.
- BMI may underestimate fat mass in Indians, Pakistanis and Bangladeshis.
- The ethnic group categories available in the HSE do not allow nuanced analyses that take into account the complexity of this concept.

Conclusion

Having overweight or obese parents (in particular an overweight or obese mother) is a stronger predictor of childhood BMI than ethnic origin. The separate ethnic group analyses find that mothers' and fathers' BMI are important predictors of childhood overweight/obesity across most of the ethnic groups we studied, however, there are differences between boys and girls who are in the same ethnic category. Mothers' social class is a predictor of childhood overweight/obesity for boys and mothers' educational level is a predictor for girls, however these results are not consistent across the ethnic groups we studied. Our results suggest that interventions aimed at reducing childhood overweight/obesity should focus on parental characteristics, but they also need to be sensitive to gender and ethnic differences.

Key messages

- There are no statistically significant ethnic differences in childhood BMI after controlling for a wide range of maternal socio-economic factors and parental obesity,
- Mothers' BMI (overweight and obesity) is an important predictor of overweight/obesity for both boys and girls – and for all ethnic groups except Bangladeshi and Irish boys.
- Fathers' overweight and obesity is associated with overweight/obesity in sons and fathers' obesity (but not overweight) with overweight/obesity in daughters. However, the

association between fathers' BMI and overweight/obesity is not consistent for separate ethnic groups for either boys or girls and does not research statistical significance for white girls.

- Girls whose mothers have degree level qualifications have a significantly lower probability of being overweight/obese than girls with less qualified mothers. Mothers' social class and qualifications are not consistent predictors of children's BMI across different ethnic groups.

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