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Does parental concern about their child's future risk of overweight vary by ethnic group? Cross-sectional analysis of a national cohort study

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Abstract

Objectives

To examine whether parental concern about future childhood overweight, reported when the child was aged five years, varied by ethnic group. We hypothesised that parents of children from South Asian and Black ethnic groups would be more likely to express such concerns, especially for their daughters.

Design: Cross-sectional

Setting: United Kingdom

Participants: 15,039 children (of 15,459 singletons) whose parent was interviewed as part of the nationally representative UK-wide cohort study, the Millennium Cohort Study, when their child was aged five years (48.9% girls; 86.7% White).

Primary outcome measure: Cross-sectional parent-reported concern (some/none) about future childhood overweight reported when their child was aged five years.

Methods

We estimated the adjusted odds ratios (aOR) of some parental concern by ethnic group (White, South Asian, Black, Mixed/Other), adjusted for parent and child weight status, and examined interactions with sex.

Results

Parents were more likely to be concerned about risks of future overweight for their daughters than for their sons (95% CI mean difference girls-boys: 5.2,8.0). Parents of girls of Pakistani (aOR; 95%CI: 0.4; 0.2,0.5), Bangladeshi (0.3; 0.2,0.5), Black African (0.5; 0.3,0.7) and Mixed (0.7; 0.5,0.99) ethnicity and of boys of Pakistani ethnicity (0.6; 0.4,0.9) were less likely, and parents of children with a BMI in the

overweight (2.5; 2.2,2.8) or obese (6.7; 5.7,7.9) range, or themselves considered overweight (1.4; 1.2,1.5) or obese (1.9; 1.7,2.2) were more likely to express concern.

Conclusions

Parents of children from South Asian and Black ethnic groups express less concern about their child's future overweight risk despite their higher future risk of obesity. Qualitative studies are needed to explore these findings and to understand their relevance for the design of weight-management interventions in ethnically diverse populations.

Article summary

Strengths and limitations of the study

- We used robust statistical methods (including imputation of missing data and use of survey weights)to analyse a large, nationally representative and ethnically diverse cohort of children, allowing examination of parental concern across ten ethnic groups
- We used a definition of overweight and obesity that indicates a severity likely to require clinical intervention, and applied ethnic-specific BMI adjustment for more accurate assessment of body fatness in children from South Asian and Black ethnic groups.
- We were able to adjust for a number of covariates in our analysis including those shown previously to be strongly associated with parental concern, including parental and child weight status (the latter based on objective measurements).
- At present there are no validated algorithms for the adjustment of BMI for children from Mixed and Other ethnic groups so no adjustments were made for these children in our analyses.
- Whilst responses to the question eliciting parental concern are unlikely to be influenced by the MCS weight measurement (as this question was asked before the child was weighed), some cohort children may have been recently weighed and information on the timing of this in relation to the MCS interview, or the feedback given to parents, is unavailable.

Abbreviations

BMI – body mass index

UK – United Kingdom

MCS – Millennium Cohort Study

CI – confidence interval

OR – odds ratio

NCMP – National Child Measurement Programme

Introduction

In England more than a quarter of children currently leave primary school with a body mass index (BMI) classified as overweight or obese, at a level of severity deemed to be in need of clinical intervention.[1] These proportions vary by ethnic group, and, after adjustment to account for ethnic variation in fat mass, are significantly higher among children of South Asian ethnicity, especially among boys.[2] This has important implications for their future health, given evidence that South Asian children are biologically more susceptible to overweight, and the higher risks of type two diabetes and cardiovascular disease in adulthood among South Asian compared to White children, which have been shown to develop in childhood.[3-5]

While the negative health consequences associated with obesity are widely acknowledged, many parents are unable to identify overweight or obesity in their children,[6-8] with the majority of parents of children with a BMI in the overweight or obese range underestimating their child's weight status,[9,10] a finding replicated in numerous developed countries across the world.[8,11,12] There is mixed evidence as to whether correct parental assessment of childhood overweight and obesity is necessary to aid obesity prevention, with some studies suggesting correct parental identification of childhood overweight informs intentions to change,[13,14] whilst others acknowledge that identification and intentions to change may not lead to engagement with interventions and ultimate weight loss.[6,13,15]

Parental concern about their child becoming overweight in the future has been considered an additional parameter of parental awareness of overweight, with the suggestion that it may be a more meaningful predictor of behaviour change and subsequent weight loss compared to parental identification of overweight. An international study assessing how incorrect parental perception of child overweight determines use of activities to alter child weight proposed that absence of parental concern about childhood overweight could hinder prevention programmes.[16]

There is strong evidence to suggest that parental concern about their child becoming overweight in the future is higher among parents of children with a BMI in the overweight or obese range compared with parents of children with a healthy weight BMI.[10,17-20] Furthermore, it has been shown that parents express higher levels of this concern for daughters with overweight or obesity than for sons,[6,21-23] as well as if they themselves have a BMI categorised as overweight or obese.[10,23] Some regional studies in the United Kingdom (UK) have also identified associations between parental concern and ethnic group, with lower levels of concern for childhood overweight reported among Black Somali parents in Liverpool,[17] and greater concern among Black Afro-Caribbean parents in London,[24] whilst others found no statistically significant difference in parental concern between White and non-White groups.[10] These findings are based on studies with low response rates and consequently small sample sizes, and did not adjust BMI for ethnicity.

Across the UK, children's heights and weights are measured on or shortly after entry to primary school at age five years. Following measurement, parents receive a feedback letter informing them of their child's weight status. Given the longitudinal evidence that obesity at the beginning of primary school strongly predicts obesity on leaving primary school,[25,26] age five may be viewed as an appropriate time to intervene to prevent and tackle obesity. It is therefore important to understand how parental concern about future childhood overweight might relate to weight status at this point in the life course.

Therefore, we used cross-sectional data from a large ethnically diverse UK-wide cohort study to examine whether parental concern about future childhood overweight, reported when the child was aged five years, varied by ethnic group. With use of ethnic-specific BMI adjustment to more appropriately assess body fat in South Asian and Black children, we hypothesised that parents of South Asian children with a BMI in the overweight or obese range would be more concerned about their child becoming overweight in the future relative to parents of White children with a BMI in the overweight or obese range, and that this would be more marked for girls than for boys.

Materials and methods

Study design

We used data from the Millennium Cohort Study (MCS), a prospective nationally representative cohort of children born between September 2000 and January 2002 in the UK, which used a stratified clustered sampling design to over-represent children born in disadvantaged areas, from ethnic minority groups or from Northern Ireland, Scotland and Wales. When the cohort child was aged nine months, 18,552 (72%) of 27,257 families contacted were interviewed at home when demographic, social and health information was obtained. An additional 692 families were recruited at age three. Further interviews were conducted when children were aged three, five, seven, 11 and 14 years, when height and weight were measured. At age five, 15,246 (85.8%) of 17,770 families eligible for interview were interviewed, providing data for 15,459 children (Figure S1).

Inclusion and exclusion criteria

We included 15,039 of 15,459 singleton children whose parent (natural mother (97.0%), else child's main care-giver, all referred to hereafter as the parent) was interviewed when their child was aged five years, having excluded 418 twins and triplets, as well as two children with extreme height and/or weight measures at age five or missing ethnicity (Figure S1). We extracted information available for these children from their two earlier and two subsequent MCS interviews. Characteristics of those who did and did not participate in the age five interview are given in Table S1. We weighted all analyses to take account of survey design and to allow for potential ethnic and socioeconomic biases in cohort attrition by age five years.

Main Outcome measure

The main outcome measure was parental concern about their child's future risk of becoming overweight. This was assessed at the age five interview from responses to a question administered by a trained interviewer who asked the parent "How concerned are you about [child's name] becoming overweight in the future?" We derived a binary variable from the five possible responses as follows: parents reporting they were unconcerned (n=10,964), were categorised as "no parental concern", with all other responses (a little concerned (n=2,645), concerned (n=540), fairly concerned (n=390), very concerned (n=418)) categorised as "parental concern". Response to this question was missing for 82 parents.

Main exposure variable

Ethnic group of the child was obtained from parental report at the first MCS interview and categorised using UK 2011 Census categories. Analyses were based on ten individual Census categories, with the exception of some analyses where individual ethnic groups were too small to create 95% confidence intervals (CI) when categories were grouped as follows: White, South Asian (Indian, Pakistani, Bangladeshi), Black (Black Caribbean, Black African, other Black), Mixed and Other (Other Asian, Chinese, Mixed, Other).[27]

Covariates

We examined two covariates: child weight status and parental weight status. At age five years, trained interviewers in the home measured the child's height and weight: height was recorded to the nearest millimetre using a Leicester Height Measure Stadiometer (Seca Ltd, Birmingham, UK) with the head positioned in the Frankfort plane. Children were weighed barefoot and without outdoor clothing on Tanita HD-305 scales (Tanita, UK Ltd, Middlesex, UK) and weight recorded in kilograms to one decimal place.[28]

To enable comparison with the current English child measurement programme, we used published guidance from Public Health England[29] to assess the quality and range of height and weight measurements. We excluded one child with extreme short stature, and in addition assigned measurements in two children with extreme weight values as missing, as these were assumed erroneous when compared with their earlier or subsequent MCS measurements.

BMI at age five was calculated and adjusted for ethnicity using methods described by Hudda et al. who used similar ethnic categories to those employed in this study.[30] This adjustment entails adding approximately 1.1kg/m^2 to the BMI of South Asian children, and subtracting between -0.12kg/m^2 and -5.52kg/m^2 dependent upon sex, age group and unadjusted BMI to the BMI of Black children. No adjustment is available to apply to children from Mixed or Other ethnic groups. We categorised the adjusted BMI according to the UK1990 clinical reference standard,[31] into four mutually exclusive groups: "underweight" (BMI<2nd centile), "healthy weight" (≥2nd to <91st centile), "overweight" (≥91st to <98th centile) or "obese" (≥98th centile) based on alignment with sex- and age-specific BMI centiles from the LMS growth tool Excel add-in.[32,33] We defined those with BMI ≥98th centile or ≥91st to <98th centile as clinically obese and clinically overweight respectively.

Parental BMI was calculated using the parent's self-reported weight (at the age five sweep) and their most recent self-reported height (usually recorded at the first contact sweep). Trained interviewers measured parental heights and weights objectively if they did not know their measurements for self-report. Parental BMI was categorised into four mutually exclusive groups: "underweight" (BMI<18.5kg/m^2), "healthy weight" (≥18.5 to <25kg/m^2), "overweight" (≥25 to <30kg/m^2) or "obese" (≥30kg/m^2). Lower thresholds for classifying overweight and obesity in South Asian adults were employed, where "overweight" is considered ≥23 to <27.5kg/m^2 and "obese" as ≥27.5kg/m^2, based on National Institute for Health Care Excellence guidelines.[34]

Statistical methods

Response to the parental concern question was missing for 82 children. Height and/or weight were missing for 235 and 234 five year-olds, respectively. BMI was missing for 2,456 parents. We used multiple imputation to estimate missing data on parental concern, child height and weight at age five, and parental BMI, and built 20 imputed datasets using the weighted iterative chain algorithm,[35] including all variables involved in the analysis steps under the assumption that missingness is at random (Table S2). All analyses were carried out on imputed datasets, and sensitivity analyses on complete-cases.

We used descriptive statistics to assess the prevalence of parental concern overall, and by sex, ethnic group and parental weight status. We examined associations of child's weight status with parental concern overall, and by sex and ethnic group. We used logistic regression to estimate the unadjusted odds of a parent being concerned about their child being overweight in the future by child's ethnic group, sex, weight status and parental weight status (reported as odds ratios [OR]). We then adjusted for child's ethnic group, after taking into account the child's sex and child and parent weight status. We tested for interactions between the child's ethnicity and sex, and between child's ethnicity and weight status and used Wald test statistics for these interaction terms to inform the final logistic regression model. We derived sex- and ethnic-specific odds ratios by multiplying the interaction term coefficient by the ethnicity coefficient and plotted these in a forest plot.

All analyses and percentages cited were weighted to take account of survey design and to allow for potential biases in attrition by age five years, using the `svyset` command (Stata/SE 15; Stata Corporation, Texas, USA).

Ethics approval

Approval for MCS was granted by the London Research Ethics Committees[36] and no further approval was required for this secondary analysis.

Patient and public involvement

This research was done without patient or public involvement. Neither were invited to comment on the study design and were not consulted to develop relevant outcomes or interpret results.

Results

Of 15,039 children, 48.9% were girls and 86.7% were White. Parental concern about their child becoming overweight in the future was reported by 27.3% of parents, and this was more common among parents of girls than of boys (Table S3; mean difference girls-boys [95% CI]: 6.6% [5.2-8.0%]).

More parents of White girls than of White boys reported parental concern; with this exception, there were no sex differences in parental concern by ethnic group (Table S3). Relative to parents of White girls, significantly fewer parents of Pakistani, Bangladeshi or Black African girls reported parental concern and no ethnic differences were found for boys.

At age five, the prevalence of overweight and obesity was 11.0% and 6.6%, respectively (Table 1), with obesity more prevalent among boys (7.5%) than girls (5.7%). Within each ethnic group, most five-year-old children were of healthy weight, however children from all South Asian ethnic groups were more likely to have a BMI in the obese range than White children (Table 1). Stratification by sex further indicated South Asian boys and girls from Pakistani or Bangladeshi ethnic groups were more likely to have a BMI in the obese range than their White counterparts (Table S3). Pakistani children were also more likely, and Black Caribbean and children of other Asian ethnicity less likely to have a BMI in the overweight category than White children.

Parental concern was strongly associated with child's concurrent BMI status (Table 2), and was more common among parents of children with overweight or obesity (42.3% and 66.2% respectively) than among parents of children with a healthy weight (22.3%). Parental concern was reported for 73.4% girls with obesity compared with 61.0% of boys with obesity (mean difference girls-boys [95% CI]: 12.4% [10.9-13.9%]).

Parental concern was reported by fewer parents of South Asian girls with overweight and obesity compared to parents of White girls (Table 2). No significant differences were found for boys.

Parent weight status was positively associated with child weight status (Table 3). Parental concern was more likely to be reported by parents with overweight and obesity: 29.9% and 39.7%, respectively, compared to parents with a healthy weight (22.7%).

In unadjusted analyses parental concern was significantly less likely for children of Pakistani and Black African ethnic origin, and significantly more likely for girls, children who had a BMI in the overweight or obese range, and among parents with overweight or obesity (Table 4).

After mutual adjustment for the ethnic group, sex and weight status of the child as well as parent weight status, parental concern was also significantly lower among children of Bangladeshi origin, with all other differences observed in unadjusted analyses remaining significant (Table 4).

The Wald test statistic for an interaction between sex and ethnic group was significant and the final adjusted model included this interaction term. There was no significant interaction between child weight status and ethnic group (Table S4). The odds of parental concern by ethnic group, for boys and girls separately using estimated coefficients from the final adjusted model are shown in Table 5 and plotted in Figure 1.

Parents of Pakistani boys were less likely than parents of White boys to be concerned about their child's future risk of being overweight (Figure 1). Similarly, parents of Pakistani, Bangladeshi, and Black African girls or of girls of Mixed or Other ethnicity were less likely to be concerned about their child becoming overweight in the future, compared to parents of White girls.

The likelihood of parental concern about future childhood overweight was higher among parents of children with overweight and obesity, and lower among parents of children with a BMI considered underweight, compared to parents of children with a healthy weight. Parents who themselves had a BMI in the overweight or obese range were more likely, and those with a BMI considered underweight less likely, to report concern than those with a healthy weight.

Findings were similar for complete case analyses (Table S5).

Discussion

In this large nationally representative study, we found that, despite their greater risk of obesity, parents of children of South Asian ethnicity were less likely to be concerned about their child's future overweight risk, compared to their White counterparts, particularly so for girls of Pakistani and Bangladeshi origin. This finding was independent of child and parent weight status. Furthermore, we confirmed associations between parental concern and child sex and weight status reported by others.

Increased understanding of parental concern about their child's future risk of becoming overweight is important to inform the development of interventions to support parents and families to alter the weight trajectories of their children with overweight or obesity. This is especially important for children of South Asian ethnicity, given their higher absolute risk of obesity and greater metabolic sensitivity to its effects. Our findings make a significant contribution to the literature on parental concern. This is to our knowledge the first study to use a UK-wide nationally representative cohort to examine whether parental concern about future risk of overweight in their child varies by ethnic group.

Strengths of our study include analyses based on a large, nationally representative and ethnically diverse cohort of children, allowing examination of parental concern across ten ethnic groups. Our findings are generalisable to the UK: the prevalence of overweight and obesity at age five in this cohort is similar to that reported from Public Health England's National Child Measurement programme (NCMP) for the 2006/07 academic year, when most MCS children were aged five years.[37,38]

We used robust statistical methods including imputation of missing data and use of survey weights to account for survey design and to allow for biases in attrition. We used a definition of overweight and obesity that indicates a severity likely to require clinical intervention, and applied ethnic-specific BMI adjustment for more accurate assessment of body fatness in children from South Asian and Black ethnic groups. This method of adjusting children's BMI to appropriately inform parents about their child's weight status is currently not employed in the NCMP, nor by clinicians.

We were able to adjust for a number of covariates in our analysis including those shown previously to be strongly associated with parental concern, including parental and child weight status (the latter based on objective measurements). Responses to the question eliciting parental concern are unlikely to be influenced by the MCS weight measurement as this question was asked before the child was weighed, and furthermore no interpretation or categorisation of BMI was provided in the feedback to parents.[36]

While some cohort children may have been recently weighed either at home, in clinical care or in school as part of the NCMP, information on the timing of this in relation to the MCS interview, or the feedback given to parents, is unavailable. One in seven children in our sample were from Black, South Asian and Other ethnic backgrounds, and while we were able to report likelihood of concern across all major ethnic groups, absolute numbers for some were small resulting in greater uncertainty for these estimates. Furthermore, at present there are no validated algorithms for the adjustment of BMI for children from Mixed and Other ethnic groups so no adjustments were made for these children in our

analyses. Finally, we followed the example of others and dichotomised parental concern into "some concern" or "no concern" in order to produce robust estimates when stratifying by both sex and ethnic group.

There are to our knowledge no other published reports examining ethnic variation in parental concerns about their child's future risk of becoming overweight using a UK-wide nationally representative cohort of children. Whilst we are unable to replicate regional findings which observed greater parental concern among Black Afro-Caribbean parents of children with a BMI considered overweight living in London,[24] our finding of less parental concern among parents of Black African girls is similar to that reported for parents of Black Somali ethnicity in Liverpool.[17]

There are a number of possible explanations for our main finding that parents of South Asian boys and girls and of Black girls are less concerned about their child's future risk of becoming overweight. These include ethnic differences in awareness of children's weight status, as well as cultural differences in the perceptions of childhood weight and size.

It is acknowledged that recognition of overweight or obesity is difficult among South Asian adults[39] and this may be due to ethnic differences in distribution of body fat. Research by Jones et al. has highlighted the potential for child age- and sex-specific body image scales to aid parental recognition of overweight and obesity, however the scale has not been tested among different ethnic groups and therefore its relevance to communities of high ethnic diversity is unknown.[40] We did not find any evidence to suggest that parental concern about child future overweight risk among children from different ethnic groups varied by child weight status.

Qualitative research has highlighted important cultural dimensions among South Asian parents and their extended families. Pallan et al. have highlighted the importance of intergenerational influences on child diet and perception of their weight status, suggesting that fatness may signal health and provision of

abundant food may symbolise parental/carer affection for the child.[41] This may be important for families relying on grandparents for informal childcare, and multi-generational households where meals are communally prepared and eaten.[41,42] For example, studies of Pakistani women in North West England and an ethnically diverse sample of families in London have both reported that in these groups familial expectations to maintain traditional home-cooking procedures as obstacles to change.[42] Similarly, qualitative research involving Somali women living in Liverpool found that many women felt restricted in their efforts to live healthier lifestyles by older relatives' perspectives which promote increased weight, although this study did not focus on the influence of the home environment on their child's weight status.[43]

In our study, whilst we confirmed sex differences in parental concern about future childhood overweight, parental concern was lower among parents of girls relative to boys within different child ethnic groups in contrast to the higher concern found in this and other studies for girls of White ethnicity. Our finding that a greater proportion of parents of White girls than White boys were concerned about their child becoming overweight in the future is consistent with findings from other UK studies of predominantly White populations[6,21,22] and with one from Australia.[23] This may reflect societal expectations of "ideal" body shapes for boys and girls[21] whereby girls are expected to be slight or petite, and boys to be bigger, stronger or more muscular.[44] Findings from a qualitative study interviewing parents of pre-school aged children in America suggest that childhood overweight is normalised through the use of euphemistic terms like 'cute baby fat' or 'podge',[45] and discussions of body size relate to how 'big', 'strong' or 'muscular' the child is.[46] Other studies have suggested that parents are less worried about their child's weight status risk because they believe their child participates in an appropriate level of physical activity and/or eats a balanced or healthy diet.[46,47] Whilst existing literature recognises societal expectations of boy's and girl's size and appearance, less is known about how these expectations vary by ethnic group, and further qualitative research is needed to address this.

Our finding that concern was reported more often for children with overweight and obesity is consistent with previously published reports.[6,10,18,21,22] Our findings are similar to those of Carnell et al. who used the same question and response scale but did not examine the influence of ethnicity on this association.[10] Parents may be better able to identify their child's weight status at the extreme end of obesity[6,21] indicating that, to some extent, parents are aware of overweight in their children. Inability to assess correctly their child's weight may be a barrier to prevention of childhood obesity,[13,21,22] since lifestyle changes are not initiated,[9,48] however Carnell et al. have argued that parental concern is a more sensitive indicator of parental awareness of child weight status than correct parental identification. Our findings lend support for this latter view: we identified a strong positive association between parental concern and child weight status.

Our study has implications for practice and research. Our cross-sectional analyses confirmed a strong positive association between the child's current weight status and parental concern, suggesting parents of children with a BMI in the overweight and obese range are more likely than other parents to be concerned about their child's future overweight risk. This is important, given evidence that appropriate parental concern is vital for effective parental engagement with obesity intervention programmes,[16] and therefore subsequent weight loss. Further research will examine whether parental concern is associated with healthier weight trajectories; a longitudinal cohort such as MCS provides appropriate opportunity for this analyses. Our study also has implications in particular for targeted interventions aimed at childhood obesity prevention and management. Ethnic groups at higher risk of obesity appear to be less concerned about future childhood overweight, particularly so for girls. This needs to be taken into account in developing ethnically sensitive interventions for weight management of children with obesity in multi-ethnic populations. As with all complex interventions, these need to be informed by qualitative studies to elucidate the factors underlying these novel observed ethnic differences and to aid their interpretation.

In summary, we have found that, in contrast to our original hypothesis, parents of children from ethnic groups at higher risk of childhood obesity and its adverse consequences are less likely to report concern for their child's future overweight risk, particularly among parents of girls. These insights into ethnic differences in parental awareness of child weight are of importance in the UK, where the highest risk of obesity is observed in communities with high ethnic minority prevalence.

Table 1 – Sex, child weight status and parental concern about future overweight risk at age five years, by ethnic group[1]

	Sex	Child weight status[2]								Parental concern	
	Girls	Underweight[3]		Healthy weight		Overweight		Obese			
	%	%	95% CI[4]	%	95% CI[4]	%	95% CI[4]	%	95% CI[4]	%	95% CI[4]
White	48.9	0.6	0.4,0.7	82.4	81.6,83.1	10.9	10.3,11.6	6.1	5.6,6.6	27.8	26.8,28.8
South Asian	49.6	0.6	0.1,1.0	71.4	69.3,73.5	14.8	12.8,16.8	13.3	11.1,15.4	23.5	20.5,26.5
Indian	48.3			72.9	68.1,77.8	13.6	9.1,18.1	12.2	8.1,16.3	28.5	23.2,33.7
Pakistani	49.7			72.0	68.7,75.3	15.9	13.0,18.8	11.8	9.4,14.1	20.9	17.0,24.7
Bangladeshi	51.6			66.8	60.9,72.7	13.7	10.3,17.1	19.3	14.0,24.5	22.6	16.8,28.4
Black	45.6	3.7	1.7,5.8	83.7	79.5,87.8	5.8	3.1,8.6	6.8	2.5,11.1	24.9	19.6,30.1
Black Caribbean	43.6			83.4	75.8,91.0	5.1	2.4,7.7	9.6	2.4,16.7	32.3	21.9,42.7
Black African	47.5			83.5	78.4,88.6	6.9	2.8,11.0	5.7	1.2,10.1	20.1	15.5,24.7
Other Black[5]	40.1			87.3	71.3,100.0					25.7	7.3,44.1
Mixed and Other	50.0	1.6	0.6,2.6	81.9	78.2,85.6	9.9	7.3,12.4	6.6	4.5,8.8	24.9	20.0,29.7
Other Asian	54.2			87.1	78.9,95.3	3.0	0.9,5.1	5.0	0.0,10.3	30.7	17.7,43.8
Chinese and Other	53.3			85.6	78.1,93.1	7.3	2.5,12.2	5.9	1.2,10.7	20.9	12.4,29.3
Mixed	48.5			80.2	75.8,84.6	11.6	8.4,14.9	7.1	4.4,9.8	24.7	19.2,30.1
All	48.9	0.7	0.5,0.9	81.7	81.0,82.5	11.0	10.4,11.6	6.6	6.1,7.1	27.3	26.3,28.3

[1]Ethnic group of the child was obtained from parental report at the first MCS interview and categorised using UK 2011 Census categories. [2]Child weight status based on ethnic-adjusted BMI and categorised according to UK90 clinical reference standard. [3]Underweight values for individual ethnic groups omitted due to small numbers. [4]95% confidence interval. [5]Overweight and obesity prevalence estimates not stated due to small numbers. Total N=15,039.

Table 2 – Parental concern about future overweight risk at age five years, by child weight status[1] at age five

	Proportion of parents reporting parental concern									
	White		South Asian		Black		Mixed and Other		All	
	%	95% CI[2]	%	95% CI[2]	%	95% CI[2]	%	95% CI[2]	%	95% CI[2]
All										
Healthy weight	22.8	21.8,23.8	16.9	14.5,19.3	21.5	15.5,27.6	19.5	14.6,24.4	22.3	21.3,23.3
Overweight	43.8	40.8,46.8	28.4	22.1,34.8	30.1	6.9,53.3	39.8	25.3,54.3	42.3	39.5,45.1
Obese	67.8	63.8,71.7	51.8	44.2,59.3	72.8	58.4,87.2	70.4	55.1,85.7	66.2	62.8,69.6
Boys										
Healthy weight	19.6	18.3,21.0	16.8	13.5,20.2	18.1	13.0,23.2	17.6	11.3,23.8	19.3	18.0,20.6
Overweight	34.2	30.1,38.3	25.9	16.4,35.4	46.7	20.4,72.9	46.6	25.9,67.3	34.5	30.8,38.3
Obese	61.4	56.1,66.7	51.4	41.6,61.2	55.6	31.8,79.3	70.7	47.9,93.4	61.0	56.7,65.4
Girls										
Healthy weight	26.0	24.7,27.3	17.0	13.6,20.3	23.6	17.7,29.6	21.3	15.4,27.3	25.3	24.1,26.5
Overweight	55.4	51.2,59.5	30.5	21.6,39.4	37.2	10.2,64.3	30.7	11.7,49.7	51.4	47.1,55.6
Obese	76.3	70.5,82.1	52.3	40.5,64.1	72.9	39.7,100.0	70.1	48.1,92.1	73.4	68.1,78.6

[1]Underweight groups omitted due to small numbers. Child weight status based on ethnic-adjusted BMI and categorised according to UK90 clinical reference standard. [2]95% confidence interval. Total N=15,039.

Table 3 – Child weight status and parental concern about future overweight risk at age five years, by parental weight status

	Parental weight status[1]							
	Underweight		Healthy weight		Overweight		Obese	
	%	95% CI[2]	%	95% CI[2]	%	95% CI[2]	%	95% CI[2]
Child weight status[3]								
Underweight	0.9	0.0,2.0	0.8	0.6,1.1	0.5	0.3,0.8	0.6	0.2,1.0
Healthy weight	90.7	87.0,94.4	86.5	85.5,87.4	78.7	77.1,80.3	70.2	67.9,72.4
Overweight	6.0	2.9,9.1	8.6	7.8,9.4	13.0	11.7,14.3	15.9	14.2,17.7
Obese	2.4	0.6,4.2	4.1	3.5,4.7	7.8	6.7,8.9	13.3	11.8,14.9
Parental concern								
Parental concern	15.4	11.1,19.6	22.7	21.5,23.9	29.9	28.0,31.9	39.7	37.4,42.0

[1]Parental weight status was categorised using BMI calculated from parental self-reported weight and height as follows: "underweight" (BMI<18.5kg/m²), "healthy weight" (≥18.5 to <25kg/m²), "overweight" (≥25 to <30kg/m²) or "obese" (≥30kg/m²), except for South Asian adults where "overweight" is ≥23 to <27.5kg/m² and "obese" is ≥27.5kg/m². [2]95% confidence interval. [3]Child weight status based on ethnic-adjusted BMI and categorised according to UK90 clinical reference standard.

Table 4 – Unadjusted and adjusted odds of parental concern about future overweight risk at age five years

	Unadjusted		Adjusted[1]		Final model[2]	
	OR (*p*-value)[3]	95% CI[4]	OR (*p*-value)[3]	95% CI[4]	OR (*p*-value)[3]	95% CI[4]
Ethnic group[5]	(0.008)		(<0.001)		(0.057)	
White (ref.)	1		1		1	
South Asian						
Indian	1.04	0.80,1.35	0.80	0.60,1.09	0.77	0.52,1.14
Pakistani	**0.69**	**0.54,0.87**	**0.46**	**0.34,0.61**	**0.59**	**0.38,0.91**
Bangladeshi	0.76	0.54,1.06	**0.43**	**0.31,0.61**	0.62	0.38,1.01
Black						
Black Caribbean	1.24	0.77,1.99	1.15	0.73,1.80	1.25	0.78,2.00
Black African	**0.66**	**0.49,0.87**	**0.61**	**0.44,0.84**	0.77	0.46,1.28
Other Black	0.90	0.34,2.36	1.17	0.43,3.20	1.36	0.37,5.04
Mixed and Other						
Other Asian	1.15	0.62,2.14	1.28	0.66,2.48	2.00	0.99,4.05
Chinese and other	0.69	0.41,1.14	0.66	0.39,1.10	0.79	0.33,1.89
Mixed	0.85	0.64,1.14	0.81	0.60,1.09	0.96	0.63,1.46
Sex	(<0.001)		(<0.001)		(<0.001)	
Male (ref.)	1		1		1	
Female	**1.39**	**1.28,1.51**	**1.52**	**1.40,1.65**	**1.59**	**1.46,1.73**
Child weight status[6]	(<0.001)		(<0.001)		(<0.001)	
Underweight	**0.32**	**0.16,0.64**	**0.34**	**0.17,0.68**	**0.34**	**0.17,0.68**
Healthy weight (ref.)	1		1		1	
Overweight	**2.56**	**2.28,2.87**	**2.47**	**2.19,2.78**	**2.47**	**2.20,2.79**
Obese	**6.84**	**5.84,8.01**	**6.70**	**5.68,7.90**	**6.71**	**5.68,7.93**
Parental weight status[7]	(<0.001)		(<0.001)		(<0.001)	
Underweight	**0.62**	**0.44,0.87**	**0.68**	**0.48,0.96**	**0.68**	**0.48,0.97**
Healthy weight (ref.)	1		1		1	
Overweight	**1.46**	**1.30,1.63**	**1.35**	**1.20,1.52**	**1.35**	**1.20,1.52**
Obese	**2.24**	**2.01,2.50**	**1.94**	**1.72,2.19**	**1.94**	**1.72,2.19**
Sex x ethnic group					(0.087)	
Female x White (ref.)					1	
Female x South Asian						
Female x Indian					1.09	0.61,1.96
Female x Pakistani					0.61	0.33,1.13
Female x Bangladeshi					**0.51**	**0.28,0.94**
Female x Black						
Female x Black Caribbean					0.84	0.46,1.53
Female x Black African					0.63	0.31,1.28
Female x Other Black					0.69	0.09,5.28

Female x Mixed and Other				
Female x Other Asian			0.44	0.17,1.15
Female x Chinese and Other			0.72	0.22,2.32
Female x Mixed			0.72	0.44,1.18

[1]Mutually adjusting for ethnic group, sex, age five weight status and parental weight status. [2]Mutually adjusting for ethnic group, sex, child weight status, parental weight status, and an interaction between sex and ethnic group. An interaction between child weight status and ethnic group was tested but deemed not statistically significant so was excluded from the final model (see Table S5). [3]Odds ratio and p-value for corresponding Wald test statistic. [4]95% confidence interval. [5]Ethnic group of the child categorised using UK 2011 Census categories. [6]Child weight status based on ethnic-adjusted BMI categorised according to UK90 clinical reference standard. [7]Parental weight status was categorised using BMI calculated from parental self-reported weight and height as follows: "underweight" (BMI<18.5kg/m²), "healthy weight" (≥18.5 to <25kg/m²), "overweight" (≥25 to <30kg/m²) or "obese" (≥30kg/m²), except for South Asian adults where "overweight" is ≥23 to <27.5kg/m² and "obese" is ≥27.5kg/m². Cells in bold font indicate the estimate is statistically significantly different to the reference category.

Table 5 – Sex- and ethnic-specific adjusted odds[1] of parental concern about future overweight risk at age five years

	Girls		Boys	
	OR[2]	95% CI[3]	OR[2]	95% CI[3]
Ethnic group[4]				
White (ref.)	1		1	
South Asian				
Indian	0.84	0.54,1.30	0.77	0.52,1.14
Pakistani	**0.36**	**0.24,0.53**	**0.59**	**0.38,0.91**
Bangladeshi	**0.32**	**0.21,0.48**	0.62	0.38,1.01
Black				
Black Caribbean	1.05	0.56,1.94	1.25	0.78,2.00
Black African	**0.49**	**0.32,0.74**	0.77	0.46,1.28
Other Black	0.94	0.20,4.48	1.36	0.37,5.04
Mixed and Other				
Other Asian	0.88	0.34,2.27	2.00	0.99,4.05
Chinese and other	0.57	0.28,1.14	0.79	0.33,1.89
Mixed	**0.69**	**0.48,0.99**	0.96	0.63,1.46
	OR[2]		95% CI[3]	
Child weight status[5]				
Underweight	**0.34**		**0.17,0.68**	
Healthy weight (ref.)	1			
Overweight	**2.47**		**2.20,2.79**	
Obese	**6.71**		**5.68,7.93**	
Parental weight status[6]				
Underweight	**0.68**		**0.48,0.97**	
Healthy weight (ref.)	1			
Overweight	**1.35**		**1.20,1.52**	
Obese	**1.94**		**1.72,2.19**	

[1]Calculated by multiplying the interaction coefficient with ethnicity coefficient in the final mutually adjusted model in Table 4. Mutually adjusting for ethnic group, sex, age five weight status and parental weight status. [2]Odds ratio. [3]95% confidence interval. [4]Ethnic group of the child categorised using UK 2011 Census categories. [5]Child weight status based on ethnic-adjusted BMI categorised according to UK90 clinical reference standard. [6]Parental weight status was categorised using BMI calculated from parental self-reported weight and height as follows: "underweight" (BMI<18.5kg/m^2), "healthy weight" (≥18.5 to <25kg/m^2), "overweight" (≥25 to <30kg/m^2) or "obese" (≥30kg/m^2), except for South Asian adults where "overweight" is ≥23 to <27.5kg/m^2 and "obese" is ≥27.5kg/m^2. Cells in bold font indicate the estimate is statistically significantly different to the reference category.

Figure 1 – Adjusted odds of parental concern about future childhood overweight[1]

[1] Mutually adjusted for ethnic group, sex, child weight status, parent weight status and an interaction between sex and ethnic group.

Conflicts of interest

The authors declare no conflict of interest.

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Author statement

NF and CD conceptualised and designed the analysis. NF carried out the literature search, conducted and interpreted the analyses, generated tables and figures and drafted the initial manuscript. CD contributed to the interpretation of analyses and reviewed and revised the manuscript. All authors were involved in writing the paper and had final approval of the submitted and published versions.

Data statement

The MCS data for surveys 1-6 can be downloaded from the UK Data Service.

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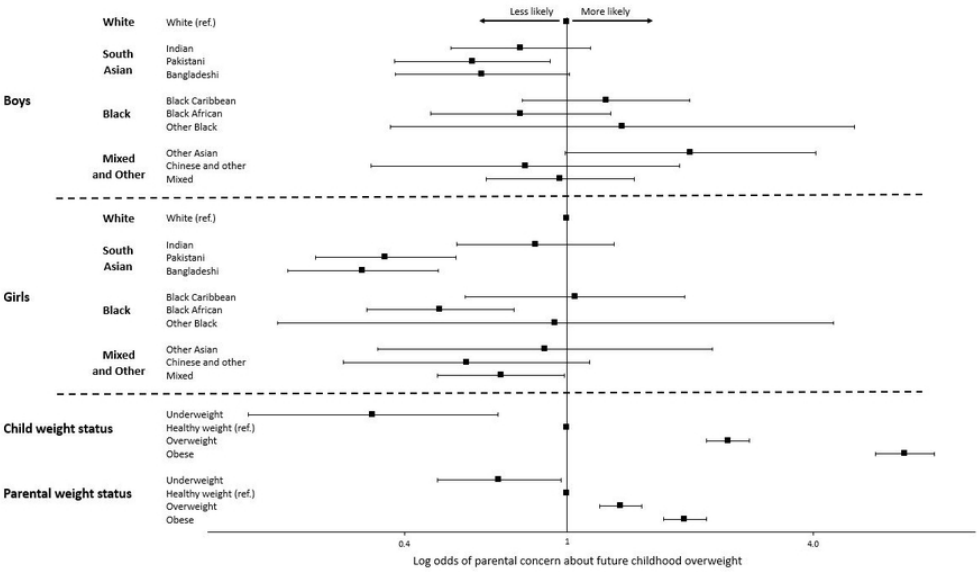

Figure 1 - Adjusted odds of parental concern about future childhood overweight.

75x43mm (300 x 300 DPI)

Does parental concern about their child's future risk of overweight vary by ethnic group? Cross-sectional analysis of a national cohort study

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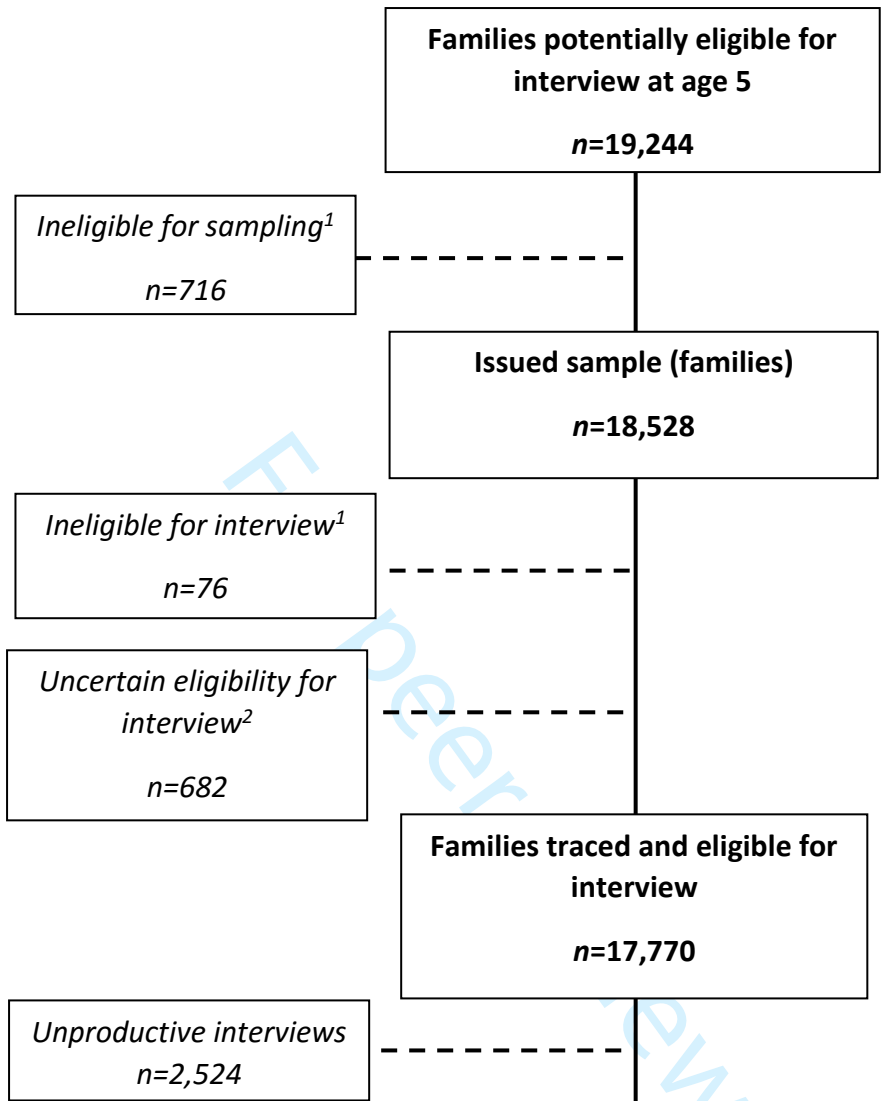
Supplementary material

Figure S1 - Flow chart of study sample



[1]Due to death, emigration, permanent refusal or sensitive family circumstances. [2]Due to untraced movers, outstanding movers or ran out of time to complete sampling. [3]Data for individual children not available prior to the point of productive interview. [4]418 twins/triplets, 1 child with extreme height values, 1 child missing ethnicity.

Table S1 - Sample characteristics of singleton children participating and not participating[1] in MCS at age five

	Singleton children participating at age 5 (n=15,041)		Singleton children not participating at age 5 (n=3,939)	
	n	%[2]	n	%[2]
Child sex				
Male	7708	51.2	2065	52.4
Female	7333	48.8	1874	47.6
Ethnic group[3]				
White	12524	83.3	2990	75.9
South Asian	1361	9.1	474	12.0
Black	505	3.3	213	5.4
Mixed or other	650	4.3	238	6.1
Missing	1	0.0	24	0.6
Parental weight status[4]				
Underweight	541	3.6	156	4.0
Healthy weight	7775	51.7	2018	51.2
Overweight	3591	23.9	880	22.3
Obese	1886	12.5	451	11.5
Missing	1248	8.3	434	11.0
OECD household income quintile[5]				
Lowest	3496	23.2	1326	33.7
2	3306	22.0	977	24.8
3	2852	19.0	685	17.4
4	2761	18.4	479	12.1
Highest	2558	17.0	425	10.8
Missing	68	0.4	47	1.2
Parental highest academic qualification[5]				
Degree or diploma in higher education	3882	25.8	625	15.9
A/AS levels	1441	9.6	296	7.5
GCSEs	6573	43.7	1753	44.5
Other academic qualifications	419	2.8	153	3.9
None	2678	17.8	1072	27.2
Missing	48	0.3	40	1.0

[1] 18,980 singleton children were first recruited/interviewed at either MCS sweep 1 (age nine months) or MCS sweep 2 (age three years). At MCS sweep 3 (age five), 3,939 singleton children did not participate. [2]Proportions are unweighted. [3]Ethnic group of the child was obtained from parental report at the first MCS interview and categorised using UK 2011 Census categories. [4]Parental weight status when the child was aged five years was categorised using BMI calculated from parental self-reported weight and height as follows: "underweight" (BMI<18.5kg/m^2), "healthy weight" (≥18.5 to <25kg/m^2), "overweight" (≥25 to <30kg/m^2) or "obese" (≥30kg/m^2), except for South Asian adults where "overweight" is ≥23 to <27.5kg/m^2 and "obese" is ≥27.5kg/m^2. [5]Recorded at the age nine month interview, or the age three interview for the boosted sample.

Table S2 - Multiple Imputation

Multiple imputation was performed to impute values for our outcome of interest (parental concern) and covariates (child and parental BM). Imputations were based on the variables below, which were all shown to be significantly correlated (at the 5% level) with non-measurement of parental concern, height or weight at ages five and 11:

Variables used in multiple imputation[1]	Number of children with missing data[2] n	%[3]
Outcome of interest		
Parental concern[4]	82	0.6
Exposures of interest		
Child's ethnic group[5]	0	-
Covariates		
Child height measurements[6]:		
Age 3	2367	15.7
Age 5	235	1.6
Age 7	2130	14.2
Age 11	2956	19.7
Child weight measurements[6]:		
Age 3	2219	14.8
Age 5	234	1.6
Age 7	2181	14.5
Age 11	3154	21.0
Parental BMI[6,7]	2456	16.3
Sociodemographic factors		
Child's sex[5]	0	-
Child's age in days[4]	0	-
OECD household income quintile[4]	1	-
Diet		
Portions of fruit eaten a day[4]	88	0.6
Reason for controlling child's diet[4]	1777	11.8
Main snack eaten between meals[4]	79	0.5
Main drink between meals[4]	79	0.5
Physical activity		
Mode of transport to and from school[4]	252	1.7
Days a week participates om sports clubs or classes[4]	69	0.5
Average hours of screen time a day[4]	78	0.5

[1]The attrition/non-response weight (for whole of UK-level analyses), a finite population correction factor, a stratum variable and a ward variable to account for clustering, were also included in the multiple imputation model. [2]Total N=15,039. [3]Proportions are unweighted. [4]Recorded at MCS sweep 3 (age five). [5]Obtained from parental report at the first MCS interview. [6]Height and weight values and parental BMI were transformed on the natural logarithmic scale to mitigate violation of the assumption of normal distributions. [7]Parental BMI based on self-reported weight at MCS sweep 3 (age five) and their most recent self-reported height (usually recorded at the first MCS sweep).

Table S3 – Overweight and obesity prevalence and parental concern about future overweight risk at age five years, by ethnic group[1] stratified by sex

	Child weight status[2]				Parental concern	
	Overweight		Obese			
	%	95% CI[3]	%	95% CI[3]	%	95% CI[3]
All	11.0	10.4, 11.6	6.6	6.1,7.1	27.3	26.3,28.3
Boys	11.5	10.7,12.4	7.5	6.8,8.1	24.1	22.8,25.4
White	11.7	10.8,12.6	6.9	6.2,7.6	24.1	22.8,25.4
South Asian	12.8	9.5,16.0	15.9	13.0,18.8	23.4	18.6,28.1
Indian	9.2	4.8,13.6	17.3	10.7,23.9	25.4	18.2,32.5
Pakistani	14.1	9.0,19.2	14.0	10.1,18.0	21.8	15.4,28.3
Bangladeshi	15.3	7.8,22.9	18.8	11.5,26.1	24.3	15.5,33.1
Black	5.1	2.0,8.2	8.2	3.6,12.8	24.5	17.9,31.2
Black Caribbean	4.9	0.5,9.4	14.8	2.7,27.0	32.1	20.3,43.9
Black African	5.8	2.4,9.3	4.7	1.0,8.5	19.2	11.4,27.1
Other Black[4]					26.3	3.1,49.5
Mixed and Other	11.3	7.5,15.1	7.0	3.8,10.3	24.6	18.1,31.1
Other Asian	3.3	0.1,6.5	9.0	0.0,19.3	35.7	19.6,51.8
Chinese and other	8.3	0.0,17.0	5.6	0.0,11.5	20.2	7.6,32.8
Mixed	13.1	8.4,17.9	7.0	3.1,10.9	23.7	16.2,31.3
Girls	10.4	9.5,11.2	5.7	5.1,6.4	30.7	29.4,31.9
White	10.1	9.2,11.1	5.4	4.7,6.0	31.6	30.3,33.0
South Asian	16.8	13.3,20.4	10.6	7.4,13.8	23.7	19.3,28.0
Indian	18.3	9.8,26.8	6.8	0.9,12.6	31.8	23.1,40.5
Pakistani	17.7	13.5,22.0	9.5	6.5,12.4	19.9	14.6,25.3
Bangladeshi	12.1	6.4,17.9	19.7	11.1,28.3	21.1	13.0,29.1
Black	6.7	2.4,10.9	5.0	0.0,10.3	25.3	18.7,31.8
Black Caribbean	5.2	0.3,10.2	2.8	0.0,6.0	32.5	19.3,45.8
Black African	8.0	1.3,14.8	6.7	0.0,14.9	21.1	15.6,26.7
Other Black[4]					24.8	0.0,54.0
Mixed and Other	8.5	4.7,12.2	6.2	3.2,9.3	25.1	19.8,30.4
Other Asian	2.7	0.2,5.2	1.7	0.0,4.0	26.5	9.9,43.2
Chinese and Other	6.5	0.4,12.6	6.2	0.0,13.5	21.5	8.6,34.3
Mixed	10.1	5.1,15.0	7.1	3.1,11.2	25.7	19.3,32.0

[1]Ethnic group of the child was obtained from parental report at the first MCS interview and categorised using UK 2011 Census categories. [2]Child weight status based on ethnic-adjusted BMI and categorised according to UK90 clinical reference standard. [3]95% confidence interval. [4]Overweight and obesity prevalence estimates not stated due to small numbers. Total N=15,039.

Table S4 – Adjusted odds of parental concern about future overweight risk at age five years, including interactions between child sex and ethnic group and between child weight status and ethnic group

	With interactions[1] OR (*p*-value)[2]	95% CI[3]
Ethnic group[4]	(0.249)	
White (ref.)	1	
South Asian	**0.72**	**0.53,0.99**
Black	1.00	0.65,1.52
Mixed and Other	1.00	0.67,1.48
Sex	(<0.001)	
Male (ref.)	1	
Female	**1.59**	**1.46,1.74**
Child weight status[5]	(<0.001)	
Underweight	**0.33**	**0.15,0.75**
Healthy weight (ref.)	1	
Overweight	**2.52**	**2.22,2.87**
Obese	**6.75**	**5.55,8.20**
Parental weight status[6]	(<0.001)	
Underweight	**0.68**	**0.48,0.96**
Healthy weight (ref.)	1	
Overweight	**1.35**	**1.19,1.52**
Obese	**1.93**	**1.72,2.18**
Sex x ethnic group	(0.034)	
Female x White (ref.)	1	
Female x South Asian	0.71	0.47,1.06
Female x Black	0.71	0.43,1.15
Female x Mixed and Other	0.68	0.45,1.02
Child weight status x ethnic group	(0.184)	
Underweight x South Asian	-	-
Underweight x Black	0.47	0.06,3.90
Underweight x Mixed and Other	2.93	0.57,15.0
Healthy weight x White (ref.)	1	
Overweight x South Asian	0.79	0.46,1.37
Overweight x Black	0.56	0.15,2.08
Overweight x Mixed and Other	0.99	0.49,2.01
Obese x South Asian	0.74	0.47,1.18
Obese x Black	1.30	0.59,2.86
Obese x Mixed and Other	1.24	0.57,2.69

[1]Mutually adjusting for ethnic group, sex, age five weight status, parental weight status as well as two interaction terms: 1) sex x ethnic group 2) age five weight status x ethnic group. Four broader ethnic groupings were used instead of individual ethnic groups to overcome small cell sizes when including both interaction terms in the model. [2]Odds ratio and p-value *for corresponding Wald test statistic. [3]95% confidence interval. [4]Ethnic group of the child categorised using UK 2011 Census categories. [5]Child weight status based on ethnic-adjusted BMI categorised according to UK90 clinical reference standard. [6]Parental weight status was categorised using BMI calculated from parental self-reported weight and height as follows: "underweight" (BMI<18.5kg/m^2), "healthy weight" (≥18.5 to <25kg/m^2), "overweight" (≥25 to <30kg/m^2) or "obese" (≥30kg/m^2), except for South Asian adults where "overweight" is ≥23 to <27.5kg/m^2 and "obese" is ≥27.5kg/m^2. Cells in bold font indicate the estimate is statistically significantly different to the reference category.*

Table S5 - Sensitivity analyses: univariable and multivariable odds of parental concern about future overweight risk at age five years using complete-cases

	Unadjusted		Adjusted[1]		With interactions[2]		Final model[3]	
	OR (*p*-value)[4]	95% CI[5]	OR (*p*-value)[4]	95% CI[5]	OR (*p*-value)[4]	95% CI[5]	OR (*p*-value)[4]	95% CI[5]
Ethnic group[6]	(0.008)		(<0.001)		(0.410)		(0.108)	
White (ref.)	1		1		1		1	
South Asian					0.75	0.53,1.07		
Indian	1.04	0.80,1.35	0.77	0.56,1.06			0.77	0.51,1.16
Pakistani	**0.68**	**0.54,0.87**	**0.50**	**0.37,0.68**			**0.64**	**0.42,0.97**
Bangladeshi	0.76	0.54,1.06	**0.47**	**0.34,0.65**			0.65	0.38,1.12
Black					0.83	0.46,1.49		
Black Caribbean	1.25	0.77,2.01	1.19	0.66,2.15			1.20	0.58,2.48
Black African	**0.65**	**0.49,0.86**	**0.63**	**0.42,0.95**			0.77	0.43,1.38
Other Black	0.90	0.34,2.39	0.87	0.28,2.74			0.64	0.15,2.71
Mixed and Other					0.89	0.56,1.39		
Other Asian	1.15	0.62,2.14	1.18	0.56,2.52			1.82	0.78,4.26
Chinese and Other	0.69	0.41,1.14	0.69	0.39,1.22			0.75	0.26,2.16
Mixed	0.85	0.63,1.14	0.74	0.53,1.05			0.83	0.52,1.33
Sex	(<0.001)		(<0.001)		(<0.001)		(<0.001)	
Male (ref.)	1		1		1		1	
Female	**1.39**	**1.28,1.51**	**1.52**	**1.42,1.70**	**1.60**	**1.46,1.77**	**1.60**	**1.46,1.77**
Child weight status[7]	(<0.001)		(<0.001)		(<0.001)		(<0.001)	
Underweight	**0.33**	**0.17,0.66**	**0.35**	**0.17,0.73**	**0.39**	**0.17,0.89**	**0.35**	**0.17,0.72**
Healthy weight (ref.)	1		1		1		1	
Overweight	**2.56**	**2.28,2.87**	**2.48**	**2.17,2.83**	**2.51**	**2.18,2.90**	**2.49**	**2.18,2.84**
Obese	**6.90**	**5.90,8.08**	**6.46**	**5.39,7.74**	**6.44**	**5.24,7.92**	**6.44**	**5.37,7.73**
Parental weight status[8]	(<0.001)		(<0.001)		(<0.001)		(<0.001)	
Underweight	**0.62**	**0.45,0.87**	**0.67**	**0.47,0.95**	**0.66**	**0.46,0.94**	**0.67**	**0.47,0.95**
Healthy weight (ref.)	1		1		1		1	
Overweight	**1.44**	**1.28,1.62**	**1.34**	**1.18,1.52**	**1.33**	**1.18,1.51**	**1.34**	**1.19,1.52**
Obese	**2.21**	**1.98,2.47**	**1.93**	**1.72,2.17**	**1.92**	**1.71,2.16**	**1.93**	**1.72,2.18**
Sex x ethnic group					(0.228)		(0.444)	
Female x White (ref.)					1		1	
Female x South Asian					0.72	0.47,1.10		
Female x Indian							0.99	0.55,1.80
Female x Pakistani							0.63	0.35,1.14
Female x Bangladeshi							0.56	0.26,1.20
Female x Black					0.96	0.54,1.68		
Female x Black Caribbean							0.98	0.48,2.02
Female x Black African							0.66	0.28,1.57
Female x Other Black							1.72	0.19,15.4
Female x Mixed and Other					0.77	0.50,1.19		
Female x Other Asian							0.47	0.16,1.37
Female x Chinese and other							0.88	0.23,3.37
Female x Mixed							0.81	0.47,1.38
Child weight status x ethnic group					(0.406)			
Underweight x South Asian					-	-		

Underweight x Black			-	-	
Underweight x Mixed and Other			2.39	0.38,15.1	
Healthy weight x White (ref.)			1		
Overweight x South Asian			0.74	0.42,1.32	
Overweight x Black			0.69	0.22,2.19	
Overweight x Mixed and Other			1.23	0.57,2.63	
Obese x South Asian			0.83	0.47,1.47	
Obese x Black			2.86	0.93,8.78	
Obese x Mixed and Other			0.83	0.35,1.99	

[1]Mutually adjusting for ethnic group, sex, age five weight status and parental weight status. [2]Mutually adjusting for ethnic group, sex, age five weight status, parental weight status as well as two interaction terms: 1) sex x ethnic group 2) age five weight status x ethnic group. [3]Mutually adjusting for ethnic group, sex, child weight status, parental weight status, and an interaction between sex and ethnic group. [4]Odds ratio and p-*value for corresponding Wald test statistic. [5]95% confidence interval. [6]Ethnic group of the child categorised using UK 2011 Census categories. [7]Child weight status based on ethnic-adjusted BMI categorised according to UK90 clinical reference standard. [8]Parental weight status was categorised using BMI calculated from parental self-reported weight and height as follows: "underweight" (BMI<18.5kg/m^2), "healthy weight" (≥18.5 to <25kg/m^2), "overweight" (≥25 to <30kg/m^2) or "obese" (≥30kg/m^2), except for South Asian adults where "overweight" is ≥23 to <27.5kg/m^2 and "obese" is ≥27.5kg/m^2. Cells in bold font indicate the estimate is statistically significantly different to the reference category.*

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1-2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-8
Bias	9	Describe any efforts to address potential sources of bias	8-9
Study size	10	Explain how the study size was arrived at	6 (and Fig S1)
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6-8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8-9
		(*b*) Describe any methods used to examine subgroups and interactions	9
		(*c*) Explain how missing data were addressed	8
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	9
		(*e*) Describe any sensitivity analyses	9
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6 (and Fig S1)
		(b) Give reasons for non-participation at each stage	6 (and Fig S1)
		(c) Consider use of a flow diagram	Fig S1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9
		(b) Indicate number of participants with missing data for each variable of interest	6-8
Outcome data	15*	Report numbers of outcome events or summary measures	6-7
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10 (and Table 4)
		(*b*) Report category boundaries when continuous variables were categorized	8
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	11
Discussion			
Key results	18	Summarise key results with reference to study objectives	11-12
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	13
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	13-16
Generalisability	21	Discuss the generalisability (external validity) of the study results	15-16
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	16

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Does parental concern about their child's future risk of overweight vary by their ethnic background? Cross-sectional analysis of a national cohort study

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Does parental concern about their child's future risk of overweight vary by their ethnic background? Cross-sectional analysis of a national cohort study

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Key words:

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Abstract

Objectives

Parental concern about their child's future risk of becoming overweight is known to be increased for girls and for overweight or obese children, however it is unclear how this varies by ethnic background. We hypothesised that parents of five year-old children from South Asian backgrounds would be more likely to express such concerns, especially for their daughters.

Design: Cross-sectional

Setting: United Kingdom

Participants: 15,039 singleton Millennium Cohort Study participants whose parents were interviewed when their child was five years old (48.9% girls; 86.7% White).

Primary outcome measure: Parent-reported concern (some/none) about future overweight risk.

Methods

We estimated the adjusted odds ratios (aOR) of some parental concern by child's ethnic background (White [reference group], South Asian, Black, Mixed/Other), adjusted for parent and child weight status, and examined interactions with sex.

Results

Parents of girls from Pakistani (aOR; 95%CI: 0.4; 0.2,0.5), Bangladeshi (0.3; 0.2,0.5), Black African (0.5; 0.3,0.7) and Mixed (0.7; 0.5,0.99) ethnic backgrounds and of boys from Pakistani backgrounds (0.6; 0.4,0.9) were less likely to report concern about their child's future overweight risk. Childhood overweight (2.5; 2.2,2.8) and obesity (6.7; 5.7,7.9), and parental overweight (1.4; 1.2,1.5) and obesity (1.9; 1.7,2.2) were associated with an increased likelihood of some parental concern.

Conclusions

Parents of children from South Asian backgrounds express less concern about their child's future overweight risk, despite their higher risk of obesity and obesity-related diseases. Qualitative studies are needed to understand the concerns of parents from different ethnic backgrounds to inform weight-management interventions in populations from diverse ethnic backgrounds.

Article summary

Strengths and limitations of the study

- We used robust statistical methods to analyse a large, nationally representative cohort of children from diverse ethnic backgrounds, allowing examination of parental concern across ten ethnic groups
- We adjusted for factors known to be associated with increased parental concern, including child weight status, using clinical definitions of overweight and obesity and applied ethnic-specific BMI adjustments for more accurate assessment of body fatness in children from South Asian and Black backgrounds.
- Validated algorithms to adjust BMI in children from Mixed or Other ethnic backgrounds are not available.
- Responses to the parental concern question are unlikely to be influenced by the study child weight measurement as this was recorded subsequently and no interpretation or categorisation of BMI was provided to parents. As our study was cross-sectional, we are unable to determine the temporal association between concern and weight status.
- Some children may have been weighed prior to interview at home, or in clinic, schools or other settings and this might have influenced parental concern, however this information was not available.

Abbreviations

BMI – body mass index

UK – United Kingdom

MCS – Millennium Cohort Study

CI – confidence interval

OR – odds ratio

NCMP – National Child Measurement Programme

FMI – fat mass index

Introduction

In England more than a quarter of children currently leave primary school with a body mass index (BMI) indicating they are overweight or obese, at a level needing clinical weight management support.[1] These proportions vary by ethnic background, and, after adjustment to account for ethnic variation in body fat mass, are significantly higher among children from South Asian backgrounds, especially boys.[2] This has important implications for their future health, as children from South Asian backgrounds are known to be biologically more susceptible to the harms of overweight, and are at higher risk of developing type two diabetes and cardiovascular disease in adulthood.[3-5]

It has been suggested that parental concern about their child becoming overweight in the future reflects parental awareness of overweight, and may be a more meaningful predictor of willingness to engage in behaviour change.[14,16]

There is evidence of increased parental concern about their child becoming overweight in the future among parents of children whose BMI is in the overweight or obese range relative to those whose children have a healthy weight BMI.[10,17-20] Furthermore, it has been shown that parents express higher levels of this concern for daughters with overweight or obesity than for sons,[6,21-23] as well as if they themselves have a BMI categorised as overweight or obese.[10,23] There is only very limited evidence regarding ethnic variation in parental concern, with lower levels of concern for childhood overweight reported in one study of parents from Black Somali backgrounds living in Liverpool,[17] and greater concern from another of parents from Black Afro-Caribbean backgrounds living in London,[24] with others reporting no differences.[10] However, these findings are based on regional studies with low response rates and consequently small sample sizes, and did not adjust BMI for ethnicity and further investigation of this is warranted.

Across the UK, children's heights and weights are measured on or shortly after entry to primary school at age five years. Following measurement, parents receive a feedback letter informing them of their child's weight status. Given the longitudinal evidence that obesity at the beginning of

primary school strongly predicts obesity on leaving primary school,[25,26] age five may be viewed as an appropriate time to intervene to prevent and tackle obesity. It is therefore important to understand how parental concern about future childhood overweight might relate to weight status at this point in the life course.

We used cross-sectional data from a large ethnically diverse UK-wide cohort study to examine whether parental concern about their child's future risk of overweight, reported when the child was aged five years, varied by ethnic background. Given the high rates of overweight and obesity observed among children from South Asian backgrounds after adjustments for body fat,[2] we hypothesised that parents of children from South Asian backgrounds with a BMI in the overweight or obese range would be more concerned about their child becoming overweight in the future relative to parents of children from White backgrounds, and that this would be more marked for girls than for boys and for children whose BMI indicated they were overweight or obese.

Materials and methods

Study design

We used data from the Millennium Cohort Study (MCS), a prospective nationally representative cohort of children born between September 2000 and January 2002 in the UK, which used a stratified clustered sampling design to over-represent children born in disadvantaged areas, from ethnic minority groups or from Northern Ireland, Scotland and Wales. When the cohort child was aged nine months, 18,552 (72%) of 27,257 families contacted were interviewed at home when demographic, social and health information was obtained. An additional 692 families were recruited at age three. Further interviews were conducted when children were aged three, five, seven, 11 and 14 years, when height and weight were measured. At age five, 15,246 (85.8%) of 17,770 families eligible for interview were interviewed, providing data for 15,459 children (Figure S1).

Inclusion and exclusion criteria

We included 15,039 of 15,459 singleton children whose parent (natural mother (97.0%), else child's main care-giver, all referred to hereafter as the parent) was interviewed when their child was aged five years, having excluded 418 twins and triplets, as well as two children with extreme height and/or weight measures at age five or missing ethnicity (Figure S1). We extracted information available for these children from their two earlier and two subsequent MCS interviews. Characteristics of those who did and did not participate in the age five interview are given in Table S1. We weighted all analyses to take account of survey design and to allow for potential ethnic and socioeconomic biases in cohort attrition by age five years.

Main Outcome measure

The main outcome measure was parental concern about their child's future risk of becoming overweight. This was assessed at the age five interview from responses to a question administered by a trained interviewer who asked the parent "How concerned are you about [child's name] becoming overweight in the future?" We followed the methods applied by others[6,10,21,23] and derived a binary variable from the five possible responses as follows: parents reporting they were unconcerned (n=10,964), were categorised as "no parental concern", with all other responses (a little concerned (n=2,645), concerned (n=540), fairly concerned (n=390), very concerned (n=418)) categorised as "parental concern". Response to this question was missing for 82 parents.

Main exposure variable

Ethnic background of the child was obtained from parental report at the first MCS interview and categorised using UK 2011 Census categories. Analyses were based on ten individual Census categories, with the exception of some analyses where individual ethnic groups were too small to create 95% confidence intervals (CI) when categories which were grouped as follows: White, South Asian (Indian, Pakistani, Bangladeshi), Black (Black Caribbean, Black African, other Black), Mixed and Other (Other Asian, Chinese, Mixed, Other).[27]

Covariates

We examined two covariates: child weight status and parental weight status. At age five years, trained interviewers in the home measured the child's height and weight: height was recorded to the nearest millimetre using a Leicester Height Measure Stadiometer (Seca Ltd, Birmingham, UK) with the head positioned in the Frankfort plane. Children were weighed barefoot and without outdoor clothing on Tanita HD-305 scales (Tanita, UK Ltd, Middlesex, UK) and weight recorded in kilograms to one decimal place.[28]

To enable comparison with the current English child measurement programme, we used published guidance from Public Health England[29] to assess the quality and range of height and weight measurements. We excluded one child with extreme short stature, and in addition assigned measurements in two children with extreme weight values as missing, as these were assumed erroneous when compared with their earlier or subsequent MCS measurements.

BMI at age five was calculated and adjusted for ethnicity using methods described by Hudda et al. who used similar ethnic categories to those employed in this study.[30] The authors pooled data from four UK studies which used the deuterium dilution method to measure body fat in approximately 2,000 children from White European, South Asian and Black African backgrounds. They derived a height-standardised fat mass index (FMI) to represent body fat and fitted linear regression models to quantify ethnic differences in BMI-FMI relationships to provide ethnic-specific BMI adjustments. This adjustment entails adding approximately 1.1kg/m^2 to the BMI of children from South Asian backgrounds, and subtracting between -0.12kg/m^2 and -5.52kg/m^2 dependent upon sex, age group and unadjusted BMI to the BMI of children from Black backgrounds to more accurately reflect adiposity in these groups since it has been shown that BMI overestimates and underestimates body fat in children from Black and South Asian backgrounds, respectively. No adjustment is available to apply to children from Mixed or Other ethnic backgrounds.

We categorised the adjusted BMI according to the UK1990 clinical reference standard,[31] into four mutually exclusive groups: "underweight" (BMI<2nd centile), "healthy weight" (≥2nd to <91st centile), "overweight" (≥91st to <98th centile) or "obese" (≥98th centile) based on alignment with sex- and age-specific BMI centiles from the LMS growth tool Excel add-in.[32,33] We defined those with BMI ≥98th centile or ≥91st to <98th centile as clinically obese and clinically overweight respectively. The UK90 clinical reference standard uses higher thresholds to define overweight and obesity compared to the UK90 population reference standard, indicating the need for clinical support for weight management. These thresholds are used by a variety of health professionals to assess individual children, as opposed to the UK90 population thresholds which are used to monitor population prevalence of overweight and obesity.[31]

Parental BMI was calculated using the parent's self-reported weight (at the age five sweep) and their most recent self-reported height (usually recorded at the first contact sweep). Trained interviewers measured parental heights and weights objectively if they did not know their measurements for self-report. Parental BMI was categorised into four mutually exclusive groups: "underweight" (BMI<18.5kg/m^2), "healthy weight" (≥18.5 to <25kg/m^2), "overweight" (≥25 to <30kg/m^2) or "obese" (≥30kg/m^2). Due to the higher risk of type two diabetes and cardiovascular disease among adults from Asian backgrounds at a BMI lower than 25kg/m^2, lower thresholds for classifying overweight and obesity in South Asian adults were employed, where "overweight" is considered ≥23 to <27.5kg/m^2 and "obese" as ≥27.5kg/m^2, based on National Institute for Health Care Excellence guidelines.[34]

Statistical methods

Response to the parental concern question was missing for 82 children. All children for whom consent was obtained from a parent or guardian and who could stand unaided had their height and weight measured.[28] Height was missing for 235, and weight 234, five year-olds. BMI was missing for 2,456 parents. We used multiple imputation to estimate missing data on parental concern, child

height and weight at age five, and parental BMI, and built 20 imputed datasets using the weighted iterative chain algorithm,[35] including all variables involved in the analysis steps under the assumption that missingness is at random (Table S2). All analyses were carried out on imputed datasets, and sensitivity analyses on complete-cases.

We used descriptive statistics to assess the prevalence of parental concern overall, and by sex, ethnic background and parental weight status. We examined associations of child's weight status with parental concern overall, and by sex and ethnic background. We used logistic regression to estimate the unadjusted odds of a parent being concerned about their child being overweight in the future by child's ethnic group, sex, weight status and parental weight status (reported as odds ratios [OR]). We then adjusted for child's ethnic background, after taking into account the child's sex and child and parent weight status. We tested for interactions between the child's ethnic background and sex, and between child's ethnic background and weight status and used Wald test statistics for these interaction terms to inform the final logistic regression model. We derived sex- and ethnic-specific odds ratios by multiplying the interaction term coefficient by the ethnicity coefficient and plotted these in a forest plot.

All analyses and percentages cited were performed in Stata and weighted to take account of survey design and to allow for potential biases in attrition by age five years, using the `svyset` command (Stata/SE 15; Stata Corporation, Texas, USA).

Ethics approval

Approval for MCS was granted by the London Research Ethics Committees[36] and no further approval was required for this secondary analysis.

Patient and public involvement

This research was done without patient or public involvement. Neither were invited to comment on the study design and were not consulted to develop relevant outcomes or interpret results.

Results

Of 15,039 children, 48.9% were girls, 86.7% were from White, and 6.1% from South Asian, backgrounds. Parental concern about their child becoming overweight in the future was reported by 27.3% of parents (17.7% 'a little concerned', 3.5% 'concerned', 2.6% 'fairly concerned', 2.6% 'very concerned'), and this was more common among parents of girls than of boys (Table S3; mean difference girls-boys [95% CI]: 6.6% [5.2-8.0%]).

Fewer parents of girls from Pakistani, Bangladeshi or Black African backgrounds reported some parental concern relative to parents of girls from White backgrounds. These differences were not seen in boys (Table 1).

At age five, the prevalence of overweight and obesity was 11.0% and 6.6%, respectively (Table 2), with obesity more prevalent among boys (7.5%) than girls (5.7%) (Table 1). Within each ethnic group, most five-year-old children were of healthy weight, however children from South Asian backgrounds were more likely to have a BMI in the obese range than children from White backgrounds (Table 2). There were some minor differences by sex, with boys from South Asian backgrounds and girls from Pakistani and Bangladeshi backgrounds more likely to have a BMI in the obese range than those from White backgrounds (Table 1).

Parental concern was reported by fewer parents of girls from South Asian backgrounds with overweight and obesity compared to parents of girls from White backgrounds (Table 3). No differences in parental concern were observed between boys from different ethnic backgrounds.

Parental concern was strongly associated with child's BMI status (Table 3), and was more common among parents of children with overweight or obesity (42.3% and 66.2% respectively) than among parents of children with a healthy weight (22.3%). Parental concern was reported for 73.4% girls with obesity compared with 61.0% of boys with obesity (mean difference girls-boys [95% CI]: 12.4% [10.9-13.9%]).

Parent weight status was positively associated with child weight status (Table 4) and parental concern more likely to be reported by parents with overweight or obesity: 29.9% and 39.7%, respectively, compared to parents with a healthy weight (22.7%).

After mutual adjustment for ethnic background, sex and child and parent weight status, some parental concern was significantly less likely among children from Pakistani, Bangladeshi and Black African ethnic backgrounds. Some parental concern was more likely among parents of overweight and obese children, as well as among parents who themselves were overweight or obese (Table 5).

As the Wald test statistic for an interaction between sex and ethnic background was significant, the final adjusted model included this interaction term. Other interactions were not significant (Table S3). The sex- and ethnic-specific odds accounting for this interaction are shown in Table 4 and Figure 1, using White ethnic background as the reference category.

Parents of boys from Pakistani backgrounds were less likely to be concerned about their child's future risk of being overweight (Figure 1), as were parents of girls from Pakistani, Bangladeshi, Black African, Mixed or Other ethnic backgrounds.

After accounting for ethnic background and its interaction with sex, parental concern about future childhood overweight was more likely among parents of children with overweight and obesity, and less likely among parents of children considered underweight, compared to parents of children with a healthy weight. Parents who themselves had a BMI in the overweight or obese range were more likely, and those with a BMI considered underweight less likely, to report concern than those with a healthy weight.

Findings were similar for complete case analyses (Table S4) and for BMI without ethnic-adjustment (data not shown).

Discussion

In this large nationally representative study, we found that, despite their greater risk of obesity and future obesity-related complications, parents of children from South Asian backgrounds were less likely to be concerned about their child's future overweight risk, compared to those from White backgrounds. This was particularly so for girls from Pakistani and Bangladeshi backgrounds, and was independent of child and parent weight status. Furthermore, we confirmed associations between parental concern and child sex and weight status reported by others.

Increased understanding of the context in which people from different ethnic backgrounds report parental concern about their child's future risk of becoming overweight is important to inform the development of interventions to support parents and families to alter the weight trajectories of their children with overweight or obesity. This is especially important for children from South Asian backgrounds, given their higher absolute risk of obesity and greater metabolic sensitivity to its effects. Our findings make a significant contribution to the literature on parental concern. This is to our knowledge the first study to use a UK-wide nationally representative cohort to examine whether parental concern about future risk of overweight in their child varies by ethnic background.

Strengths of our study include analyses based on a large, nationally representative cohort of children from diverse ethnic backgrounds, allowing examination of parental concern across ten ethnic groups. Our findings are generalisable to the UK: the prevalence of overweight and obesity at age five in this cohort is similar to that reported from Public Health England's National Child Measurement programme (NCMP) for the 2006/07 academic year, when most children included in this study were aged five years.[37,38]

We used robust statistical methods including imputation of missing data and use of survey weights to account for survey design and to allow for biases in attrition. We used a clinical definition of overweight and obesity that indicates the need for clinical weight management support, and applied ethnic-specific BMI adjustment for more accurate assessment of body fatness in children from South

Asian and Black ethnic backgrounds. While this method of adjusting children's BMI is not currently employed in the NCMP, analyses without ethnic-adjustment produced similar findings.

We were able to adjust for a number of covariates in our analysis including those shown previously to be strongly associated with parental concern, including parental and child weight status (the latter based on objective measurements). Responses to the question eliciting parental concern are unlikely to be influenced by the MCS weight measurement as this question was asked before the child was weighed, and furthermore no interpretation or categorisation of BMI was provided in the feedback to parents.[36]

Although it is possible that some children may have been recently weighed either at home, in clinical care or in school as part of the NCMP, information on the timing of this in relation to the MCS interview, or the feedback given to parents, is unavailable. The MCS interview did not ask parents about their perception of their child's weight status at age five and consequently we were unable to adjust for this in our final model. Furthermore, given the cross-sectional design of this study, we are unable to draw any conclusions about the temporal relationship between parental concern and child weight status.

As one in seven children in this study were from Black, South Asian and Other ethnic backgrounds, we were able to examine parental concern across all major ethnic groups; however, absolute numbers for some groups were small, resulting in greater uncertainty for these estimates.

We used lower thresholds for overweight and obesity to categorise BMI in adults from South Asian backgrounds to reflect the higher risk of type two diabetes and cardiovascular disease at lower levels of BMI experienced among these adults.[34] Although parental height and weight were self-reported, this is considered a reliable measure in epidemiological studies.[39,40] Furthermore, at present there are no validated algorithms for the adjustment of BMI for children from Mixed and Other ethnic backgrounds so no adjustments were made for these children in our analyses. Although we lacked statistical power to evaluate all subcategories of parental concern, we used the approach others

have taken using this instrument and dichotomised parental concern into “some concern” or “no concern” in order to produce robust estimates when stratifying by sex and ethnic background.[6,10,21,23]

There are to our knowledge no other published reports examining ethnic variation in parental concerns about their child’s future risk of becoming overweight using a UK-wide nationally representative cohort of children. Our finding of less parental concern among parents of girls from Black African backgrounds is similar to that reported for parents from Black Somali backgrounds in Liverpool,[17] but not consistent with those from a regional study which observed greater parental concern among parents from Black Afro-Caribbean backgrounds living in London.[24]

The explanations for our main finding that parents of boys and girls from South Asian backgrounds and of girls from Black backgrounds are less concerned about their child’s future risk of becoming overweight warrant further investigation. While this finding may reflect differences in awareness of children’s weight status or perceptions of childhood weight and size among parents from different ethnic backgrounds, it may be more useful to explore the wider context and barriers which children and their families from different ethnic backgrounds face in negotiating and considering healthy or ideal weight so that interventions can be considered which reflect the diverse ethnic backgrounds of children with obesity in the UK.

Many parents are unable to identify overweight or obesity in their children,[6-8] with the majority of parents of children with a BMI in the overweight or obese range underestimating their child’s weight status,[9,10] a finding replicated in numerous high income countries across the world.[8,11,12] While there is some evidence that recognition of overweight or obesity is difficult among adults from South Asian backgrounds,[41] the reasons for this remain unclear and similar studies in children are lacking.

While parental recognition of child overweight or obesity can be helped by presenting them with child age- and sex-specific body images,[42] these have not been tested among parents from different ethnic backgrounds. Furthermore, we did not find any evidence to suggest that parental concern

about child future overweight risk among children from different ethnic backgrounds varied by objectively measured child weight status.

Qualitative research provides important contextual information among South Asian parents and their extended families. Pallan et al. have highlighted the importance of intergenerational influences on child diet and perception of their weight status, suggesting that fatness may signal health and that provision of abundant food may symbolise parental/carer affection for the child.[43] This may be important for families relying on grandparents for informal childcare, and multi-generational households where meals are communally prepared and eaten.[43,44] For example, studies of women from Pakistan living in North West England and an ethnically diverse sample of families in London have both reported that in these groups familial expectations to maintain traditional home-cooking procedures as obstacles to change.[44] Similarly, qualitative research involving women from Somalia living in Liverpool found that many women felt restricted in their efforts to live healthier lifestyles by older relatives' perspectives which promote increased weight, although this study did not focus on the influence of the home environment on their child's weight status.[45]

Whilst we were unable to explore the structural barriers experienced by first and second generation migrants and how this might influence levels of parental concern about child overweight, other research has shown significant acculturation in a range of health-related lifestyle behaviours, among immigrant mothers of MCS children.[46] Further research to explore intergenerational variation in parental concern about future childhood overweight is required.

Our finding that a greater proportion of parents of girls than boys from White backgrounds were concerned about their child becoming overweight in the future is consistent with findings from other UK studies of predominantly White populations[6,21,22] and with one from Australia.[23] This may reflect societal expectations of "ideal" body shapes for boys and girls[21] whereby girls are expected to be slight or petite, and boys to be bigger, stronger or more muscular.[47] Findings from a qualitative study interviewing parents of pre-school aged children in America suggest that childhood overweight is

normalised through the use of euphemistic terms like 'cute baby fat' or 'podge',[48] and discussions of body size relate to how 'big', 'strong' or 'muscular' the child is.[49] Other studies have suggested that parents are less worried about their child's weight status risk because they believe their child participates in an appropriate level of physical activity and/or eats a balanced or healthy diet.[49,50]

Given these accounts, parents from different ethnic backgrounds may experience social contexts where monitoring child weight is not a priority, particularly in environments where weight is a signal of wellness, health and affection for the child. Similarly, given that people from ethnic minority backgrounds, particularly from Pakistan and Bangladesh, are more likely than White British people to live in the most deprived areas in England,[51] it is possible parents prioritise providing for their family over parental concern about future childhood overweight.

Whilst existing literature recognises societal expectations of boy's and girl's size and appearance, less is known about how these expectations vary by ethnic background, and further qualitative research is needed to address this.

Our finding that concern was reported more often for children with overweight and obesity is consistent with previously published reports.[6,10,18,21,22] Our findings are similar to those of Carnell et al. who used the same question and response scale but did not examine the influence of ethnicity on this association.[10] Parents may be better able to identify their child's weight status at the extreme end of obesity[6,21] indicating that, to some extent, parents are aware of overweight in their children. Inability to assess correctly their child's weight may be a barrier to prevention of childhood obesity,[13,21,22] since lifestyle changes are not initiated,[9,52] however Carnell et al. have argued that parental concern is a more sensitive indicator of parental awareness of child weight status than correct parental identification. Our findings lend support for this latter view: we identified a strong positive association between parental concern and child weight status.

The temporality of this relationship however remains unclear as our study was cross-sectional. Whilst it seems plausible that parents are more likely to report concern because their children are

already overweight, a range of studies, predominantly from Australia[53-55] and the United States[56-60] as well the UK[61] and Sweden,[62] have proposed that parents reporting concern about their child becoming overweight might be more likely to engage in behaviours such as restrictive feeding, where children's food is controlled and limited.

Longitudinal research has suggested that restrictive feeding practices can result in child weight gain. A prospective study of Australian children aged two years suggests restrictive feeding practices lead to obesogenic behaviours such as overeating,[63] whilst in the United States a study of five to seven year-olds showed a positive association between restrictive feeding and additional weight gain among children at risk of obesity.[64] Two further longitudinal studies in the United States showed restrictive feeding practices were associated with increased eating in the absence of hunger among girls aged five to nine years.[65,66]

Whether parental feeding practices vary by ethnic background is largely unknown. One study comparing feeding practices in Germany and Britain found parents from Black Afro-Caribbean backgrounds living in Britain were more likely to use restrictive feeding practices than parents from White backgrounds living in either Britain or Germany, and this was associated with higher child BMI.[67] Further research is needed to understand how social context and ethnic backgrounds might influence parents feeding practices.

Our study has implications for practice and research. Our cross-sectional analyses confirmed a strong positive association between the child's current weight status and parental concern, suggesting parents of children with a BMI in the overweight and obese range are more likely than other parents to be concerned about their child's future overweight risk. This is important, given the suggestion that appropriate parental concern is vital for effective parental engagement with obesity intervention programmes[16] and positive behaviour change.[14] Further research is needed to determine whether parental concern is associated with healthier weight trajectories, as well as to

understand how feedback given to parents about their child's weight status from the NCMP can be appropriately and accurately conveyed to parents from different ethnic backgrounds.

Our study also has implications in particular for targeted interventions aimed at childhood obesity prevention and management. Parents from particular ethnic backgrounds at higher risk of obesity are less likely to express concern about future childhood overweight, particularly so for girls. This needs to be taken into account in developing ethnically sensitive interventions for weight management of children with obesity in multi-ethnic populations. As with all complex interventions, these need to be informed by qualitative studies to elucidate the factors underlying these novel observed differences in rates of parental concern among participants from different ethnic backgrounds, and to aid their interpretation.

In summary, we have found that, in contrast to our original hypothesis, parents of children from South Asian ethnic backgrounds who are at higher risk of childhood obesity and its adverse consequences are less likely to report concern for their child's future overweight risk, particularly for their daughters. These insights are of importance to the UK population, where the highest risk of obesity is observed in individuals and communities from these backgrounds.

Table 1 – Overweight and obesity prevalence and parental concern about future overweight risk at age five years, by ethnic background[1] stratified by sex

	Child weight status[2]				Parental concern	
	Overweight		Obese			
	%	95% CI[3]	%	95% CI[3]	%	95% CI[3]
All	11.0	10.4, 11.6	6.6	6.1,7.1	27.3	26.3,28.3
Boys	11.5	10.7,12.4	7.5	6.8,8.1	24.1	22.8,25.4
White	11.7	10.8,12.6	6.9	6.2,7.6	24.1	22.8,25.4
South Asian	12.8	9.5,16.0	15.9	13.0,18.8	23.4	18.6,28.1
Indian	9.2	4.8,13.6	17.3	10.7,23.9	25.4	18.2,32.5
Pakistani	14.1	9.0,19.2	14.0	10.1,18.0	21.8	15.4,28.3
Bangladeshi	15.3	7.8,22.9	18.8	11.5,26.1	24.3	15.5,33.1
Black	5.1	2.0,8.2	8.2	3.6,12.8	24.5	17.9,31.2
Black Caribbean	4.9	0.5,9.4	14.8	2.7,27.0	32.1	20.3,43.9
Black African	5.8	2.4,9.3	4.7	1.0,8.5	19.2	11.4,27.1
Other Black[4]					26.3	3.1,49.5
Mixed and Other	11.3	7.5,15.1	7.0	3.8,10.3	24.6	18.1,31.1
Other Asian	3.3	0.1,6.5	9.0	0.0,19.3	35.7	19.6,51.8
Chinese and other	8.3	0.0,17.0	5.6	0.0,11.5	20.2	7.6,32.8
Mixed	13.1	8.4,17.9	7.0	3.1,10.9	23.7	16.2,31.3
Girls	10.4	9.5,11.2	5.7	5.1,6.4	30.7	29.4,31.9
White	10.1	9.2,11.1	5.4	4.7,6.0	31.6	30.3,33.0
South Asian	16.8	13.3,20.4	10.6	7.4,13.8	23.7	19.3,28.0
Indian	18.3	9.8,26.8	6.8	0.9,12.6	31.8	23.1,40.5
Pakistani	17.7	13.5,22.0	9.5	6.5,12.4	19.9	14.6,25.3
Bangladeshi	12.1	6.4,17.9	19.7	11.1,28.3	21.1	13.0,29.1
Black	6.7	2.4,10.9	5.0	0.0,10.3	25.3	18.7,31.8
Black Caribbean	5.2	0.3,10.2	2.8	0.0,6.0	32.5	19.3,45.8
Black African	8.0	1.3,14.8	6.7	0.0,14.9	21.1	15.6,26.7
Other Black[4]					24.8	0.0,54.0
Mixed and Other	8.5	4.7,12.2	6.2	3.2,9.3	25.1	19.8,30.4
Other Asian	2.7	0.2,5.2	1.7	0.0,4.0	26.5	9.9,43.2
Chinese and Other	6.5	0.4,12.6	6.2	0.0,13.5	21.5	8.6,34.3
Mixed	10.1	5.1,15.0	7.1	3.1,11.2	25.7	19.3,32.0

[1]Ethnic background of the child was obtained from parental report at the first MCS interview and categorised using UK 2011 Census categories. [2]Child weight status based on ethnic-adjusted BMI and categorised according to UK90 clinical reference standard. [3]95% confidence interval. [4]Overweight and obesity prevalence estimates not stated due to small numbers. Total N=15,039.

Table 2 – Sex, child weight status and parental concern about future overweight risk at age five years, by ethnic background[1]

	Sex	Child weight status[2]								Parental concern	
	Girls	Underweight[3]		Healthy weight		Overweight		Obese			
	%	%	95% CI[4]	%	95% CI[4]	%	95% CI[4]	%	95% CI[4]	%	95% CI[4]
White	48.9	0.6	0.4,0.7	82.4	81.6,83.1	10.9	10.3,11.6	6.1	5.6,6.6	27.8	26.8,28.8
South Asian	49.6	0.6	0.1,1.0	71.4	69.3,73.5	14.8	12.8,16.8	13.3	11.1,15.4	23.5	20.5,26.5
Indian	48.3			72.9	68.1,77.8	13.6	9.1,18.1	12.2	8.1,16.3	28.5	23.2,33.7
Pakistani	49.7			72.0	68.7,75.3	15.9	13.0,18.8	11.8	9.4,14.1	20.9	17.0,24.7
Bangladeshi	51.6			66.8	60.9,72.7	13.7	10.3,17.1	19.3	14.0,24.5	22.6	16.8,28.4
Black	45.6	3.7	1.7,5.8	83.7	79.5,87.8	5.8	3.1,8.6	6.8	2.5,11.1	24.9	19.6,30.1
Black Caribbean	43.6			83.4	75.8,91.0	5.1	2.4,7.7	9.6	2.4,16.7	32.3	21.9,42.7
Black African	47.5			83.5	78.4,88.6	6.9	2.8,11.0	5.7	1.2,10.1	20.1	15.5,24.7
Other Black[5]	40.1			87.3	71.3,100.0					25.7	7.3,44.1
Mixed and Other	50.0	1.6	0.6,2.6	81.9	78.2,85.6	9.9	7.3,12.4	6.6	4.5,8.8	24.9	20.0,29.7
Other Asian	54.2			87.1	78.9,95.3	3.0	0.9,5.1	5.0	0.0,10.3	30.7	17.7,43.8
Chinese and Other	53.3			85.6	78.1,93.1	7.3	2.5,12.2	5.9	1.2,10.7	20.9	12.4,29.3
Mixed	48.5			80.2	75.8,84.6	11.6	8.4,14.9	7.1	4.4,9.8	24.7	19.2,30.1
All	48.9	0.7	0.5,0.9	81.7	81.0,82.5	11.0	10.4,11.6	6.6	6.1,7.1	27.3	26.3,28.3

[1]Ethnic background of the child was obtained from parental report at the first MCS interview and categorised using UK 2011 census categories. [2]Child weight status based on ethnic-adjusted BMI and categorised according to UK90 clinical reference standard. [3]Underweight values for individual ethnic groups omitted due to small numbers. [4]95% confidence interval. [5]Overweight and obesity prevalence estimates not stated due to small numbers. Total N=15,039.

Table 3 – Parental concern about future overweight risk at age five years, by child weight status[1] at age five

	Proportion of parents reporting parental concern									
	White		South Asian		Black		Mixed and Other		All	
	%	95% CI[2]	%	95% CI[2]	%	95% CI[2]	%	95% CI[2]	%	95% CI[2]
All										
Healthy weight	22.8	21.8,23.8	16.9	14.5,19.3	21.5	15.5,27.6	19.5	14.6,24.4	22.3	21.3,23.3
Overweight	43.8	40.8,46.8	28.4	22.1,34.8	30.1	6.9,53.3	39.8	25.3,54.3	42.3	39.5,45.1
Obese	67.8	63.8,71.7	51.8	44.2,59.3	72.8	58.4,87.2	70.4	55.1,85.7	66.2	62.8,69.6
Boys										
Healthy weight	19.6	18.3,21.0	16.8	13.5,20.2	18.1	13.0,23.2	17.6	11.3,23.8	19.3	18.0,20.6
Overweight	34.2	30.1,38.3	25.9	16.4,35.4	46.7	20.4,72.9	46.6	25.9,67.3	34.5	30.8,38.3
Obese	61.4	56.1,66.7	51.4	41.6,61.2	55.6	31.8,79.3	70.7	47.9,93.4	61.0	56.6,65.4
Girls										
Healthy weight	26.0	24.7,27.3	17.0	13.6,20.3	23.6	17.7,29.6	21.3	15.4,27.3	25.3	24.1,26.5
Overweight	55.4	51.2,59.5	30.5	21.6,39.4	37.2	10.2,64.3	30.7	11.7,49.7	51.4	47.1,55.6
Obese	76.3	70.5,82.1	52.3	40.5,64.1	72.9	39.7,100.0	70.1	48.1,92.1	73.4	68.1,78.6

[1]Underweight groups omitted due to small numbers. Child weight status based on ethnic-adjusted BMI and categorised according to UK90 clinical reference standard. [2]95% confidence interval. Total N=15,039.

Table 4 – Child weight status and parental concern about future overweight risk at age five years, by parental weight status

	Parental weight status[1]							
	Underweight		Healthy weight		Overweight		Obese	
	%	95% CI[2]	%	95% CI[2]	%	95% CI[2]	%	95% CI[2]
Child weight status[3]								
Underweight	0.9	0.0,2.0	0.8	0.6,1.1	0.5	0.3,0.8	0.6	0.2,1.0
Healthy weight	90.7	87.0,94.4	86.5	85.5,87.4	78.7	77.1,80.3	70.2	67.9,72.4
Overweight	6.0	2.9,9.1	8.6	7.8,9.4	13.0	11.7,14.3	15.9	14.2,17.7
Obese	2.4	0.6,4.2	4.1	3.5,4.7	7.8	6.7,8.9	13.3	11.8,14.9
Parental concern								
Parental concern	15.4	11.1,19.6	22.7	21.5,23.9	29.9	28.0,31.9	39.7	37.4,42.0

[1]Parental weight status was categorised using BMI calculated from parental self-reported weight and height as follows: "underweight" (BMI<18.5kg/m²), "healthy weight" (≥18.5 to <25kg/m²), "overweight" (≥25 to <30kg/m²) or "obese" (≥30kg/m²), except for South Asian adults where "overweight" is ≥23 to <27.5kg/m² and "obese" is ≥27.5kg/m². [2]95% confidence interval. [3]Child weight status based on ethnic-adjusted BMI and categorised according to UK90 clinical reference standard.

Table 5 – Unadjusted, adjusted and sex- and ethnic-specific adjusted odds of parental concern about future overweight risk at age five years

	Unadjusted		Adjusted[1]		Model with interaction term[2]		Sex- and ethnic-specific adjusted odds[3]			
							Boys		Girls	
	OR (*p*-value)[4]	95% CI[5]	OR (*p*-value)[4]	95% CI[5]	OR (*p*-value)[4]	95% CI[5]	OR[4]	95% CI[5]	OR[4]	95% CI[5]
Ethnic background[6]	(0.008)		(<0.001)		(0.057)					
White (ref.)	1		1		1		1		1	
South Asian										
Indian	1.04	0.80,1.35	0.80	0.60,1.09	0.77	0.52,1.14	0.77	0.52,1.14	0.84	0.54,1.30
Pakistani	**0.69**	**0.54,0.87**	**0.46**	**0.34,0.61**	**0.59**	**0.38,0.91**	**0.59**	**0.38,0.91**	**0.36**	**0.24,0.53**
Bangladeshi	0.76	0.54,1.06	**0.43**	**0.31,0.61**	0.62	0.38,1.01	0.62	0.38,1.01	**0.32**	**0.21,0.48**
Black										
Black Caribbean	1.24	0.77,1.99	1.15	0.73,1.80	1.25	0.78,2.00	1.25	0.78,2.00	1.05	0.56,1.94
Black African	**0.66**	**0.49,0.87**	**0.61**	**0.44,0.84**	0.77	0.46,1.28	0.77	0.46,1.28	**0.49**	**0.32,0.74**
Other Black	0.90	0.34,2.36	1.17	0.43,3.20	1.36	0.37,5.04	1.36	0.37,5.04	0.94	0.20,4.48
Mixed and Other										
Other Asian	1.15	0.62,2.14	1.28	0.66,2.48	2.00	0.99,4.05	2.00	0.99,4.05	0.88	0.34,2.27
Chinese and other	0.69	0.41,1.14	0.66	0.39,1.10	0.79	0.33,1.89	0.79	0.33,1.89	0.57	0.28,1.14
Mixed	0.85	0.64,1.14	0.81	0.60,1.09	0.96	0.63,1.46	0.96	0.63,1.46	**0.69**	**0.48,0.99**
Sex	(<0.001)		(<0.001)		(<0.001)					
Male (ref.)	1		1		1					
Female	**1.39**	**1.28,1.51**	**1.52**	**1.40,1.65**	**1.59**	**1.46,1.73**				
Child weight status[7]	(<0.001)		(<0.001)		(<0.001)		**OR[4]**		**95% CI[5]**	
Underweight	**0.32**	**0.16,0.64**	**0.34**	**0.17,0.68**	**0.34**	**0.17,0.68**	**0.34**		**0.17,0.68**	
Healthy weight (ref.)	1		1		1		1			
Overweight	**2.56**	**2.28,2.87**	**2.47**	**2.19,2.78**	**2.47**	**2.20,2.79**	**2.47**		**2.20,2.79**	
Obese	**6.84**	**5.84,8.01**	**6.70**	**5.68,7.90**	**6.71**	**5.68,7.93**	**6.71**		**5.68,7.93**	
Parental weight status[8]	(<0.001)		(<0.001)		(<0.001)					
Underweight	**0.62**	**0.44,0.87**	**0.68**	**0.48,0.96**	**0.68**	**0.48,0.97**	**0.68**		**0.48,0.97**	

Healthy weight (ref.)	1		1		1			
Overweight	**1.46**	**1.30,1.63**	**1.35**	**1.20,1.52**	**1.35**	**1.20,1.52**	**1.35**	**1.20,1.52**
Obese	**2.24**	**2.01,2.50**	**1.94**	**1.72,2.19**	**1.94**	**1.72,2.19**	**1.94**	**1.72,2.19**
Sex x ethnic background					(0.087)			
Female x White (ref.)					1			
Female x South Asian								
Female x Indian					1.09	0.61,1.96		
Female x Pakistani					0.61	0.33,1.13		
Female x Bangladeshi					**0.51**	**0.28,0.94**		
Female x Black								
Female x Black Caribbean					0.84	0.46,1.53		
Female x Black African					0.63	0.31,1.28		
Female x Other Black					0.69	0.09,5.28		
Female x Mixed and Other								
Female x Other Asian					0.44	0.17,1.15		
Female x Chinese and Other					0.72	0.22,2.32		
Female x Mixed					0.72	0.44,1.18		

[1]Mutually adjusting for ethnic background, sex, age five weight status and parental weight status. [2]Mutually adjusting for ethnic background, sex, child weight status, parental weight status, and an interaction between sex and ethnic background. An interaction between child weight status and ethnic background was tested but deemed not statistically significant so was excluded from the final model (see Table S4). [3]Calculated by multiplying the interaction coefficient with ethnicity coefficient in the model with the interaction term. Mutually adjusting for ethnic background, sex, age five weight status and parental weight status. [4]odd ratio (and p*-value for corresponding Wald test statistic). [5]95% confidence interval. [6]Ethnic background of the child categorised using UK 2011 Census categories. [7]child weight status based on ethnic-adjusted BMI categorised according to UK90 clinical reference standard. [8]Parental weight status was categorised using BMI calculated from parental self-reported weight and height as follows: "underweight" (BMI<18.5kg/m^2), "healthy weight" (≥18.5 to <25kg/m^2), "overweight" (≥25 to <30kg/m^2) or "obese" (≥30kg/m^2), except for South Asian adults where "overweight" is ≥23 to <27.5kg/m^2 and "obese" is ≥27.5kg/m^2. Cells in bold font indicate the estimate is statistically significantly different to the reference category.*

Figure 1 – Adjusted odds of parental concern about future childhood overweight[1]

[1] Mutually adjusted for ethnic background, sex, child weight status, parent weight status and an interaction between sex and ethnic background.

Conflicts of interest

The authors declare no conflict of interest.

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Author statement

NF and CD conceptualised and designed the analysis. NF carried out the literature search, conducted and interpreted the analyses, generated tables and figures and drafted the initial manuscript. CD contributed to the interpretation of analyses and reviewed and revised the manuscript. All authors were involved in writing the paper and had final approval of the submitted and published versions.

Data statement

The MCS data for surveys 1-6 can be downloaded from the UK Data Service.

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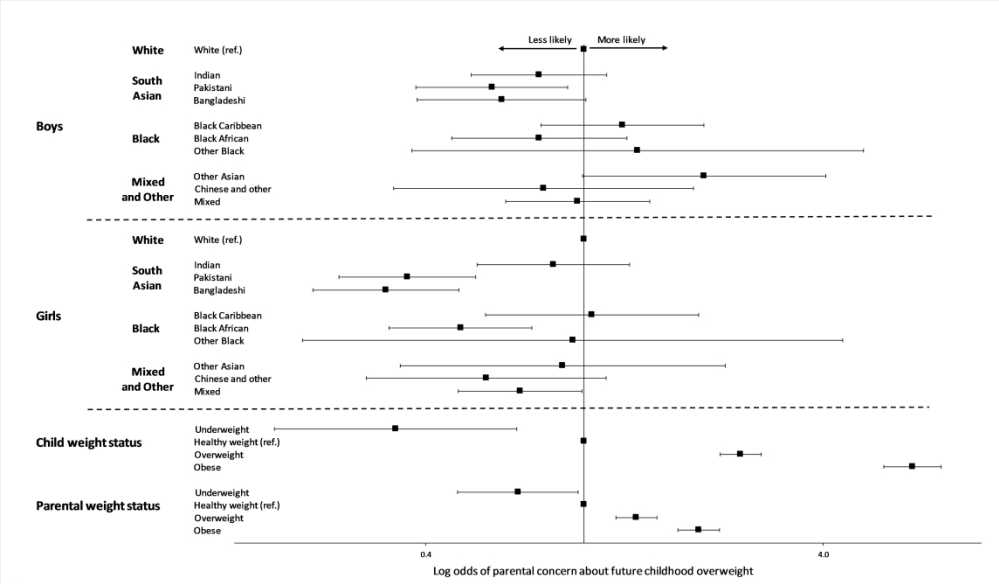

Figure 1 – Adjusted odds of parental concern about future childhood overweight

Does parental concern about their child's future risk of overweight vary by ethnic background? Cross-sectional analysis of a national cohort study

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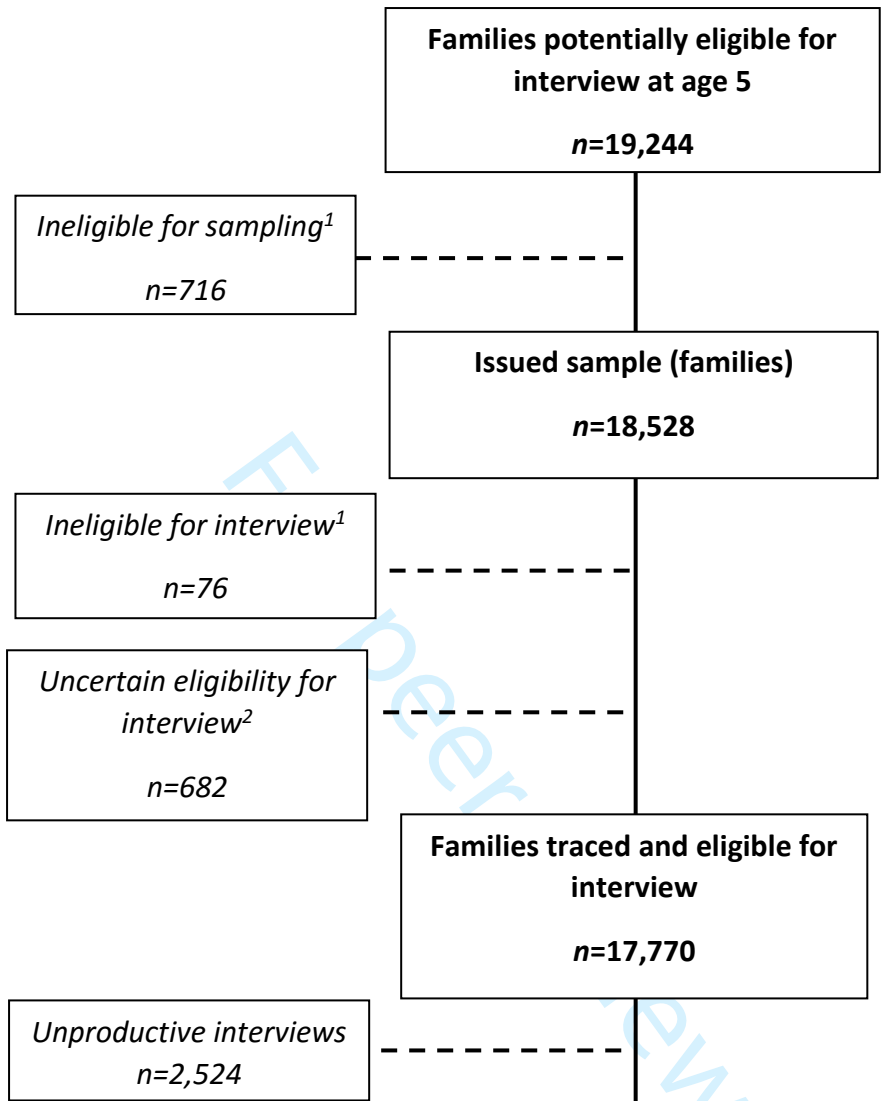
Supplementary material

Figure S1 - Flow chart of study sample



[1]Due to death, emigration, permanent refusal or sensitive family circumstances. [2]Due to untraced movers, outstanding movers or ran out of time to complete sampling. [3]Data for individual children not available prior to the point of productive interview. [4]418 twins/triplets, 1 child with extreme height values, 1 child missing ethnicity.

Table S1 - Sample characteristics of singleton children participating and not participating[1] in MCS at age five

	Singleton children participating at age 5 (n=15,041)		Singleton children not participating at age 5 (n=3,939)	
	n	%[2]	n	%[2]
Child sex				
Male	7708	51.2	2065	52.4
Female	7333	48.8	1874	47.6
Ethnic background[3]				
White	12524	83.3	2990	75.9
South Asian	1361	9.1	474	12.0
Black	505	3.3	213	5.4
Mixed or other	650	4.3	238	6.1
Missing	1	0.0	24	0.6
Parental weight status[4]				
Underweight	541	3.6	156	4.0
Healthy weight	7775	51.7	2018	51.2
Overweight	3591	23.9	880	22.3
Obese	1886	12.5	451	11.5
Missing	1248	8.3	434	11.0
OECD household income quintile[5]				
Lowest	3496	23.2	1326	33.7
2	3306	22.0	977	24.8
3	2852	19.0	685	17.4
4	2761	18.4	479	12.1
Highest	2558	17.0	425	10.8
Missing	68	0.4	47	1.2
Parental highest academic qualification[5]				
Degree or diploma in higher education	3882	25.8	625	15.9
A/AS levels	1441	9.6	296	7.5
GCSEs	6573	43.7	1753	44.5
Other academic qualifications	419	2.8	153	3.9
None	2678	17.8	1072	27.2
Missing	48	0.3	40	1.0

[1] 18,980 singleton children were first recruited/interviewed at either MCS sweep 1 (age nine months) or MCS sweep 2 (age three years). At MCS sweep 3 (age five), 3,939 singleton children did not participate. [2]Proportions are unweighted. [3]Ethnic background of the child was obtained from parental report at the first MCS interview and categorised using UK 2011 Census categories. [4]Parental weight status when the child was aged five years was categorised using BMI calculated from parental self-reported weight and height as follows: "underweight" (BMI<18.5kg/m^2), "healthy weight" (≥18.5 to <25kg/m^2), "overweight" (≥25 to <30kg/m^2) or "obese" (≥30kg/m^2), except for South Asian adults where "overweight" is ≥23 to <27.5kg/m^2 and "obese" is ≥27.5kg/m^2. [5]Recorded at the age nine month interview, or the age three interview for the boosted sample.

Table S2 - Multiple Imputation

Multiple imputation was performed to impute values for our outcome of interest (parental concern) and covariates (child and parental BM). Imputations were based on the variables below, which were all shown to be significantly correlated (at the 5% level) with non-measurement of parental concern, height or weight at ages five and 11:

Variables used in multiple imputation[1]	Number of children with missing data[2] n	%[3]
Outcome of interest		
Parental concern[4]	82	0.6
Exposures of interest		
Child's ethnic background[5]	0	-
Covariates		
Child height measurements[6]:		
Age 3	2367	15.7
Age 5	235	1.6
Age 7	2130	14.2
Age 11	2956	19.7
Child weight measurements[6]:		
Age 3	2219	14.8
Age 5	234	1.6
Age 7	2181	14.5
Age 11	3154	21.0
Parental BMI[6,7]	2456	16.3
Sociodemographic factors		
Child's sex[5]	0	-
Child's age in days[4]	0	-
OECD household income quintile[4]	1	-
Diet		
Portions of fruit eaten a day[4]	88	0.6
Reason for controlling child's diet[4]	1777	11.8
Main snack eaten between meals[4]	79	0.5
Main drink between meals[4]	79	0.5
Physical activity		
Mode of transport to and from school[4]	252	1.7
Days a week participates om sports clubs or classes[4]	69	0.5
Average hours of screen time a day[4]	78	0.5

[1]The attrition/non-response weight (for whole of UK-level analyses), a finite population correction factor, a stratum variable and a ward variable to account for clustering, were also included in the multiple imputation model. [2]Total N=15,039. [3]Proportions are unweighted. [4]Recorded at MCS sweep 3 (age five). [5]Obtained from parental report at the first MCS interview. [6]Height and weight values and parental BMI were transformed on the natural logarithmic scale to mitigate violation of the assumption of normal distributions. [7]Parental BMI based on self-reported weight at MCS sweep 3 (age five) and their most recent self-reported height (usually recorded at the first MCS sweep).

Table S3 – Adjusted odds of parental concern about future overweight risk at age five years, including interactions between child sex and ethnic background and between child weight status and ethnic background

	With interactions[1]	
	OR (*p*-value)[2]	95% CI[3]
Ethnic background[4]	(0.249)	
White (ref.)	1	
South Asian	**0.72**	**0.53,0.99**
Black	1.00	0.65,1.52
Mixed and Other	1.00	0.67,1.48
Sex	(<0.001)	
Male (ref.)	1	
Female	**1.59**	**1.46,1.74**
Child weight status[5]	(<0.001)	
Underweight	**0.33**	**0.15,0.75**
Healthy weight (ref.)	1	
Overweight	**2.52**	**2.22,2.87**
Obese	**6.75**	**5.55,8.20**
Parental weight status[6]	(<0.001)	
Underweight	**0.68**	**0.48,0.96**
Healthy weight (ref.)	1	
Overweight	**1.35**	**1.19,1.52**
Obese	**1.93**	**1.72,2.18**
Sex x ethnic background	(0.034)	
Female x White (ref.)	1	
Female x South Asian	0.71	0.47,1.06
Female x Black	0.71	0.43,1.15
Female x Mixed and Other	0.68	0.45,1.02
Child weight status x ethnic background	(0.184)	
Underweight x South Asian	-	-
Underweight x Black	0.47	0.06,3.90
Underweight x Mixed and Other	2.93	0.57,15.0
Healthy weight x White (ref.)	1	
Overweight x South Asian	0.79	0.46,1.37
Overweight x Black	0.56	0.15,2.08
Overweight x Mixed and Other	0.99	0.49,2.01
Obese x South Asian	0.74	0.47,1.18
Obese x Black	1.30	0.59,2.86
Obese x Mixed and Other	1.24	0.57,2.69

[1]Mutually adjusting for ethnic background, sex, age five weight status, parental weight status as well as two interaction terms: 1) sex x ethnic background 2) age five weight status x ethnic background. Four broader ethnic groupings were used instead of individual ethnic backgrounds to overcome small cell sizes when including both interaction terms in the model. [2]Odds ratio and p*-value for corresponding Wald test statistic. [3]95% confidence interval. [4]Ethnic background of the child categorised using UK 2011 Census categories. [5]Child weight status based on ethnic-adjusted BMI categorised according to UK90 clinical reference standard. [6]Parental weight status was categorised using BMI calculated from parental self-reported weight and height as follows: "underweight" (BMI<18.5kg/m^2), "healthy weight" (≥18.5 to <25kg/m^2), "overweight" (≥25 to <30kg/m^2) or "obese" (≥30kg/m^2), except for South Asian adults where "overweight" is ≥23 to <27.5kg/m^2 and "obese" is ≥27.5kg/m^2. Cells in bold font indicate the estimate is statistically significantly different to the reference category.*

Table S4 - Sensitivity analyses: univariable and multivariable odds of parental concern about future overweight risk at age five years using complete-cases

	Unadjusted		Adjusted[1]		With interactions[2]		Final model[3]	
	OR (*p*-value)[4]	95% CI[5]	OR (*p*-value)[4]	95% CI[5]	OR (*p*-value)[4]	95% CI[5]	OR (*p*-value)[4]	95% CI[5]
Ethnic background[6]	(0.008)		(<0.001)		(0.410)		(0.108)	
White (ref.)	1		1		1		1	
South Asian					0.75	0.53,1.07		
Indian	1.04	0.80,1.35	0.77	0.56,1.06			0.77	0.51,1.16
Pakistani	**0.68**	**0.54,0.87**	**0.50**	**0.37,0.68**			**0.64**	**0.42,0.97**
Bangladeshi	0.76	0.54,1.06	**0.47**	**0.34,0.65**			0.65	0.38,1.12
Black					0.83	0.46,1.49		
Black Caribbean	1.25	0.77,2.01	1.19	0.66,2.15			1.20	0.58,2.48
Black African	**0.65**	**0.49,0.86**	**0.63**	**0.42,0.95**			0.77	0.43,1.38
Other Black	0.90	0.34,2.39	0.87	0.28,2.74			0.64	0.15,2.71
Mixed and Other					0.89	0.56,1.39		
Other Asian	1.15	0.62,2.14	1.18	0.56,2.52			1.82	0.78,4.26
Chinese and Other	0.69	0.41,1.14	0.69	0.39,1.22			0.75	0.26,2.16
Mixed	0.85	0.63,1.14	0.74	0.53,1.05			0.83	0.52,1.33
Sex	(<0.001)		(<0.001)		(<0.001)		(<0.001)	
Male (ref.)	1		1		1		1	
Female	**1.39**	**1.28,1.51**	**1.52**	**1.42,1.70**	**1.60**	**1.46,1.77**	**1.60**	**1.46,1.77**
Child weight status[7]	(<0.001)		(<0.001)		(<0.001)		(<0.001)	
Underweight	**0.33**	**0.17,0.66**	**0.35**	**0.17,0.73**	**0.39**	**0.17,0.89**	**0.35**	**0.17,0.72**
Healthy weight (ref.)	1		1		1		1	
Overweight	**2.56**	**2.28,2.87**	**2.48**	**2.17,2.83**	**2.51**	**2.18,2.90**	**2.49**	**2.18,2.84**
Obese	**6.90**	**5.90,8.08**	**6.46**	**5.39,7.74**	**6.44**	**5.24,7.92**	**6.44**	**5.37,7.73**
Parental weight status[8]	(<0.001)		(<0.001)		(<0.001)		(<0.001)	
Underweight	**0.62**	**0.45,0.87**	**0.67**	**0.47,0.95**	**0.66**	**0.46,0.94**	**0.67**	**0.47,0.95**
Healthy weight (ref.)	1		1		1		1	
Overweight	**1.44**	**1.28,1.62**	**1.34**	**1.18,1.52**	**1.33**	**1.18,1.51**	**1.34**	**1.19,1.52**
Obese	**2.21**	**1.98,2.47**	**1.93**	**1.72,2.17**	**1.92**	**1.71,2.16**	**1.93**	**1.72,2.18**
Sex x ethnic background					(0.228)		(0.444)	
Female x White (ref.)					1		1	
Female x South Asian					0.72	0.47,1.10		
Female x Indian							0.99	0.55,1.80
Female x Pakistani							0.63	0.35,1.14
Female x Bangladeshi							0.56	0.26,1.20
Female x Black					0.96	0.54,1.68		
Female x Black Caribbean							0.98	0.48,2.02
Female x Black African							0.66	0.28,1.57
Female x Other Black							1.72	0.19,15.4
Female x Mixed and Other					0.77	0.50,1.19		
Female x Other Asian							0.47	0.16,1.37
Female x Chinese and other							0.88	0.23,3.37
Female x Mixed							0.81	0.47,1.38
Child weight status x ethnic background					(0.406)			
Underweight x South Asian					-	-		
Underweight x Black					-	-		
Underweight x Mixed and Other					2.39	0.38,15.1		

Healthy weight x White (ref.)			1		
Overweight x South Asian			0.74	0.42,1.32	
Overweight x Black			0.69	0.22,2.19	
Overweight x Mixed and Other			1.23	0.57,2.63	
Obese x South Asian			0.83	0.47,1.47	
Obese x Black			2.86	0.93,8.78	
Obese x Mixed and Other			0.83	0.35,1.99	

[1]Mutually adjusting for ethnic background, sex, age five weight status and parental weight status. [2]Mutually adjusting for ethnic background, sex, age five weight status, parental weight status as well as two interaction terms: 1) sex x ethnic background 2) age five weight status x ethnic background. [3]Mutually adjusting for ethnic background, sex, child weight status, parental weight status, and an interaction between sex and ethnic background. [4]Odds ratio and p*-value for corresponding Wald test statistic. [5]95% confidence interval. [6]Ethnic background of the child categorised using UK 2011 Census categories. [7]Child weight status based on ethnic-adjusted BMI categorised according to UK90 clinical reference standard. [8]Parental weight status was categorised using BMI calculated from parental self-reported weight and height as follows: "underweight" (BMI<18.5kg/m^2), "healthy weight" (≥18.5 to <25kg/m^2), "overweight" (≥25 to <30kg/m^2) or "obese" (≥30kg/m^2), except for South Asian adults where "overweight" is ≥23 to <27.5kg/m^2 and "obese" is ≥27.5kg/m^2. Cells in bold font indicate the estimate is statistically significantly different to the reference category.*

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1-2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-8
Bias	9	Describe any efforts to address potential sources of bias	8-9
Study size	10	Explain how the study size was arrived at	6 (and Fig S1)
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6-8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8-9
		(*b*) Describe any methods used to examine subgroups and interactions	9
		(*c*) Explain how missing data were addressed	8
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	9
		(*e*) Describe any sensitivity analyses	9
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6 (and Fig S1)
		(b) Give reasons for non-participation at each stage	6 (and Fig S1)
		(c) Consider use of a flow diagram	Fig S1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9
		(b) Indicate number of participants with missing data for each variable of interest	6-8
Outcome data	15*	Report numbers of outcome events or summary measures	6-7
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10 (and Table 4)
		(*b*) Report category boundaries when continuous variables were categorized	8
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	11
Discussion			
Key results	18	Summarise key results with reference to study objectives	11-12
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	13
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	13-16
Generalisability	21	Discuss the generalisability (external validity) of the study results	15-16
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	16

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Does parental concern about their child's future risk of overweight vary by their ethnic background? Cross-sectional analysis of a national cohort study

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Does parental concern about their child's future risk of overweight vary by their ethnic background? Cross-sectional analysis of a national cohort study

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Key words:

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Abstract

Objectives

Children from South Asian ethnic backgrounds are at increased risk of obesity and its associated future health risks, however evidence is lacking as to whether parental concern about their child's future overweight risk varies by ethnic background. We hypothesised that parents of five-year-old children from South Asian backgrounds would be more likely to express such concerns.

Design: Cross-sectional

Setting: United Kingdom

Participants: 15,039 singleton five-year-old Millennium Cohort Study participants (48.9% girls; 86.7% White).

Primary outcome measure: Parent-reported concern (some/none) about future overweight risk.

Methods

We estimated the adjusted odds ratios (aOR) of some parental concern (ranging from a little to very concerned) by child's ethnic background (reference group: White), adjusted for parent and child weight status, and child sex.

Results

Parents of girls from Pakistani (aOR; 95%CI: 0.4; 0.2,0.5), Bangladeshi (0.3; 0.2,0.5), Black African (0.5; 0.3,0.7) and Mixed (0.7; 0.5,0.99) ethnic backgrounds and of boys from Pakistani ethnic backgrounds (0.6; 0.4,0.9) were less likely to report concern about their child's future overweight risk than parents of White girls and boys, respectively. Overweight (2.5; 2.2,2.8) and obesity (6.7; 5.7,7.9) in children, and overweight (1.4; 1.2,1.5) and obesity (1.9; 1.7,2.2) in parents, were associated with increased likelihood of concern.

Conclusions

Parents of children from South Asian and Mixed ethnic backgrounds express less concern about their child's future overweight risk, despite their higher risk of obesity and obesity-related diseases. Qualitative studies are needed to understand the concerns of parents from different ethnic backgrounds to inform weight-management interventions in ethnically-diverse populations.

Article summary

Strengths and limitations of the study

- We used robust statistical methods to analyse a large, nationally representative cohort of children from diverse ethnic backgrounds, allowing examination of parental concern across ten ethnic groups
- We adjusted for factors known to be associated with increased parental concern, including child weight status, using clinical definitions of overweight and obesity, and applied ethnic-specific BMI adjustments for more accurate assessment of body fatness in children from South Asian and Black backgrounds.
- We were unable to apply adjustments to the BMI of children from Mixed and Other ethnic backgrounds because validated algorithms to adjust BMI among children from these groups are not available.
- Responses to the parental concern question are unlikely to be influenced by the study child weight measurement as weight was recorded after this question was answered and no interpretation or categorisation of BMI was provided to parents. As our study was cross-sectional, we are unable to determine the temporal association between concern and weight status.
- Some children may have been weighed prior to interview at home, or in clinic, schools or other settings and this might have influenced parental concern, however this information was not available.

Abbreviations

BMI – body mass index

UK – United Kingdom

MCS – Millennium Cohort Study

CI – confidence interval

OR – odds ratio

NCMP – National Child Measurement Programme

FMI – fat mass index

Introduction

In England more than a quarter of children currently leave primary school with a body mass index (BMI) indicating they are overweight or obese, at a level needing clinical weight management support.[1] These proportions vary by ethnic background, and, after adjustment to account for ethnic variation in body fat mass, are significantly higher among children from South Asian backgrounds, especially boys.[2] This has important implications for their future health, as children from South Asian backgrounds are known to be biologically more susceptible to the harms of overweight, and are at higher risk of developing type two diabetes and cardiovascular disease in adulthood.[3-5]

It has been suggested that parental concern about their child becoming overweight in the future may be a meaningful predictor of willingness to engage in behaviour change.[6,7].

Among parents of children whose BMI is in the overweight or obese range, there is evidence of increased parental concern about both their child's present weight status[8-11] and about their child becoming overweight in the future[12] relative to those whose children have a healthy weight BMI. Furthermore, it has been shown that parents express higher levels of this concern about current[13,14] and future[15,16] weight status for daughters with overweight or obesity than for sons,[13-16] as well as if they themselves have a BMI categorised as overweight or obese.[12,16] There is only very limited evidence regarding ethnic variation in parental concern, with lower levels of concern for current childhood overweight reported in one study of parents from Black Somali backgrounds living in Liverpool,[8] and greater concern about future child overweight from another study of parents from Black Afro-Caribbean backgrounds living in London,[17] with others reporting no differences.[12]

However, these findings are based on regional studies with low response rates and consequently small sample sizes. Moreover, none adjusted BMI for ethnicity and few specifically examine parental concern about future child overweight (as opposed to current child weight status), warranting further investigation.

Across the UK, children's heights and weights are measured on or shortly after entry to primary school at age five years. Following measurement, parents receive a feedback letter informing them of their child's weight status. Given the longitudinal evidence that obesity at the beginning of primary school strongly predicts obesity on leaving primary school,[18,19] age five may be viewed as an appropriate time to intervene to prevent and tackle obesity. It is therefore important to understand how parental concern about future childhood overweight might relate to weight status at this point in the life course.

We used cross-sectional data from a large ethnically diverse UK-wide cohort study to examine whether parental concern about their child's future risk of overweight, reported when the child was aged five years, varied by ethnic background. Given the high rates of overweight and obesity observed among children from South Asian backgrounds after adjustments for body fat,[2] and having taken parent weight status and child sex into account, we hypothesised that parents of overweight and obese children from South Asian backgrounds would be more concerned about their child becoming overweight in the future relative to parents of children from White backgrounds.

Materials and methods

Study design

We used data from the Millennium Cohort Study (MCS), a prospective nationally representative cohort of children born between September 2000 and January 2002 in the UK, which used a stratified clustered sampling design to over-represent children born in disadvantaged areas, from ethnic minority groups or from Northern Ireland, Scotland and Wales. When the cohort child was aged nine months, 18,552 (68%) of 27,257 families contacted were interviewed at home when demographic, social and health information was obtained. An additional 692 families were recruited at age three. Further interviews were conducted when children were aged three, five, seven, 11 and 14 years, when height and weight were measured. At age five, 15,246 (85.8%) of 17,770 families eligible for interview were interviewed, providing data for 15,459 children (Figure S1).

Inclusion and exclusion criteria

We included 15,039 of 15,459 singleton children whose parent (natural mother (97.0%), else child's main care-giver, all referred to hereafter as the parent) was interviewed when their child was aged five years, having excluded 418 twins and triplets, as well as two children with extreme height and/or weight measures at age five or missing ethnicity (Figure S1). We extracted information available for these children from their two earlier and two subsequent MCS interviews. Characteristics of those who did and did not participate in the age five interview are given in Table S1; participating children were more likely to be from families in the highest income quintiles and to have more highly educated mothers compared to non-participating children. We weighted all analyses to take account of survey design and to allow for potential ethnic and socioeconomic biases in cohort attrition by age five years.

Main Outcome measure

The main outcome measure was parental concern about their child's future risk of becoming overweight. This was assessed at the age five interview from responses to a question administered by a trained interviewer who asked the parent "How concerned are you about [child's name] becoming overweight in the future?" We followed the methods applied by others[12,14-16] and derived a binary variable from the five possible responses as follows: parents reporting they were unconcerned (n=10,964), were categorised as "no parental concern", with all other responses (a little concerned (n=2,645), concerned (n=540), fairly concerned (n=390), very concerned (n=418)) categorised as "parental concern". Response to this question was missing for 82 parents.

Main exposure variable

Ethnic background of the child was obtained from parental report at the first MCS interview and categorised using UK 2011 Census categories. Analyses were based on ten individual Census categories, with the exception of some analyses where individual ethnic groups were too small to

create 95% confidence intervals (CI) when categories which were grouped as follows: White (Irish, Traveller, Other), South Asian (Indian, Pakistani, Bangladeshi), Black (Black Caribbean, Black African, other Black), Mixed and Other (Other Asian, Chinese, Mixed, Other).[20]

Covariates

We examined two covariates: child weight status and parental weight status. At age five years, trained interviewers in the home measured the child's height and weight: height was recorded to the nearest millimetre using a Leicester Height Measure Stadiometer (Seca Ltd, Birmingham, UK) with the head positioned in the Frankfort plane. Children were weighed barefoot and without outdoor clothing on Tanita HD-305 scales (Tanita, UK Ltd, Middlesex, UK) and weight recorded in kilograms to one decimal place.[21]

To enable comparison with the current English child measurement programme, we used published guidance from Public Health England[22] to assess the quality and range of height and weight measurements. We excluded one child with extreme short stature, and in addition assigned measurements in two children with extreme weight values as missing, as these were assumed erroneous when compared with their earlier or subsequent MCS measurements.

BMI at age five was calculated and adjusted for ethnicity using methods described by Hudda et al. who used similar ethnic categories to those employed in this study.[23] The authors pooled data from four UK studies which used the deuterium dilution method to measure body fat in approximately 2,000 children from White European, South Asian and Black African backgrounds. They derived a height-standardised fat mass index (FMI) to represent body fat and fitted linear regression models to quantify ethnic differences in BMI-FMI relationships to provide ethnic-specific BMI adjustments. This adjustment entails adding approximately 1.1kg/m^2 to the BMI of children from South Asian backgrounds, and subtracting between -0.12kg/m^2 and -5.52kg/m^2 dependent upon sex, age group and unadjusted BMI to the BMI of children from Black backgrounds to more accurately reflect adiposity in these groups since it has been shown that BMI overestimates and underestimates body

fat in children from Black and South Asian backgrounds, respectively. No adjustment is available to apply to children from Mixed or Other ethnic backgrounds.

We categorised the adjusted BMI according to the UK1990 clinical reference standard,[24] into four mutually exclusive groups: "underweight" (BMI<2nd centile), "healthy weight" (≥2nd to <91st centile), "overweight" (≥91st to <98th centile) or "obese" (≥98th centile) based on alignment with sex- and age-specific BMI centiles from the LMS growth tool Excel add-in.[25,26] We defined those with BMI ≥98th centile or ≥91st to <98th centile as clinically obese and clinically overweight respectively. The UK90 clinical reference standard uses higher thresholds to define overweight and obesity compared to the UK90 population reference standard, indicating the need for clinical support for weight management. These thresholds are used by a variety of health professionals to assess individual children, as opposed to the UK90 population thresholds which are used to monitor population prevalence of overweight and obesity.[24]

Parental BMI was calculated using the parent's self-reported weight (at the age five sweep) and their most recent self-reported height (usually recorded at the first contact sweep). Trained interviewers measured parental heights and weights objectively if they did not know their measurements for self-report. Parental BMI was categorised into four mutually exclusive groups: "underweight" (BMI<18.5kg/m^2), "healthy weight" (≥18.5 to <25kg/m^2), "overweight" (≥25 to <30kg/m^2) or "obese" (≥30kg/m^2). Due to the higher risk of type two diabetes and cardiovascular disease among adults from Asian backgrounds at a BMI lower than 25kg/m^2, lower thresholds for classifying overweight and obesity in South Asian adults were employed, where "overweight" is considered ≥23 to <27.5kg/m^2 and "obese" as ≥27.5kg/m^2, based on National Institute for Health Care Excellence guidelines.[27]

Statistical methods

Response to the parental concern question was missing for 82 children. All children for whom consent was obtained from a parent or guardian and who could stand unaided had their height and

weight measured.[21] Height was missing for 235 and weight was missing for 234 five year-olds (both height and weight were missing for 218 five year-olds). BMI was missing for 2,456 parents. We used multiple imputation to estimate missing data on parental concern, child height and weight at age five, and parental BMI, and built 20 imputed datasets using the weighted iterative chain algorithm,[28] including all variables involved in the analysis steps under the assumption that missingness is at random (Table S2). All analyses were carried out on imputed datasets, and sensitivity analyses on complete-cases.

We used descriptive statistics (proportions and 95% confidence intervals) to assess the prevalence of parental concern overall, and by sex, ethnic background, child weight status and parental weight status. Similarly, we examined associations of child's weight status with parental concern by sex and ethnic background. We used logistic regression to estimate the unadjusted odds of a parent being concerned about their child being overweight in the future by child's ethnic group, sex, weight status and parental weight status (reported as odds ratios [OR]). We then mutually adjusted for child's ethnic background, sex and child and parent weight status. We tested for interactions between the child's ethnic background and sex, and between child's ethnic background and weight status and used Wald test statistics for these interaction terms to inform the final logistic regression model. We derived sex- and ethnic-specific odds ratios by multiplying the interaction term coefficient by the ethnicity coefficient and plotted these in a forest plot.

All analyses and percentages cited were performed in Stata and weighted to take account of survey design and to allow for potential biases in attrition by age five years, using the `svyset` command (Stata/SE 15; Stata Corporation, Texas, USA).

Ethics approval

Approval for MCS was granted by the London Research Ethics Committees[29] and no further approval was required for this secondary analysis.

Patient and public involvement

This research was done without patient or public involvement. Neither were invited to comment on the study design and were not consulted to develop relevant outcomes or interpret results.

Results

Sample characteristics

Of 15,039 children, 48.9% were girls, 86.7% were from White, and 6.1% from South Asian, backgrounds (Table 1). Parental concern about their child becoming overweight in the future was reported by 27.3% of parents (17.7% 'a little concerned', 3.5% 'concerned', 2.6% 'fairly concerned', 2.6% 'very concerned'), and this was more common among parents of girls than of boys (Table 1).

Parental concern

Parental concern was strongly associated with child's BMI status, and was more common among parents of children with overweight or obesity (42.3% and 66.2% respectively) than among parents of children with a healthy weight (22.3%; Table 1). Similarly, parental concern was more likely to be reported by parents with overweight or obesity: 29.9% and 39.7%, respectively, compared to parents with a healthy weight (22.7%; Table 1).

Parental concern was reported significantly less among parents of children from Pakistani (20.9%) and Black African (20.1%) backgrounds, compared to parents of children from White ethnic backgrounds (27.8%; Table 1).

Overweight and obesity prevalence by ethnic background and sex

At age five, the prevalence of overweight and obesity was 11.0% and 6.6%, respectively, with obesity more prevalent among boys (7.5%) than girls (5.7%) (Table 2; parent weight status was positively associated with child weight status, see Table S3).

Within each ethnic group, most five-year-old children were of healthy weight, however children from South Asian backgrounds were more likely to have a BMI in the obese range than children from White backgrounds (Table 2). There were some minor differences by sex, with boys from South Asian backgrounds and girls from Pakistani and Bangladeshi backgrounds more likely to have a BMI in the obese range than those from White backgrounds (Table 2).

Parental concern by ethnic background and sex

Fewer parents of girls from Pakistani, Bangladeshi or Black African backgrounds reported parental concern relative to parents of girls from White backgrounds. These differences were not seen in boys (Table 3).

Parental concern by weight status, ethnic background and sex

Parental concern was reported for 73.4% of girls with obesity compared with 61.0% of boys with obesity (Table 4).

Parental concern was reported by fewer parents of healthy weight, overweight and obese girls from South Asian backgrounds compared to parents of girls from White backgrounds (Table 4). No differences in parental concern by weight status were observed between boys from different ethnic backgrounds (Table 4).

Logistic regression analyses

After mutual adjustment for ethnic background, sex and child and parent weight status, parental concern was significantly less likely among children from Pakistani, Bangladeshi and Black African ethnic backgrounds. Parental concern was more likely among parents of overweight and obese children, as well as among parents who themselves were overweight or obese (Table 5 'Adjusted' model).

As the Wald test statistic for an interaction between sex and ethnic background was significant, the final adjusted model included this interaction term (other interactions were not significant and were

excluded from the final model, see Table S4). The sex- and ethnic-specific odds accounting for this interaction are shown in Table 5 and Figure 1, using White ethnic background as the reference category.

Parents of boys from Pakistani backgrounds were less likely to be concerned about their child's future risk of being overweight (Figure 1), as were parents of girls from Pakistani, Bangladeshi, Black African, Mixed or Other ethnic backgrounds.

In the final model, parental concern about future childhood overweight was more likely among parents of children with overweight and obesity, and less likely among parents of children considered underweight, compared to parents of children with a healthy weight (Figure 1). Parents who themselves had a BMI in the overweight or obese range were more likely, and those with a BMI considered underweight less likely, to report concern than those with a healthy weight (Figure 1).

Findings were similar for complete case analyses (with the exception of the interaction between female sex and Bangladeshi ethnic background; Table S5) and for BMI without ethnic-adjustment (data not shown).

Discussion

Principal findings

In this large nationally representative study, we found that, despite their greater risk of obesity and future obesity-related complications, parents of children from South Asian backgrounds were less likely to be concerned about their child's future overweight risk, compared to those from White backgrounds. This was particularly so for girls from Pakistani and Bangladeshi backgrounds, and was independent of child and parent weight status. Furthermore, among our total sample of more than 15,000 children, we confirmed associations between parental concern and child sex and weight status reported by others.

Increased understanding of the context in which people from different ethnic backgrounds report parental concern is important to inform the development of interventions to support parents and families to alter the weight trajectories of their children with overweight or obesity. This is especially important for children from South Asian backgrounds, given their higher absolute risk of obesity and greater metabolic sensitivity to its effects. Our findings make a significant contribution to the literature on parental concern. This is to our knowledge the first study to use a UK-wide nationally representative cohort to examine whether parental concern about future risk of overweight in their child varies by ethnic background.

Strengths and limitations

Strengths of our study include analyses based on a large, nationally representative cohort of children from diverse ethnic backgrounds, allowing examination of parental concern across ten ethnic groups. Our findings are generalisable to the UK supporting the nationally representative nature of the MCS: both the prevalence of overweight and obesity and the proportions of children from each ethnic background at age five in this cohort are similar to that reported from Public Health England's National Child Measurement programme (NCMP) for the 2006/07 academic year, when most children included in this study were aged five years.[30,31]

We used robust statistical methods including imputation of missing data and use of survey weights to account for survey design and to allow for biases in attrition. We used a clinical definition of overweight and obesity that indicates the need for clinical weight management support, and applied ethnic-specific BMI adjustment for more accurate assessment of body fatness in children from South Asian and Black ethnic backgrounds. While this method of adjusting children's BMI is not currently employed in the NCMP, which may make comparisons with other studies less straightforward, analyses without ethnic-adjustment produced similar findings.

We were able to adjust for a number of covariates in our analysis including those shown previously to be strongly associated with parental concern, including parental and child weight status (the

latter based on objective measurements). Responses to the question eliciting parental concern are unlikely to be influenced by the MCS weight measurement as this question was asked before the child was weighed, and furthermore no interpretation or categorisation of BMI was provided in the feedback to parents.[29]

Although it is possible that some children may have been recently weighed either at home, in clinical care or in school as part of the NCMP, information on the timing of this in relation to the MCS interview, or the feedback given to parents, is unavailable. The MCS interview did not ask parents about their perception of their child's weight status at age five and consequently we were unable to adjust for this in our final model. Furthermore, given the cross-sectional design of this study, we are unable to draw any conclusions about the temporal relationship between parental concern and child weight status.

As one in seven children in this study were from Black, South Asian and Other ethnic backgrounds, we were able to examine parental concern across all major ethnic groups; however, absolute numbers for some groups were small, resulting in greater uncertainty for these estimates.

We used lower thresholds for overweight and obesity to categorise BMI in adults from South Asian backgrounds to reflect the higher risk of type two diabetes and cardiovascular disease at lower levels of BMI experienced among these adults.[27] Although parental height and weight were self-reported, this is considered a reliable measure in epidemiological studies.[32,33] Furthermore, at present there are no validated algorithms for the adjustment of BMI for children from Mixed and Other ethnic backgrounds so no adjustments were made for these children in our analyses. Although we lacked statistical power to evaluate all subcategories of parental concern, we used the approach others have taken using this instrument and dichotomised parental concern into "concern" or "no concern" in order to produce robust estimates when examining parental concern by sex and ethnic background.[12,14-16]

Other studies

There are to our knowledge no other published reports examining ethnic variation in parental concerns about their child's future risk of becoming overweight using a UK-wide nationally representative cohort of children. Our finding of less parental concern among parents of girls from Black African backgrounds is similar to that reported for parents from Black Somali backgrounds in Liverpool,[8] but not consistent with those from a regional study which observed greater parental concern among parents from Black Afro-Caribbean backgrounds living in London.[17]

The explanations for our main finding that parents of boys and girls from South Asian backgrounds and of girls from Black backgrounds are less concerned about their child's future risk of becoming overweight compared to parents of children from White backgrounds warrant further investigation. This finding may reflect differences in awareness of children's weight status or perceptions of childhood weight and size among parents from different ethnic backgrounds. However, it may be more useful to explore the wider context and barriers which children and their families from different ethnic backgrounds face in negotiating healthy or "ideal" weight so that interventions can be considered which reflect the diverse ethnic backgrounds of children with obesity in the UK.

Many parents are unable to identify overweight or obesity in their children,[15,34,35] with the majority of parents of children with a BMI in the overweight or obese range underestimating their child's weight status,[12,36] a finding replicated in numerous high income countries across the world.[35,37,38] While there is some evidence that recognition of overweight or obesity is difficult among adults from South Asian backgrounds,[39] the reasons for this remain unclear and similar studies in children are lacking.

While parental recognition of child overweight or obesity can be helped by presenting them with child age- and sex-specific body images,[40] these have not been tested among parents from different ethnic backgrounds. Furthermore, we did not find any evidence to suggest that parental concern about child future overweight risk among children from different ethnic backgrounds varied by objectively measured child weight status.

Qualitative research provides important contextual information about South Asian parents and their extended families. Pallan et al. have highlighted the importance of intergenerational influences on child diet and perception of their weight status, suggesting that fatness may signal health and that provision of abundant food may symbolise parental/carer affection for the child.[41] This may be important for families relying on grandparents for informal childcare, and multi-generational households where meals are communally prepared and eaten.[41,42] For example, studies of women from Pakistan living in North West England and an ethnically diverse sample of families in London have both reported that in these groups, familial expectations to maintain traditional home-cooking procedures are obstacles to changing food preparation and eating practices.[42] Similarly, qualitative research involving women from Somalia living in Liverpool found that many women felt restricted in their efforts to live healthier lifestyles by older relatives' perspectives which promote increased weight, although this study did not focus on the influence of the home environment on their child's weight status,[43] highlighting differences between people from different ethnic backgrounds.

There is evidence that acculturation can alter maternal health behaviours with the adoption of potentially less healthy behaviours by migrants over time.[44] We did no set out to examine structural barriers or acculturation amongst migrants in this study and further research to explore intergenerational variation in parental concern about future childhood overweight is required.

Our finding that a greater proportion of parents of girls compared to parents of boys from White backgrounds were concerned about their child becoming overweight in the future is consistent with findings from other UK studies of predominantly White populations[13-15] and with one from Australia.[16] This may reflect societal expectations of "ideal" body shapes for boys and girls[14] whereby girls are expected to be slight or petite, and boys to be bigger, stronger or more muscular.[45] Findings from a qualitative study interviewing parents of pre-school aged children in America suggest that childhood overweight is normalised through the use of euphemistic terms like 'cute baby fat' or 'podge',[46] and discussions of body size relate to how 'big', 'strong' or 'muscular' the child is.[47] Other

studies have suggested that parents are less worried about their child's weight status because they believe their child participates in an appropriate level of physical activity and/or eats a balanced or healthy diet.[47,48]

Given these accounts, parents from different ethnic backgrounds may experience social contexts where monitoring child weight is not a priority, particularly in environments where higher weight is a signal of wellness, health and affection for the child. Similarly, given that people from ethnic minority backgrounds, particularly from Pakistan and Bangladesh, are more likely than White British people to live in the most deprived areas in England,[49] it is possible parents prioritise providing for their family over parental concern about future childhood overweight, a less immediate concern. This view is supported by literature which suggests that the future may be perceived differently depending upon personal circumstances, such that concepts of 'public health futures' are not applicable to all individuals.[50]

Our finding that concern was reported more often for children with overweight and obesity is consistent with previously published reports.[9,12-15] Our findings are similar to those of Carnell et al. who used the same question and response scale but did not examine the influence of ethnicity on this association.[12] Parents may be better able to identify their child's weight status at the extreme end of obesity[14,15] indicating that, to some extent, parents are aware of overweight in their children. Inability to assess correctly their child's weight may be a barrier to prevention of childhood obesity,[13,14,51] since lifestyle changes are not initiated,[36,52] however Carnell et al. have argued that parental concern is a more sensitive indicator of parental awareness of child weight status than correct parental identification of a child's weight status. Our finding of a strong positive association between parental concern and child weight status offers empirical evidence which could be used to investigate this latter view.

The temporality of this relationship however remains unclear as our study was cross-sectional. Whilst it seems plausible that parents are more likely to report concern because their children are

already overweight, a range of studies, predominantly from Australia[53-55] and the United States[56-60] as well the UK[61] and Sweden,[62] have proposed that parents reporting concern about their child becoming overweight might be more likely to engage in behaviours such as restrictive feeding, where children's food is controlled and limited.

Longitudinal research has suggested that restrictive feeding practices can result in child weight gain. A prospective study of Australian children aged two years suggests restrictive feeding practices lead to obesogenic behaviours such as overeating,[63] whilst in the United States a study of five to seven year-olds showed a positive association between restrictive feeding and additional weight gain among children at risk of obesity.[64] Two further longitudinal studies in the United States showed restrictive feeding practices were associated with increased eating in the absence of hunger among girls aged five to nine years.[65,66]

With this in mind and given the cross-sectional nature of our study, our findings require careful interpretation: whilst it is possible parental concern is a response to child overweight, it remains that child overweight could be in part driven by parental concern and associated feeding practices.

Whether parental feeding practices vary by ethnic background is largely unknown,[67] but remains an important research question particularly as it has been suggested that there may be benefits to restrictive feeding for older, more overweight children but less so for younger, healthy weight children who are yet to develop their eating behaviours.[67] One study comparing feeding practices in Germany and Britain found that parents from Black Afro-Caribbean backgrounds living in Britain were more likely to use restrictive feeding practices than parents from White backgrounds living in either Britain or Germany, and this was associated with higher child BMI.[68] Further research is needed to understand how social context and ethnic backgrounds might influence parents' feeding practices.

Implications for policy and practice

Our study has implications for practice and research. Our cross-sectional analyses confirmed a strong positive association between the child's current weight status and parental concern, suggesting parents of children with a BMI in the overweight and obese range are more likely than other parents to be concerned about their child's future overweight risk. This is important, given the suggestion that appropriate parental concern is vital for effective parental engagement with obesity intervention programmes[6] and positive behaviour change.[7] Further research is needed to determine whether parental concern is associated with healthier weight trajectories, as well as to understand how feedback given to parents about their child's weight status from the NCMP can be appropriately and accurately conveyed to parents from different ethnic backgrounds.

Our study also has implications in particular for targeted interventions aimed at childhood obesity prevention and management. Parents from particular ethnic backgrounds at higher risk of obesity are less likely to express concern about future childhood overweight, particularly so for girls. This needs to be taken into account in developing ethnically sensitive interventions for weight management of children with obesity in multi-ethnic populations. As with all complex interventions, these need to be informed by qualitative studies to elucidate the factors underlying these novel observed differences in rates of parental concern among participants from different ethnic backgrounds, and to aid their interpretation.

Conclusion

In summary, we have found that, in contrast to our original hypothesis and after taking into account child and parental weight status, parents of children from South Asian ethnic backgrounds who are at higher risk of childhood obesity and its adverse consequences are less likely to report concern for their child's future overweight risk, particularly for their daughters. These novel insights are of importance to the UK population, where the highest risk of obesity is observed in individuals and communities from these backgrounds.

Table 1 – Sample characteristics and proportion of parents reporting parental concern

	Sample characteristics[1]		Parental concern	
	%	95% CI[2]	%	95% CI[2]
All	100		27.3	26.3,28.3
Sex				
Boys	51.1	50.2,52.1	24.1	22.8,25.4
Girls	48.9	47.9,49.8	30.7	29.4,31.9
Child weight status[3]				
Healthy weight	81.7	81.0,82.5	22.3	21.3,23.3
Overweight	11.0	10.4,11.6	42.3	39.6,45.1
Obese	6.6	6.1,7.1	66.2	62.9,69.6
Parent weight status[4]				
Underweight	3.1	2.7,3.4	15.4	11.1,19.6
Healthy weight	52.8	51.5,54.0	22.7	21.5,23.9
Overweight	27.2	26.2,28.2	29.9	28.0,31.9
Obese	16.9	16.0,17.8	39.7	37.4,42.0
Ethnic background[5]				
White	86.7	84.3,89.0	27.8	26.8,28.8
South Asian	6.1	4.3,7.8	23.5	20.5,26.5
Indian	*1.8*	*1.3,2.4*	*28.5*	*23.2,33.7*
Pakistani	*3.1*	*1.7,4.6*	*20.9*	*17.0,24.7*
Bangladeshi	*1.1*	*0.5,1.6*	*22.6*	*16.8,28.4*
Black	2.8	1.8,3.8	24.9	19.6,30.1
Black Caribbean	*1.0*	*0.6,1.4*	*32.3*	*21.9,42.7*
Black African	*1.6*	*1.0,2.3*	*20.1*	*15.5,24.7*
Other Black	*0.2*	*0.1,0.2*	*25.7*	*7.3,44.1*
Mixed and Other	4.5	3.8,5.2	24.9	20.0,29.7
Other Asian	*0.6*	*0.3,0.8*	*30.7*	*17.7,43.8*
Chinese and Other	*0.7*	*0.5,0.9*	*20.9*	*12.4,29.3*
Mixed	*3.2*	*2.7,3.7*	*24.7*	*19.2,30.1*

[1]Total N=15,039. [2]95% confidence interval. [3]Child weight status based on ethnic-adjusted BMI and categorised according to UK90 clinical reference standard. [4]Parental weight status was categorised using BMI calculated from parental self-reported weight and height as follows: "underweight" (BMI<18.5kg/m^2), "healthy weight" (≥18.5 to <25kg/m^2), "overweight" (≥25 to <30kg/m^2) or "obese" (≥30kg/m^2), except for South Asian adults where "overweight" is ≥23 to <27.5kg/m^2 and "obese" is ≥27.5kg/m^2. [5]Ethnic background of the child was obtained from parental report at the first MCS interview and categorised using UK 2011 Census categories.

Table 2 – Overweight and obesity[1] prevalence by ethnic background[2] and sex

	Boys				Girls				All			
	Overweight		Obese		Overweight		Obese		Overweight		Obese	
	%	95% CI[3]	%	95% CI[3]	%	95% CI[3]	%	95% CI[3]	%	95% CI[3]	%	95% CI[3]
White	11.7	10.8,12.6	6.9	6.2,7.6	10.1	9.2,11.1	5.4	4.7,6.0	10.9	10.3,11.6	6.1	5.6,6.6
South Asian	12.8	9.5,16.0	15.9	13.0,18.8	16.8	13.3,20.4	10.6	7.4,13.8	14.8	12.8,16.8	13.3	11.1,15.4
Indian	*9.2*	*4.8,13.6*	*17.3*	*10.7,23.9*	*18.3*	*9.8,26.8*	*6.8*	*0.9,12.6*	*13.6*	*9.1,18.1*	*12.2*	*8.1,16.3*
Pakistani	*14.1*	*9.0,19.2*	*14.0*	*10.1,18.0*	*17.7*	*13.5,22.0*	*9.5*	*6.5,12.4*	*15.7*	*13.0,18.8*	*11.8*	*9.4,14.1*
Bangladeshi	*15.3*	*7.8,22.9*	*18.8*	*11.5,26.1*	*12.1*	*6.4,17.9*	*19.7*	*11.1,28.3*	*13.8*	*10.3,17.1*	*19.3*	*14.0,24.5*
Black	5.1	2.0,8.2	8.2	3.6,12.8	6.7	2.4,10.9	5.0	0.0,10.3	5.8	4.1,8.6	6.8	2.5,11.1
Black Caribbean	*4.9*	*0.5,9.4*	*14.8*	*2.7,27.0*	*5.2*	*0.3,10.2*	*2.8*	*0.0,6.0*	*5.1*	*2.4,7.7*	*9.6*	*2.4,16.7*
Black African	*5.8*	*2.4,9.3*	*4.7*	*1.0,8.5*	*8.0*	*1.3,14.8*	*6.7*	*0.0,14.9*	*6.7*	*2.8,11.0*	*5.7*	*1.2,10.1*
Other Black[4]												
Mixed and Other	11.3	7.5,15.1	7.0	3.8,10.3	8.5	4.7,12.2	6.2	3.2,9.3	9.9	7.3,12.4	6.6	4.5,8.8
Other Asian	*3.3*	*0.1,6.5*	*9.0*	*0.0,19.3*	*2.7*	*0.2,5.2*	*1.7*	*0.0,4.0*	*3.1*	*0.9,5.1*	*5.0*	*0.0,10.3*
Chinese and Other	*8.3*	*0.0,17.0*	*5.6*	*0.0,11.5*	*6.5*	*0.4,12.6*	*6.2*	*0.0,13.5*	*7.3*	*2.5,12.2*	*5.9*	*1.2,10.7*
Mixed	*13.1*	*8.4,17.9*	*7.0*	*3.1,10.9*	*10.1*	*5.1,15.0*	*7.1*	*3.1,11.2*	*11.6*	*8.4,14.9*	*7.1*	*4.4,9.8*
Total	11.5	10.7,12.4	7.5	6.8,8.1	10.4	9.5,11.2	5.7	5.1,6.4	11.1	10.4,11.6	6.6	6.1,7.1

[1] Child weight status based on ethnic-adjusted BMI and categorised according to UK90 clinical reference standard.[2]Ethnic background of the child was obtained from parental report at the first MCS interview and categorised using UK 2011 Census categories. [3]95% confidence interval. [4]Overweight and obesity prevalence estimates not stated due to small numbers. Total N=15,039.

Table 3 – Parental concern about future overweight risk at age five years by ethnic background[1], and sex

	Boys		Girls	
	%	95% CI[2]	%	95% CI[2]
White	24.1	22.8,25.4	31.6	30.3,33.0
South Asian				
Indian	25.4	18.2,32.5	31.8	23.1,40.5
Pakistani	21.8	15.4,28.3	19.9	14.6,25.3
Bangladeshi	24.3	15.5,33.1	21.1	13.0,29.1
Black				
Black Caribbean	32.1	20.3,43.9	32.5	19.3,45.8
Black African	19.2	11.4,27.1	21.1	15.6,26.7
Other Black	26.3	3.1,49.5	24.8	0.0,54.0
Mixed and Other				
Other Asian	35.7	19.6,51.8	26.5	9.9,43.2
Chinese and Other	20.2	7.6,32.8	21.5	8.6,34.3
Mixed	23.7	16.2,31.3	25.7	19.3,32.0

[1]Ethnic background of the child was obtained from parental report at the first MCS interview and categorised using UK 2011 Census categories. [2]95% confidence interval. Total N=15,039.

Table 4 – Parental concern about future overweight risk at age five years, by child weight status[1] at age five

	Proportion of parents reporting parental concern									
	White		South Asian		Black		Mixed and Other		All	
	%	95% CI[2]	%	95% CI[2]	%	95% CI[2]	%	95% CI[2]	%	95% CI[2]
All										
Healthy weight	22.8	21.8,23.8	16.9	14.5,19.3	21.5	15.5,27.6	19.5	14.6,24.4	22.3	21.3,23.3
Overweight	43.8	40.8,46.8	28.4	22.1,34.8	30.1	6.9,53.3	39.8	25.3,54.3	42.3	39.5,45.1
Obese	67.8	63.8,71.7	51.8	44.2,59.3	72.8	58.4,87.2	70.4	55.1,85.7	66.2	62.8,69.6
Boys										
Healthy weight	19.6	18.3,21.0	16.8	13.5,20.2	18.1	13.0,23.2	17.6	11.3,23.8	19.3	18.0,20.6
Overweight	34.2	30.1,38.3	25.9	16.4,35.4	46.7	20.4,72.9	46.6	25.9,67.3	34.5	30.8,38.3
Obese	61.4	56.1,66.7	51.4	41.6,61.2	55.6	31.8,79.3	70.7	47.9,93.4	61.0	56.6,65.4
Girls										
Healthy weight	26.0	24.7,27.3	17.0	13.6,20.3	23.6	17.7,29.6	21.3	15.4,27.3	25.3	24.1,26.5
Overweight	55.4	51.2,59.5	30.5	21.6,39.4	37.2	10.2,64.3	30.7	11.7,49.7	51.4	47.2,55.6
Obese	76.3	70.5,82.1	52.3	40.5,64.1	72.9	39.7,100.0	70.1	48.1,92.1	73.4	68.4,78.6

[1]Underweight groups omitted due to small numbers. Child weight status based on ethnic-adjusted BMI and categorised according to UK90 clinical reference standard. [2]95% confidence interval. Total N=15,039.

Table 5 – Unadjusted, adjusted and sex- and ethnic-specific adjusted odds of parental concern about future overweight risk at age five years

	Unadjusted		Adjusted[1]		Model with interaction term[2]		Sex- and ethnic-specific adjusted odds[3]			
							Boys		Girls	
	OR (*p*-value)[4]	95% CI[5]	OR (*p*-value)[4]	95% CI[5]	OR (*p*-value)[4]	95% CI[5]	OR[4]	95% CI[5]	OR[4]	95% CI[5]
Ethnic background[6]	(0.008)		(<0.001)		(0.057)					
White (ref.)	1		1		1		1		1	
South Asian										
Indian	1.04	0.80,1.35	0.80	0.60,1.09	0.77	0.52,1.14	0.77	0.52,1.14	0.84	0.54,1.30
Pakistani	**0.69**	**0.54,0.87**	**0.46**	**0.34,0.61**	**0.59**	**0.38,0.91**	**0.59**	**0.38,0.91**	**0.36**	**0.24,0.53**
Bangladeshi	0.76	0.54,1.06	**0.43**	**0.31,0.61**	0.62	0.38,1.01	0.62	0.38,1.01	**0.32**	**0.21,0.48**
Black										
Black Caribbean	1.24	0.77,1.99	1.15	0.73,1.80	1.25	0.78,2.00	1.25	0.78,2.00	1.05	0.56,1.94
Black African	**0.66**	**0.49,0.87**	**0.61**	**0.44,0.84**	0.77	0.46,1.28	0.77	0.46,1.28	**0.49**	**0.32,0.74**
Other Black	0.90	0.34,2.36	1.17	0.43,3.20	1.36	0.37,5.04	1.36	0.37,5.04	0.94	0.20,4.48
Mixed and Other										
Other Asian	1.15	0.62,2.14	1.28	0.66,2.48	2.00	0.99,4.05	2.00	0.99,4.05	0.88	0.34,2.27
Chinese and other	0.69	0.41,1.14	0.66	0.39,1.10	0.79	0.33,1.89	0.79	0.33,1.89	0.57	0.28,1.14
Mixed	0.85	0.64,1.14	0.81	0.60,1.09	0.96	0.63,1.46	0.96	0.63,1.46	**0.69**	**0.48,0.99**
Sex	(<0.001)		(<0.001)		(<0.001)					
Male (ref.)	1		1		1					
Female	**1.39**	**1.28,1.51**	**1.52**	**1.40,1.65**	**1.59**	**1.46,1.73**				
Child weight status[7]	(<0.001)		(<0.001)		(<0.001)		**OR[4]**		**95% CI[5]**	
Underweight	**0.32**	**0.16,0.64**	**0.34**	**0.17,0.68**	**0.34**	**0.17,0.68**	**0.34**		**0.17,0.68**	
Healthy weight (ref.)	1		1		1		1			
Overweight	**2.56**	**2.28,2.87**	**2.47**	**2.19,2.78**	**2.47**	**2.20,2.79**	**2.47**		**2.20,2.79**	
Obese	**6.84**	**5.84,8.01**	**6.70**	**5.68,7.90**	**6.71**	**5.68,7.93**	**6.71**		**5.68,7.93**	
Parental weight status[8]	(<0.001)		(<0.001)		(<0.001)					
Underweight	**0.62**	**0.44,0.87**	**0.68**	**0.48,0.96**	**0.68**	**0.48,0.97**	**0.68**		**0.48,0.97**	

Healthy weight (ref.)	1		1		1			
Overweight	**1.46**	**1.30,1.63**	**1.35**	**1.20,1.52**	**1.35**	**1.20,1.52**	**1.35**	**1.20,1.52**
Obese	**2.24**	**2.01,2.50**	**1.94**	**1.72,2.19**	**1.94**	**1.72,2.19**	**1.94**	**1.72,2.19**
Sex x ethnic background					(0.087)			
Female x White (ref.)					1			
Female x South Asian								
Female x Indian					1.09	0.61,1.96		
Female x Pakistani					0.61	0.33,1.13		
Female x Bangladeshi					**0.51**	**0.28,0.94**		
Female x Black								
Female x Black Caribbean					0.84	0.46,1.53		
Female x Black African					0.63	0.31,1.28		
Female x Other Black					0.69	0.09,5.28		
Female x Mixed and Other								
Female x Other Asian					0.44	0.17,1.15		
Female x Chinese and Other					0.72	0.22,2.32		
Female x Mixed					0.72	0.44,1.18		

[1]Mutually adjusting for ethnic background, sex, age five weight status and parental weight status. [2]Mutually adjusting for ethnic background, sex, child weight status, parental weight status, and an interaction between sex and ethnic background. An interaction between child weight status and ethnic background was tested but deemed not statistically significant so was excluded from the final model (see Table S4). [3]Calculated by multiplying the interaction coefficient with ethnicity coefficient in the model with the interaction term. Mutually adjusting for ethnic background, sex, age five weight status and parental weight status. [4]odd ratio (and p*-value for corresponding Wald test statistic). [5]95% confidence interval. [6]Ethnic background of the child categorised using UK 2011 Census categories. [7]child weight status based on ethnic-adjusted BMI categorised according to UK90 clinical reference standard. [8]Parental weight status was categorised using BMI calculated from parental self-reported weight and height as follows: "underweight" (BMI<18.5kg/m^2), "healthy weight" (≥18.5 to <25kg/m^2), "overweight" (≥25 to <30kg/m^2) or "obese" (≥30kg/m^2), except for South Asian adults where "overweight" is ≥23 to <27.5kg/m^2 and "obese" is ≥27.5kg/m^2. Cells in bold font indicate the estimate is statistically significantly different to the reference category.*

Figure 1 – Adjusted odds of parental concern about future childhood overweight[1]

[1] Mutually adjusted for ethnic background, sex, child weight status, parent weight status and an interaction between sex and ethnic background.

Conflicts of interest

The authors declare no conflict of interest.

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Author statement

NF and CD conceptualised and designed the analysis. NF carried out the literature search, conducted and interpreted the analyses, generated tables and figures and drafted the initial manuscript. CD contributed to the interpretation of analyses and reviewed and revised the manuscript. All authors were involved in writing the paper and had final approval of the submitted and published versions.

Data statement

The MCS data for surveys 1-6 can be downloaded from the UK Data Service.

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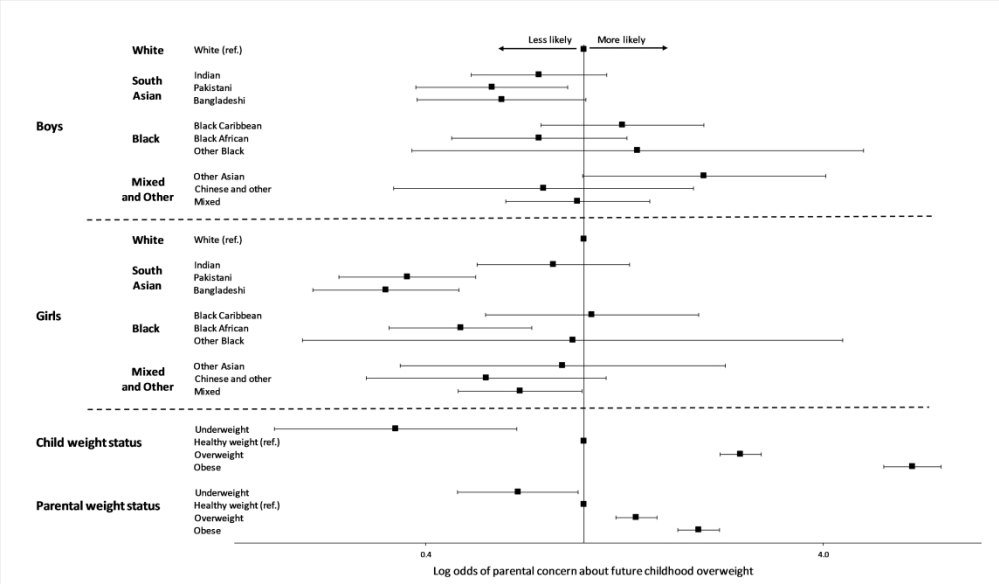

Figure 1 – Adjusted odds of parental concern about future childhood overweight

Does parental concern about their child's future risk of overweight vary by ethnic background? Cross-sectional analysis of a national cohort study

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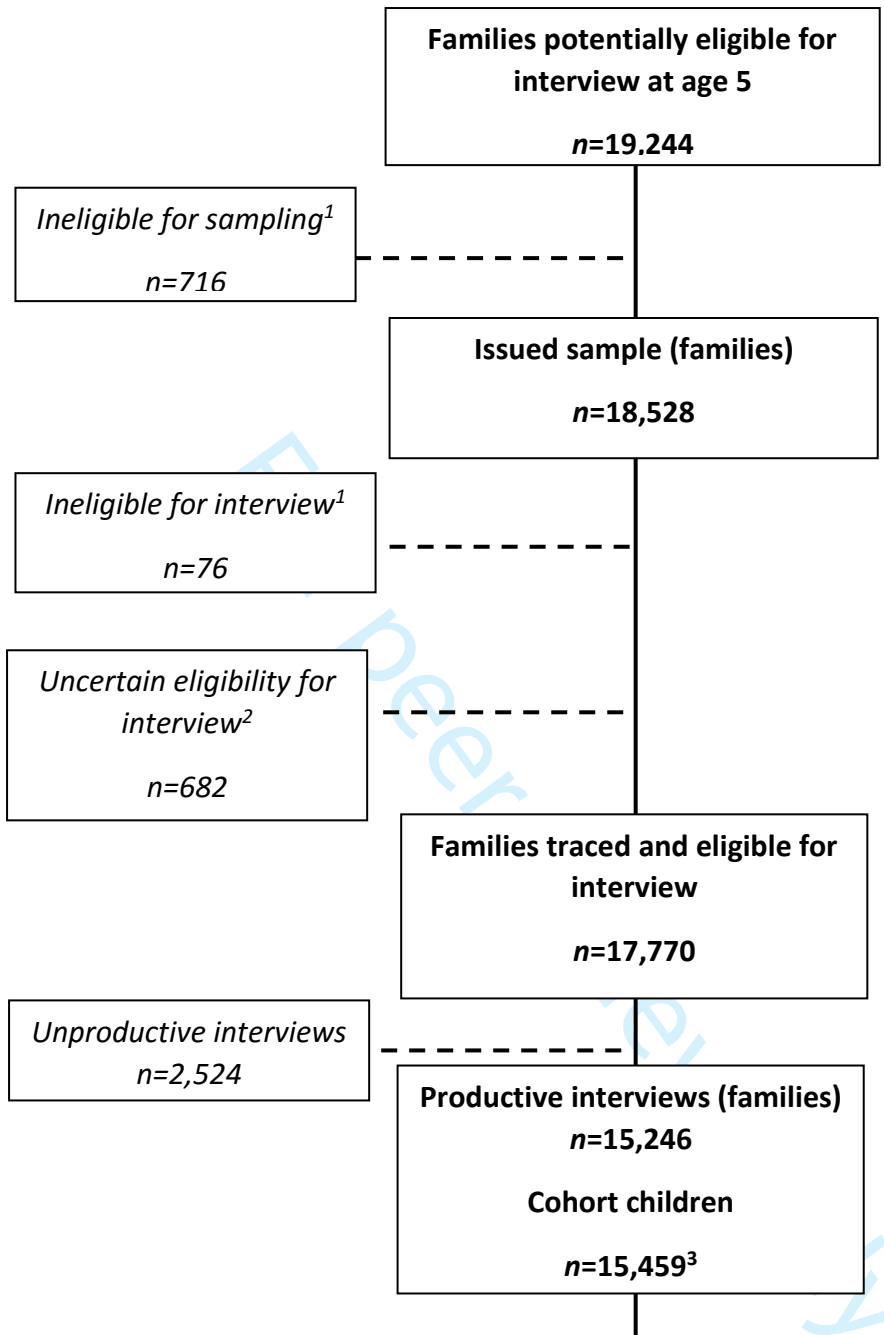
Supplementary material

Figure S1 - Flow chart of study sample



[1]Due to death, emigration, permanent refusal or sensitive family circumstances. [2]Due to untraced movers, outstanding movers or ran out of time to complete sampling. [3]Data for individual children not available prior to the point of productive interview. [4]418 twins/triplets, 1 child with extreme height values, 1 child missing ethnicity.

Table S1 - Sample characteristics of singleton children participating and not participating[1] in MCS at age five

	Singleton children participating at age 5 (n=15,041)		Singleton children not participating at age 5 (n=3,939)	
	n	%[2]	n	%[2]
Child sex				
Male	7708	51.2	2065	52.4
Female	7333	48.8	1874	47.6
Ethnic background[3]				
White	12524	83.3	2990	75.9
South Asian	1361	9.1	474	12.0
Black	505	3.3	213	5.4
Mixed or other	650	4.3	238	6.1
Missing	1	0.0	24	0.6
Parental weight status[4]				
Underweight	541	3.6	156	4.0
Healthy weight	7775	51.7	2018	51.2
Overweight	3591	23.9	880	22.3
Obese	1886	12.5	451	11.5
Missing	1248	8.3	434	11.0
OECD household income quintile[5]				
Lowest	3496	23.2	1326	33.7
2	3306	22.0	977	24.8
3	2852	19.0	685	17.4
4	2761	18.4	479	12.1
Highest	2558	17.0	425	10.8
Missing	68	0.4	47	1.2
Parental highest academic qualification[5]				
Degree or diploma in higher education	3882	25.8	625	15.9
A/AS levels	1441	9.6	296	7.5
GCSEs	6573	43.7	1753	44.5
Other academic qualifications	419	2.8	153	3.9
None	2678	17.8	1072	27.2
Missing	48	0.3	40	1.0

[1] 18,980 singleton children were first recruited/interviewed at either MCS sweep 1 (age nine months) or MCS sweep 2 (age three years). At MCS sweep 3 (age five), 3,939 singleton children did not participate. [2]Proportions are unweighted. [3]Ethnic background of the child was obtained from parental report at the first MCS interview and categorised using UK 2011 Census categories. [4]Parental weight status when the child was aged five years was categorised using BMI calculated from parental self-reported weight and height as follows: "underweight" (BMI<18.5kg/m^2), "healthy weight" (≥18.5 to <25kg/m^2), "overweight" (≥25 to <30kg/m^2) or "obese" (≥30kg/m^2), except for South Asian adults where "overweight" is ≥23 to <27.5kg/m^2 and "obese" is ≥27.5kg/m^2. [5]Recorded at the age nine month interview, or the age three interview for the boosted sample.

Table S2 - Multiple Imputation

Multiple imputation was performed to impute values for our outcome of interest (parental concern) and covariates (child and parental BM). Imputations were based on the variables below, which were all shown to be significantly correlated (at the 5% level) with non-measurement of parental concern, height or weight at ages five and 11:

Variables used in multiple imputation[1]	Number of children with missing data[2] n	%[3]
Outcome of interest		
Parental concern[4]	82	0.6
Exposures of interest		
Child's ethnic background[5]	0	-
Covariates		
Child height measurements[6]:		
Age 3	2367	15.7
Age 5	235	1.6
Age 7	2130	14.2
Age 11	2956	19.7
Child weight measurements[6]:		
Age 3	2219	14.8
Age 5	234	1.6
Age 7	2181	14.5
Age 11	3154	21.0
Parental BMI[6,7]	2456	16.3
Sociodemographic factors		
Child's sex[5]	0	-
Child's age in days[4]	0	-
OECD household income quintile[4]	1	-
Diet		
Portions of fruit eaten a day[4]	88	0.6
Reason for controlling child's diet[4]	1777	11.8
Main snack eaten between meals[4]	79	0.5
Main drink between meals[4]	79	0.5
Physical activity		
Mode of transport to and from school[4]	252	1.7
Days a week participates om sports clubs or classes[4]	69	0.5
Average hours of screen time a day[4]	78	0.5

[1]The attrition/non-response weight (for whole of UK-level analyses), a finite population correction factor, a stratum variable and a ward variable to account for clustering, were also included in the multiple imputation model. [2]Total N=15,039. [3]Proportions are unweighted. [4]Recorded at MCS sweep 3 (age five). [5]Obtained from parental report at the first MCS interview. [6]Height and weight values and parental BMI were transformed on the natural logarithmic scale to mitigate violation of the assumption of normal distributions. [7]Parental BMI based on self-reported weight at MCS sweep 3 (age five) and their most recent self-reported height (usually recorded at the first MCS sweep).

Table S3 – Child weight status at age five years by parent weight status

	Parental weight status[1]							
	Underweight		Healthy weight		Overweight		Obese	
	%	95% CI[2]	%	95% CI[2]	%	95% CI[2]	%	95% CI[2]
Child weight status[3]								
Underweight	0.9	0.0,2.0	0.8	0.6,1.1	0.5	0.3,0.8	0.6	0.2,1.0
Healthy weight	90.7	87.0,94.4	86.5	85.5,87.4	78.7	77.1,80.3	70.2	67.9,72.4
Overweight	6.0	2.9,9.1	8.6	7.8,9.4	13.0	11.7,14.3	15.9	14.2,17.7
Obese	2.4	0.6,4.2	4.1	3.5,4.7	7.8	6.7,8.9	13.3	11.8,14.9

[1]Parental weight status was categorised using BMI calculated from parental self-reported weight and height as follows: "underweight" (BMI<18.5kg/m^2), "healthy weight" (≥18.5 to <25kg/m^2), "overweight" (≥25 to <30kg/m^2) or "obese" (≥30kg/m^2), except for South Asian adults where "overweight" is ≥23 to <27.5kg/m^2 and "obese" is ≥27.5kg/m^2. [2]95% confidence interval. [3]Child weight status based on ethnic-adjusted BMI and categorised according to UK90 clinical reference standard.

Table S4 – Adjusted odds of parental concern about future overweight risk at age five years, including interactions between child sex and ethnic background and between child weight status and ethnic background

	With interactions[1] OR (*p*-value)[2]	95% CI[3]
Ethnic background[4]	(0.249)	
White (ref.)	1	
South Asian	**0.72**	**0.53,0.99**
Black	1.00	0.65,1.52
Mixed and Other	1.00	0.67,1.48
Sex	(<0.001)	
Male (ref.)	1	
Female	**1.59**	**1.46,1.74**
Child weight status[5]	(<0.001)	
Underweight	**0.33**	**0.15,0.75**
Healthy weight (ref.)	1	
Overweight	**2.52**	**2.22,2.87**
Obese	**6.75**	**5.55,8.20**
Parental weight status[6]	(<0.001)	
Underweight	**0.68**	**0.48,0.96**
Healthy weight (ref.)	1	
Overweight	**1.35**	**1.19,1.52**
Obese	**1.93**	**1.72,2.18**
Sex x ethnic background	(0.034)	
Female x White (ref.)	1	
Female x South Asian	0.71	0.47,1.06
Female x Black	0.71	0.43,1.15
Female x Mixed and Other	0.68	0.45,1.02
Child weight status x ethnic background	(0.184)	
Underweight x South Asian	-	-
Underweight x Black	0.47	0.06,3.90
Underweight x Mixed and Other	2.93	0.57,15.0
Healthy weight x White (ref.)	1	
Overweight x South Asian	0.79	0.46,1.37
Overweight x Black	0.56	0.15,2.08
Overweight x Mixed and Other	0.99	0.49,2.01
Obese x South Asian	0.74	0.47,1.18
Obese x Black	1.30	0.59,2.86
Obese x Mixed and Other	1.24	0.57,2.69

[1]Mutually adjusting for ethnic background, sex, age five weight status, parental weight status as well as two interaction terms: 1) sex x ethnic background 2) age five weight status x ethnic background. Four broader ethnic groupings were used instead of individual ethnic backgrounds to overcome small cell sizes when including both interaction terms in the model. [2]Odds ratio and p*-value for corresponding Wald test statistic. [3]95% confidence interval. [4]Ethnic background of the child categorised using UK 2011 Census categories. [5]Child weight status based on ethnic-adjusted BMI categorised according to UK90 clinical reference standard. [6]Parental weight status was categorised using BMI calculated from parental self-reported weight and height as follows: "underweight" (BMI<18.5kg/m^2), "healthy weight" (≥18.5 to <25kg/m^2), "overweight" (≥25 to <30kg/m^2) or "obese" (≥30kg/m^2), except for South Asian adults where "overweight" is ≥23 to <27.5kg/m^2 and "obese" is ≥27.5kg/m^2. Cells in bold font indicate the estimate is statistically significantly different to the reference category.*

Table S5 - Sensitivity analyses: univariable and multivariable odds of parental concern about future overweight risk at age five years using complete-cases

	Unadjusted		Adjusted[1]		With interactions[2]		Model with significant interaction[3]	
	OR (*p*-value)[4]	95% CI[5]	OR (*p*-value)[4]	95% CI[5]	OR (*p*-value)[4]	95% CI[5]	OR (*p*-value)[4]	95% CI[5]
Ethnic background[6]	(0.008)		(<0.001)		(0.410)		(0.108)	
White (ref.)	1		1		1		1	
South Asian					0.75	0.53,1.07		
Indian	1.04	0.80,1.35	0.77	0.56,1.06			0.77	0.51,1.16
Pakistani	**0.68**	**0.54,0.87**	**0.50**	**0.37,0.68**			**0.64**	**0.42,0.97**
Bangladeshi	0.76	0.54,1.06	**0.47**	**0.34,0.65**			0.65	0.38,1.12
Black					0.83	0.46,1.49		
Black Caribbean	1.25	0.77,2.01	1.19	0.66,2.15			1.20	0.58,2.48
Black African	**0.65**	**0.49,0.86**	**0.63**	**0.42,0.95**			0.77	0.43,1.38
Other Black	0.90	0.34,2.39	0.87	0.28,2.74			0.64	0.15,2.71
Mixed and Other					0.89	0.56,1.39		
Other Asian	1.15	0.62,2.14	1.18	0.56,2.52			1.82	0.78,4.26
Chinese and Other	0.69	0.41,1.14	0.69	0.39,1.22			0.75	0.26,2.16
Mixed	0.85	0.63,1.14	0.74	0.53,1.05			0.83	0.52,1.33
Sex	(<0.001)		(<0.001)		(<0.001)		(<0.001)	
Male (ref.)	1		1		1		1	
Female	**1.39**	**1.28,1.51**	**1.52**	**1.42,1.70**	**1.60**	**1.46,1.77**	**1.60**	**1.46,1.77**
Child weight status[7]	(<0.001)		(<0.001)		(<0.001)		(<0.001)	
Underweight	**0.33**	**0.17,0.66**	**0.35**	**0.17,0.73**	**0.39**	**0.17,0.89**	**0.35**	**0.17,0.72**
Healthy weight (ref.)	1		1		1		1	
Overweight	**2.56**	**2.28,2.87**	**2.48**	**2.17,2.83**	**2.51**	**2.18,2.90**	**2.49**	**2.18,2.84**
Obese	**6.90**	**5.90,8.08**	**6.46**	**5.39,7.74**	**6.44**	**5.24,7.92**	**6.44**	**5.37,7.73**
Parental weight status[8]	(<0.001)		(<0.001)		(<0.001)		(<0.001)	
Underweight	**0.62**	**0.45,0.87**	**0.67**	**0.47,0.95**	**0.66**	**0.46,0.94**	**0.67**	**0.47,0.95**
Healthy weight (ref.)	1		1		1		1	
Overweight	**1.44**	**1.28,1.62**	**1.34**	**1.18,1.52**	**1.33**	**1.18,1.51**	**1.34**	**1.19,1.52**
Obese	**2.21**	**1.98,2.47**	**1.93**	**1.72,2.17**	**1.92**	**1.71,2.16**	**1.93**	**1.72,2.18**
Sex x ethnic background					(0.228)		(0.444)	
Female x White (ref.)					1		1	
Female x South Asian					0.72	0.47,1.10		
Female x Indian							0.99	0.55,1.80
Female x Pakistani							0.63	0.35,1.14
Female x Bangladeshi							0.56	0.26,1.20
Female x Black					0.96	0.54,1.68		
Female x Black Caribbean							0.98	0.48,2.02
Female x Black African							0.66	0.28,1.57
Female x Other Black							1.72	0.19,15.4
Female x Mixed and Other					0.77	0.50,1.19		
Female x Other Asian							0.47	0.16,1.37
Female x Chinese and other							0.88	0.23,3.37
Female x Mixed							0.81	0.47,1.38
Child weight status x ethnic background					(0.406)			

Underweight x South Asian			-	-	
Underweight x Black			-	-	
Underweight x Mixed and Other			2.39	0.38,15.1	
Healthy weight x White (ref.)			1		
Overweight x South Asian			0.74	0.42,1.32	
Overweight x Black			0.69	0.22,2.19	
Overweight x Mixed and Other			1.23	0.57,2.63	
Obese x South Asian			0.83	0.47,1.47	
Obese x Black			2.86	0.93,8.78	
Obese x Mixed and Other			0.83	0.35,1.99	

[1]Mutually adjusting for ethnic background, sex, age five weight status and parental weight status. [2]Mutually adjusting for ethnic background, sex, age five weight status, parental weight status as well as two interaction terms: 1) sex x ethnic background 2) age five weight status x ethnic background. [3]Mutually adjusting for ethnic background, sex, child weight status, parental weight status, and an interaction between sex and ethnic background. [4]Odds ratio and p-*value for corresponding Wald test statistic. [5]95% confidence interval. [6]Ethnic background of the child categorised using UK 2011 Census categories. [7]Child weight status based on ethnic-adjusted BMI categorised according to UK90 clinical reference standard. [8]Parental weight status was categorised using BMI calculated from parental self-reported weight and height as follows: "underweight" (BMI<18.5kg/m^2), "healthy weight" (≥18.5 to <25kg/m^2), "overweight" (≥25 to <30kg/m^2) or "obese" (≥30kg/m^2), except for South Asian adults where "overweight" is ≥23 to <27.5kg/m^2 and "obese" is ≥27.5kg/m^2. Cells in bold font indicate the estimate is statistically significantly different to the reference category.*

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2-3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	6-7
Objectives	3	State specific objectives, including any prespecified hypotheses	7
Methods			
Study design	4	Present key elements of study design early in the paper	7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	8
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8-10
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	8-10
Bias	9	Describe any efforts to address potential sources of bias	10-11
Study size	10	Explain how the study size was arrived at	8 (and Fig S1)
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8-10
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	10-11
		(*b*) Describe any methods used to examine subgroups and interactions	10-11
		(*c*) Explain how missing data were addressed	11
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	11
		(*e*) Describe any sensitivity analyses	11
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8 (and Fig S1)
		(b) Give reasons for non-participation at each stage	8 (and Fig S1)
		(c) Consider use of a flow diagram	Fig S1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	12 (and Table 1)
		(b) Indicate number of participants with missing data for each variable of interest	10-11
Outcome data	15*	Report numbers of outcome events or summary measures	8
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	13-14 (and Table 5)
		(*b*) Report category boundaries when continuous variables were categorized	10
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	11
Discussion			
Key results	18	Summarise key results with reference to study objectives	14
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	15-16
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	17-20
Generalisability	21	Discuss the generalisability (external validity) of the study results	15-20
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	29

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Does parental concern about their child's future risk of overweight vary by their ethnic background? Cross-sectional analysis of a national cohort study

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Does parental concern about their child's future risk of overweight vary by their ethnic background? Cross-sectional analysis of a national cohort study

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Key words:

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Abstract

Objectives

Children from South Asian ethnic backgrounds are at increased risk of obesity and its associated future health risks, however evidence is lacking as to whether parental concern about their child's future overweight risk varies by ethnic background. We hypothesised that parents of five-year-old children from South Asian backgrounds would be more likely to express such concerns.

Design: Cross-sectional

Setting: United Kingdom

Participants: 15,039 singleton five-year-old Millennium Cohort Study participants (48.9% girls; 86.7% White).

Primary outcome measure: Parent-reported concern (some/none) about future overweight risk.

Methods

We estimated the adjusted odds ratios (aOR) of some parental concern (ranging from a little to very concerned) by child's ethnic background (reference group: White), adjusted for parent and child weight status, and child sex.

Results

Parents of girls from Pakistani (aOR; 95%CI: 0.4; 0.2,0.5), Bangladeshi (0.3; 0.2,0.5), Black African (0.5; 0.3,0.7) and Mixed (0.7; 0.5,0.99) ethnic backgrounds and of boys from Pakistani ethnic backgrounds (0.6; 0.4,0.9) were less likely to report concern about their child's future overweight risk than parents of White girls and boys, respectively. Overweight (2.5; 2.2,2.8) and obesity (6.7; 5.7,7.9) in children, and overweight (1.4; 1.2,1.5) and obesity (1.9; 1.7,2.2) in parents, were associated with increased likelihood of concern.

Conclusions

Parents of children from South Asian ethnic backgrounds express less concern about their child's future overweight risk. Qualitative studies are needed to understand the concerns of parents from different ethnic backgrounds to inform weight-management interventions in ethnically-diverse populations.

Article summary

Strengths and limitations of the study

- We used robust statistical methods to analyse a large, nationally representative cohort of children from diverse ethnic backgrounds, allowing examination of parental concern across ten ethnic groups
- We adjusted for factors known to be associated with increased parental concern, including child weight status, using clinical definitions of overweight and obesity, and applied ethnic-specific BMI adjustments for more accurate assessment of body fatness in children from South Asian and Black backgrounds.
- We were unable to apply adjustments to the BMI of children from Mixed and Other ethnic backgrounds because validated algorithms to adjust BMI among children from these groups are not available.
- Responses to the parental concern question are unlikely to be influenced by the study child weight measurement as weight was recorded after this question was answered and no interpretation or categorisation of BMI was provided to parents. As our study was cross-sectional, we are unable to determine the temporal association between concern and weight status.
- Some children may have been weighed prior to interview at home, or in clinic, schools or other settings and this might have influenced parental concern, however this information was not available.

Abbreviations

BMI – body mass index

UK – United Kingdom

MCS – Millennium Cohort Study

CI – confidence interval

OR – odds ratio

NCMP – National Child Measurement Programme

FMI – fat mass index

Introduction

In England more than a quarter of children currently leave primary school with a body mass index (BMI) indicating they are overweight or obese, at a level needing clinical weight management support.(1) These proportions vary by ethnic background, and, after adjustment to account for ethnic variation in body fat mass, are significantly higher among children from South Asian backgrounds, especially boys.(2) This has important implications for their future health, as children from South Asian backgrounds are known to be biologically more susceptible to the harms of overweight, and are at higher risk of developing type two diabetes and cardiovascular disease in adulthood.(3-5)

It has been suggested that parental concern about their child's current weight status(6) and about their child becoming overweight in the future(7) may be a meaningful predictor of willingness to engage in behaviour change.

Among parents of children whose BMI is in the overweight or obese range, there is evidence of increased parental concern about both their child's present weight status(8-11) and about their child becoming overweight in the future(12) relative to those whose children have a healthy weight BMI. Furthermore, it has been shown that parents express higher levels of this concern about current(13, 14) and future(15, 16) weight status for daughters with overweight or obesity than for sons,(13-16) as well as if they themselves have a BMI categorised as overweight or obese.(12, 16) There is only very limited evidence regarding ethnic variation in parental concern, with lower levels of concern for current childhood overweight reported in one study of parents from Black Somali backgrounds living in Liverpool,(8) and greater concern about future child overweight from another study of parents from Black Afro-Caribbean backgrounds living in London,(17) with others reporting no differences.(12)

However, these findings are based on regional studies with low response rates and consequently small sample sizes. Moreover, none adjusted BMI for ethnicity and few specifically examine parental

concern about future child overweight (as opposed to current child weight status), warranting further investigation.

Across the UK, children's heights and weights are measured on or shortly after entry to primary school at age five years. Following measurement, parents receive a feedback letter informing them of their child's weight status. Given the longitudinal evidence that obesity at the beginning of primary school strongly predicts obesity on leaving primary school,(18, 19) age five may be viewed as an appropriate time to intervene to prevent and tackle obesity. It is therefore important to understand how parental concern about future childhood overweight might relate to weight status at this point in the life course.

We used cross-sectional data from a large ethnically diverse UK-wide cohort study to examine whether parental concern about their child's future risk of overweight, reported when the child was aged five years, varied by ethnic background. Given the high rates of overweight and obesity observed among children from South Asian backgrounds after adjustments for body fat,(2) and having taken parent weight status and child sex into account, we hypothesised that parents of overweight and obese children from South Asian backgrounds would be more concerned about their child becoming overweight in the future relative to parents of overweight and obese children from White backgrounds.

Materials and methods

Study design

We used data from the Millennium Cohort Study (MCS), a prospective nationally representative cohort of children born between September 2000 and January 2002 in the UK, which used a stratified clustered sampling design to over-represent children born in disadvantaged areas, from ethnic minority groups or from Northern Ireland, Scotland and Wales. When the cohort child was aged nine months, 18,552 (68%) of 27,257 families contacted were interviewed at home when

demographic, social and health information was obtained. An additional 692 families were recruited at age three. Further interviews were conducted when children were aged three, five, seven, 11 and 14 years, when height and weight were measured. At age five, 15,246 (85.8%) of 17,770 families eligible for interview were interviewed, providing data for 15,459 children (Figure S1).

Inclusion and exclusion criteria

We included 15,039 of 15,459 singleton children whose parent (natural mother (97.0%), else child's main care-giver, all referred to hereafter as the parent) was interviewed when their child was aged five years, having excluded 418 twins and triplets, as well as two children with extreme height and/or weight measures at age five or missing ethnicity (Figure S1). We extracted information available for these children from their two earlier and two subsequent MCS interviews. Characteristics of those who did and did not participate in the age five interview are given in Table S1; participating children were more likely to be from families in the highest income quintiles and to have more highly educated mothers compared to non-participating children. We weighted all analyses to take account of survey design and to allow for potential ethnic and socioeconomic biases in cohort attrition by age five years.

Main Outcome measure

The main outcome measure was parental concern about their child's future risk of becoming overweight. This was assessed at the age five interview from responses to a question administered by a trained interviewer who asked the parent "How concerned are you about [child's name] becoming overweight in the future?" We followed the methods applied by others(12, 14-16) and derived a binary variable from the five possible responses as follows: parents reporting they were unconcerned (n=10,964), were categorised as "no parental concern", with all other responses (a little concerned (n=2,645), concerned (n=540), fairly concerned (n=390), very concerned (n=418)) categorised as "parental concern". Response to this question was missing for 82 parents.

Main exposure variable

Ethnic background of the child was obtained from parental report at the first MCS interview and categorised using UK 2011 Census categories. Analyses were based on ten individual Census categories, with the exception of some analyses where individual ethnic groups were too small to create 95% confidence intervals (CI) when categories which were grouped as follows: White (Irish, Traveller, Other), South Asian (Indian, Pakistani, Bangladeshi), Black (Black Caribbean, Black African, other Black), Mixed and Other (Other Asian, Chinese, Mixed, Other).(20)

Covariates

We examined two covariates: child weight status and parental weight status. At age five years, trained interviewers in the home measured the child's height and weight: height was recorded to the nearest millimetre using a Leicester Height Measure Stadiometer (Seca Ltd, Birmingham, UK) with the head positioned in the Frankfort plane. Children were weighed barefoot and without outdoor clothing on Tanita HD-305 scales (Tanita, UK Ltd, Middlesex, UK) and weight recorded in kilograms to one decimal place.(21)

To enable comparison with the current English child measurement programme, we used published guidance from Public Health England(22) to assess the quality and range of height and weight measurements. We excluded one child with extreme short stature, and in addition assigned measurements in two children with extreme weight values as missing, as these were assumed erroneous when compared with their earlier or subsequent MCS measurements.

BMI at age five was calculated and adjusted for ethnicity using methods described by Hudda et al. who used similar ethnic categories to those employed in this study.(23) The authors pooled data from four UK studies which used the deuterium dilution method to measure body fat in approximately 2,000 children from White European, South Asian and Black African backgrounds. They derived a height-standardised fat mass index (FMI) to represent body fat and fitted linear

regression models to quantify ethnic differences in BMI-FMI relationships to provide ethnic-specific BMI adjustments. This adjustment entails adding approximately 1.1kg/m^2 to the BMI of children from South Asian backgrounds, and subtracting between -0.12kg/m^2 and -5.52kg/m^2 dependent upon sex, age group and unadjusted BMI to the BMI of children from Black backgrounds to more accurately reflect adiposity in these groups since it has been shown that BMI overestimates and underestimates body fat in children from Black and South Asian backgrounds, respectively. No adjustment is available to apply to children from Mixed or Other ethnic backgrounds.

We categorised the adjusted BMI according to the UK1990 clinical reference standard,(24) into four mutually exclusive groups: "underweight" (BMI<2nd centile), "healthy weight" (≥2nd to <91st centile), "overweight" (≥91st to <98th centile) or "obese" (≥98th centile) based on alignment with sex- and age-specific BMI centiles from the LMS growth tool Excel add-in.(25, 26) We defined those with BMI ≥98th centile or ≥91st to <98th centile as clinically obese and clinically overweight respectively. The UK90 clinical reference standard uses higher thresholds to define overweight and obesity compared to the UK90 population reference standard, indicating the need for clinical support for weight management. These thresholds are used by a variety of health professionals to assess individual children, as opposed to the UK90 population thresholds which are used to monitor population prevalence of overweight and obesity.(24)

Parental BMI was calculated using the parent's self-reported weight (at the age five sweep) and their most recent self-reported height (usually recorded at the first contact sweep). Trained interviewers measured parental heights and weights objectively if they did not know their measurements for self-report. Parental BMI was categorised into four mutually exclusive groups: "underweight" (BMI<18.5kg/m^2), "healthy weight" (≥18.5 to <25kg/m^2), "overweight" (≥25 to <30kg/m^2) or "obese" (≥30kg/m^2). Due to the higher risk of type two diabetes and cardiovascular disease among adults from Asian backgrounds at a BMI lower than 25kg/m^2, lower thresholds for classifying overweight and obesity in South Asian adults were employed, where "overweight" is considered ≥23 to

<27.5kg/m^2 and "obese" as ≥27.5kg/m^2, based on National Institute for Health Care Excellence guidelines.(27)

Statistical methods

Response to the parental concern question was missing for 82 children. All children for whom consent was obtained from a parent or guardian and who could stand unaided had their height and weight measured.(21) Height was missing for 235 and weight was missing for 234 five year-olds (both height and weight were missing for 218 five year-olds). BMI was missing for 2,456 parents. We used multiple imputation to estimate missing data on parental concern, child height and weight at age five, and parental BMI, and built 20 imputed datasets using the weighted iterative chain algorithm,(28) including all variables involved in the analysis steps under the assumption that missingness is at random (Table S2). All analyses were carried out on imputed datasets, and sensitivity analyses on complete-cases.

We used descriptive statistics (proportions and 95% confidence intervals) to assess the prevalence of parental concern overall, and by sex, ethnic background, child weight status and parental weight status. Similarly, we examined associations of child's weight status with parental concern by sex and ethnic background. We used logistic regression to estimate the unadjusted odds of a parent being concerned about their child being overweight in the future by child's ethnic group, sex, weight status and parental weight status (reported as odds ratios [OR]). We then mutually adjusted for child's ethnic background, sex and child and parent weight status. We tested for interactions between the child's ethnic background and sex, and between child's ethnic background and weight status and used Wald test statistics for these interaction terms to inform the final logistic regression model. We derived sex- and ethnic-specific odds ratios by multiplying the interaction term coefficient by the ethnicity coefficient and plotted these in a forest plot.

All analyses and percentages cited were performed in Stata and weighted to take account of survey design and to allow for potential biases in attrition by age five years, using the `svyset` command (Stata/SE 15; Stata Corporation, Texas, USA).

Ethics approval

Approval for MCS was granted by the London Research Ethics Committees(29) and no further approval was required for this secondary analysis.

Patient and public involvement

This research was done without patient or public involvement. Neither were invited to comment on the study design and were not consulted to develop relevant outcomes or interpret results.

Results

Sample characteristics

Of 15,039 children, 48.9% were girls, 86.7% were from White, and 6.1% from South Asian, backgrounds (Table 1). Parental concern about their child becoming overweight in the future was reported by 27.3% of parents (18.6% 'a little concerned', 3.5% 'concerned', 2.6% 'fairly concerned', 2.6% 'very concerned'), and this was more common among parents of girls than of boys (Table 1).

Parental concern

Parental concern was strongly associated with child's BMI status, and was more common among parents of children with overweight or obesity (42.3% and 66.2% respectively) than among parents of children with a healthy weight (22.3%; Table 1). Similarly, parental concern was more likely to be reported by parents with overweight or obesity: 29.9% and 39.7%, respectively, compared to parents with a healthy weight (22.7%; Table 1).

Parental concern was reported significantly less among parents of children from Pakistani (20.9%) and Black African (20.1%) backgrounds, compared to parents of children from White ethnic backgrounds (27.8%; Table 1).

Overweight and obesity prevalence by ethnic background and sex

At age five, the prevalence of overweight and obesity was 11.0% and 6.6%, respectively, with obesity more prevalent among boys (7.5%) than girls (5.7%) (Table 2; parent weight status was positively associated with child weight status, see Table S3).

Within each ethnic group, most five-year-old children were of healthy weight, however children from South Asian backgrounds were more likely to have a BMI in the obese range than children from White backgrounds (Table 2). There were some minor differences by sex, with boys from South Asian backgrounds and girls from Pakistani and Bangladeshi backgrounds more likely to have a BMI in the obese range than those from White backgrounds (Table 2).

Parental concern by ethnic background and sex

Fewer parents of girls from Pakistani, Bangladeshi or Black African backgrounds reported parental concern relative to parents of girls from White backgrounds. These differences were not seen in boys (Table 3).

Parental concern by weight status, ethnic background and sex

Parental concern was reported for 73.4% of girls with obesity compared with 61.0% of boys with obesity (Table 4).

Parental concern was reported by fewer parents of healthy weight, overweight and obese girls from South Asian backgrounds compared to parents of girls from White backgrounds (Table 4). No differences in parental concern by weight status were observed between boys from different ethnic backgrounds (Table 4).

Logistic regression analyses

After mutual adjustment for ethnic background, sex and child and parent weight status, parental concern was significantly less likely among children from Pakistani, Bangladeshi and Black African ethnic backgrounds. Parental concern was more likely among parents of overweight and obese children, or of girls, and among parents who themselves were overweight or obese (Table 5 'Adjusted' model).

As the Wald test statistic for an interaction between sex and ethnic background was significant (Table S4), the final adjusted model included this interaction term (other interactions were not significant and were excluded from the final model, see Table S4). The sex- and ethnic-specific odds accounting for this interaction are shown in Table 5 and Figure 1, using White ethnic background as the reference category.

Parents of boys from Pakistani backgrounds were less likely to be concerned about their child's future risk of being overweight (Figure 1), as were parents of girls from Pakistani, Bangladeshi, Black African, Mixed or Other ethnic backgrounds.

In the final model, parental concern about future childhood overweight was more likely among parents of children with overweight and obesity, and less likely among parents of children considered underweight, compared to parents of children with a healthy weight (Figure 1). Parents who themselves had a BMI in the overweight or obese range were more likely, and those with a BMI considered underweight less likely, to report concern than those with a healthy weight (Figure 1).

Adjusted odds ratios were similar for complete case analyses (with the exception of the interaction between female sex and Bangladeshi ethnic background; Table S5) and for BMI without ethnic-adjustment (data not shown).

Discussion

Principal findings

In this large nationally representative study, we found that parents of children from South Asian backgrounds were less likely to be concerned about their child's future overweight risk, compared to those from White backgrounds. This was particularly so for girls from Pakistani and Bangladeshi backgrounds, and was independent of child and parent weight status. Furthermore, among our total sample of more than 15,000 children, we confirmed associations between parental concern and child sex and weight status reported by others.

Increased understanding of the context in which people from different ethnic backgrounds report parental concern is important to inform the development of interventions to support parents and families to alter the weight trajectories of their children with overweight or obesity. This is especially important for children from South Asian backgrounds, given their higher absolute risk of obesity and greater metabolic sensitivity to its effects. Our findings make a significant contribution to the literature on parental concern. This is to our knowledge the first study to use a UK-wide nationally representative cohort to examine whether parental concern about future risk of overweight in their child varies by ethnic background.

Strengths and limitations

Strengths of our study include analyses based on a large, nationally representative cohort of children from diverse ethnic backgrounds, allowing examination of parental concern across ten ethnic groups. Our findings are generalisable to the UK reflecting the nationally representative nature of the MCS: both the prevalence of overweight and obesity and the proportions of children from each ethnic background at age five in this cohort are similar to that reported from Public Health England's National Child Measurement programme (NCMP) for the 2006/07 academic year, when most children included in this study were aged five years.(30, 31)

We used robust statistical methods including imputation of missing data and use of survey weights to account for survey design and to allow for biases in attrition. We used a clinical definition of overweight and obesity that indicates the need for clinical weight management support, and applied

ethnic-specific BMI adjustment for more accurate assessment of body fatness in children from South Asian and Black ethnic backgrounds. While this method of adjusting children's BMI is not currently employed in the NCMP, which may make comparisons with other studies less straightforward, analyses without ethnic-adjustment produced similar findings.

We were able to adjust for a number of covariates in our analysis including those shown previously to be strongly associated with parental concern, including parental and child weight status (the latter based on objective measurements). Responses to the question eliciting parental concern are unlikely to be influenced by the MCS weight measurement as this question was asked before the child was weighed, and furthermore no interpretation or categorisation of BMI was provided in the feedback to parents.(29)

Although it is possible that some children may have been recently weighed either at home, in clinical care or in school as part of the NCMP, information on the timing of this in relation to the MCS interview, or the feedback given to parents, is unavailable. The MCS interview did not ask parents about their perception of their child's weight status at age five and consequently we were unable to adjust for this in our final model. Furthermore, given the cross-sectional design of this study, we are unable to draw any conclusions about the temporal relationship between parental concern and child weight status. Since the majority of main respondents were natural mothers our findings may not be generalizable to fathers or other parents.

As one in seven children in this study were from Black, South Asian and Other ethnic backgrounds, we were able to examine parental concern across all major ethnic groups; however, absolute numbers for some groups were small, resulting in greater uncertainty for these estimates.

We used lower thresholds for overweight and obesity to categorise BMI in adults from South Asian backgrounds to reflect the higher risk of type two diabetes and cardiovascular disease at lower levels of BMI experienced among these adults.(27) Although parental height and weight were self-reported, this is considered a reliable measure in epidemiological studies.(32, 33) Furthermore, at

present there are no validated algorithms for the adjustment of BMI for children from Mixed and Other ethnic backgrounds so no adjustments were made for these children in our analyses. Although we lacked statistical power to evaluate all subcategories of parental concern, we used the approach others have taken using this instrument and dichotomised parental concern into "concern" or "no concern" in order to produce robust estimates when examining parental concern by sex and ethnic background.(12, 14-16)

Other studies

There are to our knowledge no other published reports examining ethnic variation in parental concerns about their child's future risk of becoming overweight using a UK-wide nationally representative cohort of children. Our finding of less parental concern among parents of girls from Black African backgrounds is similar to that reported for parents from Black Somali backgrounds in Liverpool,(8) but not consistent with those from a regional study which observed greater parental concern among parents from Black Afro-Caribbean backgrounds living in London.(17)

The explanations for our main finding that parents of boys and girls from South Asian backgrounds and of girls from Black backgrounds are less concerned about their child's future risk of becoming overweight compared to parents of children from White backgrounds warrant further investigation. This finding may reflect differences in awareness of children's weight status or perceptions of childhood weight and size among parents from different ethnic backgrounds. However, it may be more useful to explore the wider context and barriers which children and their families from different ethnic backgrounds face in negotiating healthy or "ideal" weight so that interventions can be considered which reflect the diverse ethnic backgrounds of children with obesity in the UK.

Many parents are unable to identify overweight or obesity in their children,(15, 34, 35) with the majority of parents of children with a BMI in the overweight or obese range underestimating their child's weight status,(12, 36) a finding replicated in numerous high income countries across the world.(35, 37, 38) While there is some evidence that recognition of overweight or obesity is difficult

among adults from South Asian backgrounds,(39) the reasons for this remain unclear and similar studies in children are lacking.

While parental recognition of child overweight or obesity can be helped by presenting them with child age- and sex-specific body images,(40) these have not been tested among parents from different ethnic backgrounds. Furthermore, we did not find any evidence to suggest that parental concern about child future overweight risk among children from different ethnic backgrounds varied by objectively measured child weight status.

Qualitative research provides important contextual information about South Asian parents and their extended families. Pallan et al. have highlighted the importance of intergenerational influences on child diet and perception of their weight status, suggesting that fatness may signal health and that provision of abundant food may symbolise parental/carer affection for the child.(41) This may be important for families relying on grandparents for informal childcare, and multi-generational households where meals are communally prepared and eaten.(41, 42) For example, studies of women from Pakistan living in North West England and an ethnically diverse sample of families in London have both reported that in these groups, familial expectations to maintain traditional home-cooking procedures are obstacles to changing food preparation and eating practices.(42) Similarly, qualitative research involving women from Somalia living in Liverpool found that many women felt restricted in their efforts to live healthier lifestyles by older relatives' perspectives which promote increased weight, although this study did not focus on the influence of the home environment on their child's weight status,(43) highlighting differences between people from different ethnic backgrounds.

While there is evidence that acculturation can alter maternal health behaviours with the adoption of potentially less healthy behaviours by migrants over time,(44) we did not set out to examine structural barriers or acculturation amongst migrants in this study and further research to explore intergenerational variation in parental concern about future childhood overweight is required.

Our finding that a greater proportion of parents of girls compared to parents of boys from White backgrounds were concerned about their child becoming overweight in the future is consistent with findings from other UK studies of predominantly White populations(13-15) and with one from Australia.(16) This may reflect societal expectations of "ideal" body shapes for boys and girls(14) whereby girls are expected to be slight or petite, and boys to be bigger, stronger or more muscular.(45) Findings from a qualitative study interviewing parents of pre-school aged children in America suggest that childhood overweight is normalised through the use of euphemistic terms like 'cute baby fat' or 'podge',(46) and discussions of body size relate to how 'big', 'strong' or 'muscular' the child is.(47) Other studies have suggested that parents do not worry about their child's weight status because they believe their child participates in an appropriate level of physical activity and/or eats a balanced or healthy diet.(47, 48)

Given these accounts, parents from different ethnic backgrounds may experience social contexts where monitoring child weight is not a priority, particularly in environments where higher weight is a signal of wellness, health and affection for the child. Similarly, given that people from ethnic minority backgrounds, particularly from Pakistan and Bangladesh, are more likely than White British people to live in the most deprived areas in England,(49) it is possible parents prioritise providing for their family over parental concern about future childhood overweight, a less immediate concern. This view is supported by literature which suggests that the future may be perceived differently depending upon personal circumstances, such that concepts of 'public health futures' are not applicable to all individuals.(50)

Our finding that concern was reported more often for children with overweight and obesity is consistent with previously published reports.(9, 12-15) Our findings are similar to those of Carnell et al. who used the same question and response scale but did not examine the influence of ethnicity on this association.(12) Parents may be better able to identify their child's weight status at the extreme end of obesity(14, 15) indicating that, to some extent, parents are aware of overweight in their

children. Inability to assess correctly their child's weight may be a barrier to prevention of childhood obesity,(13, 14, 51) since lifestyle changes are not initiated,(36, 52) however Carnell et al. have argued that parental concern is a more sensitive indicator of parental awareness of child weight status than parental identification of a child's weight status.

The temporality of this relationship however remains unclear as our study was cross-sectional. Whilst it seems plausible that parents are more likely to report concern because their children are already overweight, a range of studies, predominantly from Australia(53-55) and the United States(56-60) as well the UK(61) and Sweden,(62) have proposed that parents reporting concern about their child becoming overweight might be more likely to engage in behaviours such as restrictive feeding, where children's food is controlled and limited.

Longitudinal research has suggested that restrictive feeding practices can result in child weight gain. A prospective study of Australian children aged two years suggests restrictive feeding practices lead to obesogenic behaviours such as overeating,(63) whilst in the United States a study of five to seven year-olds showed a positive association between restrictive feeding and additional weight gain among children at risk of obesity.(64) Two further longitudinal studies in the United States showed restrictive feeding practices were associated with increased eating in the absence of hunger among girls aged five to nine years.(65, 66)

With this in mind and given the cross-sectional nature of our study, our findings require careful interpretation: whilst it is possible that parental concern is a response to child overweight, it remains that child overweight could be in part driven by parental concern and associated feeding practices.

Whether parental feeding practices vary by ethnic background is largely unknown,(67) but remains an important research question particularly as it has been suggested that there may be benefits to restrictive feeding for older, more overweight children but less so for younger, healthy weight children who are yet to develop their eating behaviours.(67) One cross-sectional study comparing feeding practices in Germany and Britain found that parents from Black Afro-Caribbean backgrounds

living in Britain were more likely to use restrictive feeding practices than parents from White backgrounds living in either Britain or Germany, and this was associated with higher child BMI.(68) Further research is needed to understand how social context and ethnic backgrounds might influence parents' feeding practices.

Implications for policy and practice

Our study has implications for practice and research. Our cross-sectional analyses confirmed a strong positive association between the child's current weight status and parental concern, suggesting parents of children with a BMI in the overweight and obese range are more likely than other parents to be concerned about their child's future overweight risk. This is important, given the suggestion that appropriate parental concern is vital for effective parental engagement with obesity intervention programmes(7) and positive behaviour change.(6) Further research is needed to determine whether parental concern is associated with healthier weight trajectories, as well as to understand how feedback given to parents about their child's weight status from the NCMP can be appropriately and accurately conveyed to parents from different ethnic backgrounds.

Our study also has implications in particular for targeted interventions aimed at childhood obesity prevention and management. Parents from particular ethnic backgrounds at higher risk of obesity are less likely to express concern about future childhood overweight, particularly so for girls. This needs to be taken into account in developing ethnically sensitive interventions for weight management of children with obesity in multi-ethnic populations. As with all complex interventions, these need to be informed by qualitative studies to elucidate the factors underlying these novel observed differences in rates of parental concern among participants from different ethnic backgrounds, and to aid their interpretation.

Conclusion

In summary, we have found that, in contrast to our original hypothesis and after taking into account child and parental weight status, parents of children from South Asian ethnic backgrounds who are at higher risk of childhood obesity and its adverse consequences are less likely to report concern for their child's future overweight risk, particularly for their daughters. These novel insights are of importance to the UK population, where the highest risk of obesity is observed in individuals and communities from these backgrounds.

Table 1 – Sample characteristics and proportion of parents reporting parental concern

	Sample characteristics[1]		Parental concern	
	%	95% CI[2]	%	95% CI[2]
All	100		27.3	26.3,28.3
Sex				
Boys	51.1	50.2,52.1	24.1	22.8,25.4
Girls	48.9	47.9,49.8	30.7	29.4,31.9
Child weight status[3]				
Healthy weight	81.7	81.0,82.5	22.3	21.3,23.3
Overweight	11.0	10.4,11.6	42.3	39.6,45.1
Obese	6.6	6.1,7.1	66.2	62.9,69.6
Parent weight status[4]				
Underweight	3.1	2.7,3.4	15.4	11.1,19.6
Healthy weight	52.8	51.5,54.0	22.7	21.5,23.9
Overweight	27.2	26.2,28.2	29.9	28.0,31.9
Obese	16.9	16.0,17.8	39.7	37.4,42.0
Ethnic background[5]				
White	86.7	84.3,89.0	27.8	26.8,28.8
South Asian	6.1	4.3,7.8	23.5	20.5,26.5
Indian	*1.8*	*1.3,2.4*	*28.5*	*23.2,33.7*
Pakistani	*3.1*	*1.7,4.6*	*20.9*	*17.0,24.7*
Bangladeshi	*1.1*	*0.5,1.6*	*22.6*	*16.8,28.4*
Black	2.8	1.8,3.8	24.9	19.6,30.1
Black Caribbean	*1.0*	*0.6,1.4*	*32.3*	*21.9,42.7*
Black African	*1.6*	*1.0,2.3*	*20.1*	*15.5,24.7*
Other Black	*0.2*	*0.1,0.2*	*25.7*	*7.3,44.1*
Mixed and Other	4.5	3.8,5.2	24.9	20.0,29.7
Other Asian	*0.6*	*0.3,0.8*	*30.7*	*17.7,43.8*
Chinese and Other	*0.7*	*0.5,0.9*	*20.9*	*12.4,29.3*
Mixed	*3.2*	*2.7,3.7*	*24.7*	*19.2,30.1*

[1]Total N=15,039. [2]95% confidence interval. [3]Child weight status based on ethnic-adjusted BMI and categorised according to UK90 clinical reference standard. [4]Parental weight status was categorised using BMI calculated from parental self-reported weight and height as follows: "underweight" (BMI<18.5kg/m^2), "healthy weight" (≥18.5 to <25kg/m^2), "overweight" (≥25 to <30kg/m^2) or "obese" (≥30kg/m^2), except for South Asian adults where "overweight" is ≥23 to <27.5kg/m^2 and "obese" is ≥27.5kg/m^2. [5]Ethnic background of the child was obtained from parental report at the first MCS interview and categorised using UK 2011 Census categories.

Table 2 – Overweight and obesity[1] prevalence by ethnic background[2] and sex

	Boys				Girls				All			
	Overweight		Obese		Overweight		Obese		Overweight		Obese	
	%	95% CI[3]	%	95% CI[3]	%	95% CI[3]	%	95% CI[3]	%	95% CI[3]	%	95% CI[3]
White	11.7	10.8,12.6	6.9	6.2,7.6	10.1	9.2,11.1	5.4	4.7,6.0	10.9	10.3,11.6	6.1	5.6,6.6
South Asian	12.8	9.5,16.0	15.9	13.0,18.8	16.8	13.3,20.4	10.6	7.4,13.8	14.8	12.8,16.8	13.3	11.1,15.4
Indian	*9.2*	*4.8,13.6*	*17.3*	*10.7,23.9*	*18.3*	*9.8,26.8*	*6.8*	*0.9,12.6*	*13.6*	*9.1,18.1*	*12.2*	*8.1,16.3*
Pakistani	*14.1*	*9.0,19.2*	*14.0*	*10.1,18.0*	*17.7*	*13.5,22.0*	*9.5*	*6.5,12.4*	*15.7*	*13.0,18.8*	*11.8*	*9.4,14.1*
Bangladeshi	*15.3*	*7.8,22.9*	*18.8*	*11.5,26.1*	*12.1*	*6.4,17.9*	*19.7*	*11.1,28.3*	*13.8*	*10.3,17.1*	*19.3*	*14.0,24.5*
Black	5.1	2.0,8.2	8.2	3.6,12.8	6.7	2.4,10.9	5.0	0.0,10.3	5.8	4.1,8.6	6.8	2.5,11.1
Black Caribbean	*4.9*	*0.5,9.4*	*14.8*	*2.7,27.0*	*5.2*	*0.3,10.2*	*2.8*	*0.0,6.0*	*5.1*	*2.4,7.7*	*9.6*	*2.4,16.7*
Black African	*5.8*	*2.4,9.3*	*4.7*	*1.0,8.5*	*8.0*	*1.3,14.8*	*6.7*	*0.0,14.9*	*6.7*	*2.8,11.0*	*5.7*	*1.2,10.1*
Other Black[4]												
Mixed and Other	11.3	7.5,15.1	7.0	3.8,10.3	8.5	4.7,12.2	6.2	3.2,9.3	9.9	7.3,12.4	6.6	4.5,8.8
Other Asian	*3.3*	*0.1,6.5*	*9.0*	*0.0,19.3*	*2.7*	*0.2,5.2*	*1.7*	*0.0,4.0*	*3.1*	*0.9,5.1*	*5.0*	*0.0,10.3*
Chinese and Other	*8.3*	*0.0,17.0*	*5.6*	*0.0,11.5*	*6.5*	*0.4,12.6*	*6.2*	*0.0,13.5*	*7.3*	*2.5,12.2*	*5.9*	*1.2,10.7*
Mixed	*13.1*	*8.4,17.9*	*7.0*	*3.1,10.9*	*10.1*	*5.1,15.0*	*7.1*	*3.1,11.2*	*11.6*	*8.4,14.9*	*7.1*	*4.4,9.8*
Total	11.5	10.7,12.4	7.5	6.8,8.1	10.4	9.5,11.2	5.7	5.1,6.4	11.1	10.4,11.6	6.6	6.1,7.1

[1] Child weight status based on ethnic-adjusted BMI and categorised according to UK90 clinical reference standard.[2]Ethnic background of the child was obtained from parental report at the first MCS interview and categorised using UK 2011 Census categories. [3]95% confidence interval. [4]Overweight and obesity prevalence estimates not stated due to small numbers. Total N=15,039.

Table 3 – Parental concern about future overweight risk at age five years by ethnic background[1], and sex

	Boys		Girls	
	%	95% CI[2]	%	95% CI[2]
White	24.1	22.8,25.4	31.6	30.3,33.0
South Asian				
Indian	25.4	18.2,32.5	31.8	23.1,40.5
Pakistani	21.8	15.4,28.3	19.9	14.6,25.3
Bangladeshi	24.3	15.5,33.1	21.1	13.0,29.1
Black				
Black Caribbean	32.1	20.3,43.9	32.5	19.3,45.8
Black African	19.2	11.4,27.1	21.1	15.6,26.7
Other Black	26.3	3.1,49.5	24.8	0.0,54.0
Mixed and Other				
Other Asian	35.7	19.6,51.8	26.5	9.9,43.2
Chinese and Other	20.2	7.6,32.8	21.5	8.6,34.3
Mixed	23.7	16.2,31.3	25.7	19.3,32.0

[1]Ethnic background of the child was obtained from parental report at the first MCS interview and categorised using UK 2011 Census categories. [2]95% confidence interval. Total N=15,039.

Table 4 – Parental concern about future overweight risk at age five years, by child weight status[1] at age five

	Proportion of parents reporting parental concern									
	White		South Asian		Black		Mixed and Other		All	
	%	95% CI[2]	%	95% CI[2]	%	95% CI[2]	%	95% CI[2]	%	95% CI[2]
All										
Healthy weight	22.8	21.8,23.8	16.9	14.5,19.3	21.5	15.5,27.6	19.5	14.6,24.4	22.3	21.3,23.3
Overweight	43.8	40.8,46.8	28.4	22.1,34.8	30.1	6.9,53.3	39.8	25.3,54.3	42.3	39.5,45.1
Obese	67.8	63.8,71.7	51.8	44.2,59.3	72.8	58.4,87.2	70.4	55.1,85.7	66.2	62.8,69.6
Boys										
Healthy weight	19.6	18.3,21.0	16.8	13.5,20.2	18.1	13.0,23.2	17.6	11.3,23.8	19.3	18.0,20.6
Overweight	34.2	30.1,38.3	25.9	16.4,35.4	46.7	20.4,72.9	46.6	25.9,67.3	34.5	30.8,38.3
Obese	61.4	56.1,66.7	51.4	41.6,61.2	55.6	31.8,79.3	70.7	47.9,93.4	61.0	56.6,65.4
Girls										
Healthy weight	26.0	24.7,27.3	17.0	13.6,20.3	23.6	17.7,29.6	21.3	15.4,27.3	25.3	24.1,26.5
Overweight	55.4	51.2,59.5	30.5	21.6,39.4	37.2	10.2,64.3	30.7	11.7,49.7	51.4	47.2,55.6
Obese	76.3	70.5,82.1	52.3	40.5,64.1	72.9	39.7,100.0	70.1	48.1,92.1	73.4	68.8,78.6

[1]Underweight groups omitted due to small numbers. Child weight status based on ethnic-adjusted BMI and categorised according to UK90 clinical reference standard. [2]95% confidence interval. Total N=15,039.

Table 5 – Unadjusted, adjusted and sex- and ethnic-specific adjusted odds of parental concern about future overweight risk at age five years

	Unadjusted		Adjusted[1]		Model with interaction term[2]		Final model: Sex- and ethnic-specific adjusted odds[3]			
							Boys		Girls	
	OR (*p*-value)[4]	95% CI[5]	OR (*p*-value)[4]	95% CI[5]	OR (*p*-value)[4]	95% CI[5]	OR[4]	95% CI[5]	OR[4]	95% CI[5]
Ethnic background[6]	(0.008)		(<0.001)		(0.057)					
White (ref.)	1		1		1		1		1	
South Asian										
Indian	1.04	0.80,1.35	0.80	0.60,1.09	0.77	0.52,1.14	0.77	0.52,1.14	0.84	0.54,1.30
Pakistani	**0.69**	**0.54,0.87**	**0.46**	**0.34,0.61**	**0.59**	**0.38,0.91**	**0.59**	**0.38,0.91**	**0.36**	**0.24,0.53**
Bangladeshi	0.76	0.54,1.06	**0.43**	**0.31,0.61**	0.62	0.38,1.01	0.62	0.38,1.01	**0.32**	**0.21,0.48**
Black										
Black Caribbean	1.24	0.77,1.99	1.15	0.73,1.80	1.25	0.78,2.00	1.25	0.78,2.00	1.05	0.56,1.94
Black African	**0.66**	**0.49,0.87**	**0.61**	**0.44,0.84**	0.77	0.46,1.28	0.77	0.46,1.28	**0.49**	**0.32,0.74**
Other Black	0.90	0.34,2.36	1.17	0.43,3.20	1.36	0.37,5.04	1.36	0.37,5.04	0.94	0.20,4.48
Mixed and Other										
Other Asian	1.15	0.62,2.14	1.28	0.66,2.48	2.00	0.99,4.05	2.00	0.99,4.05	0.88	0.34,2.27
Chinese and other	0.69	0.41,1.14	0.66	0.39,1.10	0.79	0.33,1.89	0.79	0.33,1.89	0.57	0.28,1.14
Mixed	0.85	0.64,1.14	0.81	0.60,1.09	0.96	0.63,1.46	0.96	0.63,1.46	**0.69**	**0.48,0.99**
Sex	(<0.001)		(<0.001)		(<0.001)					
Male (ref.)	1		1		1					
Female	**1.39**	**1.28,1.51**	**1.52**	**1.40,1.65**	**1.59**	**1.46,1.73**				
Child weight status[7]	(<0.001)		(<0.001)		(<0.001)		**OR[4]**	**95% CI[5]**		
Underweight	**0.32**	**0.16,0.64**	**0.34**	**0.17,0.68**	**0.34**	**0.17,0.68**	**0.34**	**0.17,0.68**		
Healthy weight (ref.)	1		1		1		1			
Overweight	**2.56**	**2.28,2.87**	**2.47**	**2.19,2.78**	**2.47**	**2.20,2.79**	**2.47**	**2.20,2.79**		
Obese	**6.84**	**5.84,8.01**	**6.70**	**5.68,7.90**	**6.71**	**5.68,7.93**	**6.71**	**5.68,7.93**		
Parental weight status[8]	(<0.001)		(<0.001)		(<0.001)					

Underweight	**0.62**	**0.44,0.87**	**0.68**	**0.48,0.96**	**0.68**	**0.48,0.97**	**0.68**	**0.48,0.97**
Healthy weight (ref.)	1		1		1			
Overweight	**1.46**	**1.30,1.63**	**1.35**	**1.20,1.52**	**1.35**	**1.20,1.52**	**1.35**	**1.20,1.52**
Obese	**2.24**	**2.01,2.50**	**1.94**	**1.72,2.19**	**1.94**	**1.72,2.19**	**1.94**	**1.72,2.19**
Sex x ethnic background					(0.087)			
Female x White (ref.)					1			
Female x South Asian								
Female x Indian					1.09	0.61,1.96		
Female x Pakistani					0.61	0.33,1.13		
Female x Bangladeshi					**0.51**	**0.28,0.94**		
Female x Black								
Female x Black Caribbean					0.84	0.46,1.53		
Female x Black African					0.63	0.31,1.28		
Female x Other Black					0.69	0.09,5.28		
Female x Mixed and Other								
Female x Other Asian					0.44	0.17,1.15		
Female x Chinese and Other					0.72	0.22,2.32		
Female x Mixed					0.72	0.44,1.18		

*[1]Mutually adjusting for ethnic background, sex, age five weight status and parental weight status. [2]Mutually adjusting for ethnic background, sex, child weight status, parental weight status, and an interaction between sex and ethnic background. An interaction between child weight status and ethnic background was tested but deemed not statistically significant so was excluded from the final model (see Table S4). [3]Calculated by multiplying the interaction coefficient with ethnicity coefficient in the model with the interaction term. Mutually adjusting for ethnic background, sex, age five weight status and parental weight status. [4]*Odd ratio (and p-*value for corresponding Wald test statistic). [5]95% confidence interval. [6]Ethnic background of the child categorised using UK 2011 Census categories. [7]Child weight status based on ethnic-adjusted BMI categorised according to UK90 clinical reference standard. [8]Parental weight status was categorised using BMI calculated from parental self-reported weight and height as follows: "underweight" (BMI<18.5kg/m^2), "healthy weight" (≥18.5 to <25kg/m^2), "overweight" (≥25 to <30kg/m^2) or "obese" (≥30kg/m^2), except for South Asian adults where "overweight" is ≥23 to <27.5kg/m^2 and "obese" is ≥27.5kg/m^2. Cells in bold font indicate the estimate is statistically significantly different to the reference category.*

Figure 1 – Adjusted odds of parental concern about future childhood overweight[1]

[1] Mutually adjusted for ethnic background, sex, child weight status, parent weight status and an interaction between sex and ethnic background.

Conflicts of interest

The authors declare no conflict of interest.

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Author statement

NF and CD conceptualised and designed the analysis. NF carried out the literature search, conducted and interpreted the analyses, generated tables and figures and drafted the initial manuscript. CD contributed to the interpretation of analyses and reviewed and revised the manuscript. All authors were involved in writing the paper and had final approval of the submitted and published versions.

Data statement

The MCS data for surveys 1-6 can be downloaded from the UK Data Service.

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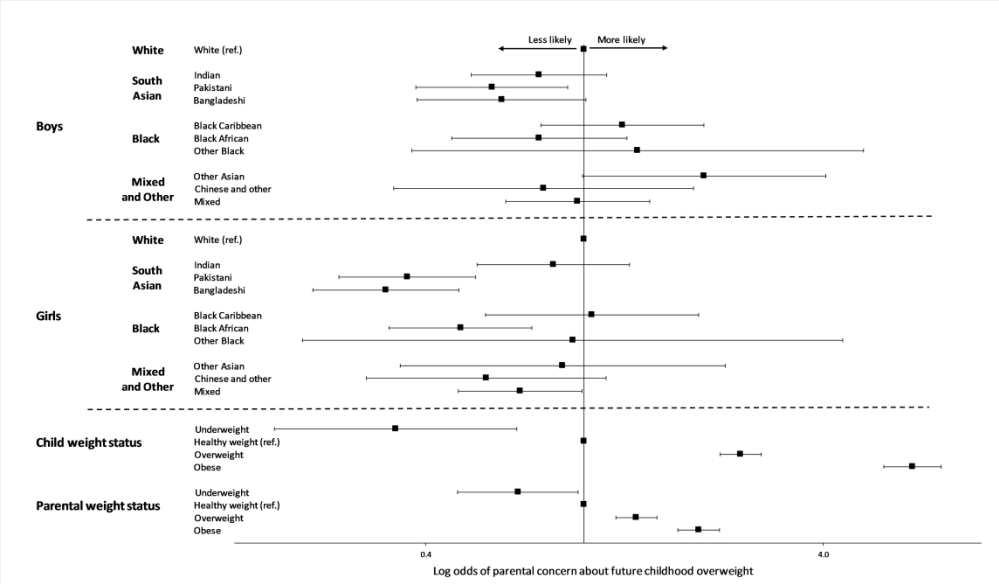

Figure 1 – Adjusted odds of parental concern about future childhood overweight

Does parental concern about their child's future risk of overweight vary by ethnic background? Cross-sectional analysis of a national cohort study

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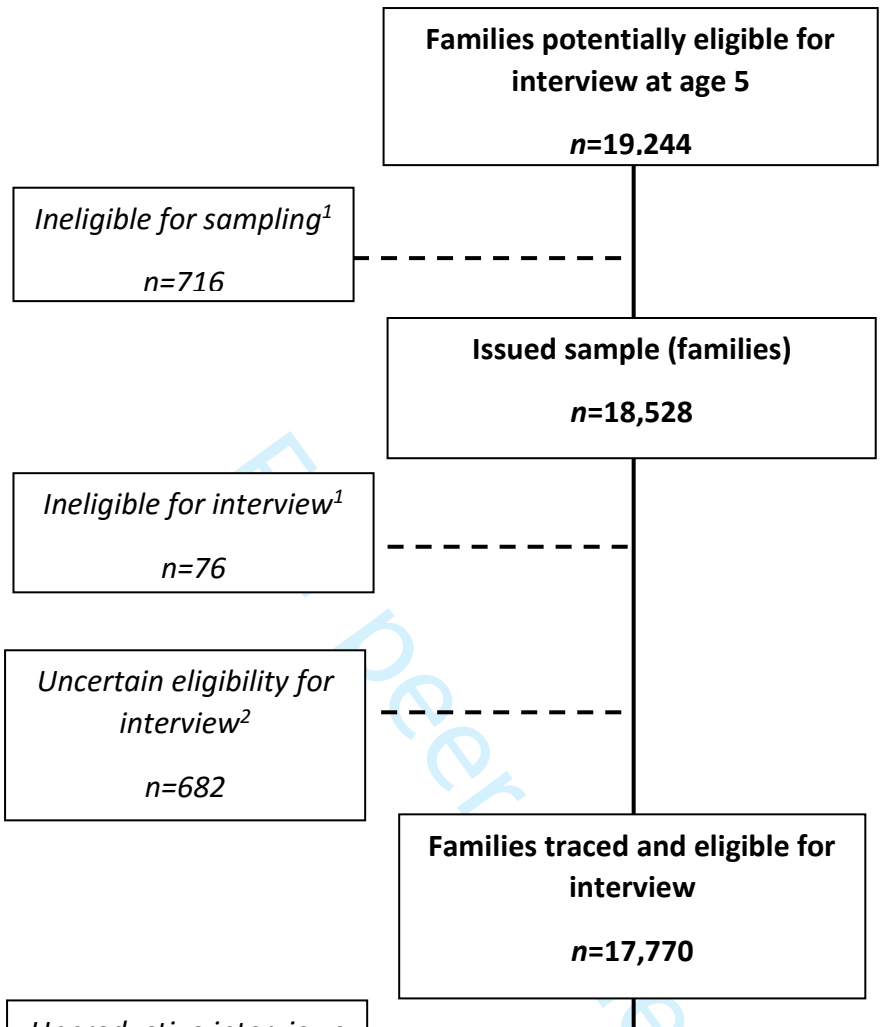
Supplementary material

Figure S1 - Flow chart of study sample



[1]Due to death, emigration, permanent refusal or sensitive family circumstances. [2]Due to untraced movers, outstanding movers or ran out of time to complete sampling. [3]Data for individual children not available prior to the point of productive interview. [4]418 twins/triplets, 1 child with extreme height values, 1 child missing ethnicity.

Table S1 - Sample characteristics of singleton children participating and not participating[1] in MCS at age five

	Singleton children participating at age 5 (n=15,041)		Singleton children not participating at age 5 (n=3,939)	
	n	%[2]	n	%[2]
Child sex				
Male	7708	51.2	2065	52.4
Female	7333	48.8	1874	47.6
Ethnic background[3]				
White	12524	83.3	2990	75.9
South Asian	1361	9.1	474	12.0
Black	505	3.3	213	5.4
Mixed or other	650	4.3	238	6.1
Missing	1	0.0	24	0.6
Parental weight status[4]				
Underweight	541	3.6	156	4.0
Healthy weight	7775	51.7	2018	51.2
Overweight	3591	23.9	880	22.3
Obese	1886	12.5	451	11.5
Missing	1248	8.3	434	11.0
OECD household income quintile[5]				
Lowest	3496	23.2	1326	33.7
2	3306	22.0	977	24.8
3	2852	19.0	685	17.4
4	2761	18.4	479	12.1
Highest	2558	17.0	425	10.8
Missing	68	0.4	47	1.2
Parental highest academic qualification[5]				
Degree or diploma in higher education	3882	25.8	625	15.9
A/AS levels	1441	9.6	296	7.5
GCSEs	6573	43.7	1753	44.5
Other academic qualifications	419	2.8	153	3.9
None	2678	17.8	1072	27.2
Missing	48	0.3	40	1.0

[1] 18,980 singleton children were first recruited/interviewed at either MCS sweep 1 (age nine months) or MCS sweep 2 (age three years). At MCS sweep 3 (age five), 3,939 singleton children did not participate. [2]Proportions are unweighted. [3]Ethnic background of the child was obtained from parental report at the first MCS interview and categorised using UK 2011 Census categories. [4]Parental weight status when the child was aged five years was categorised using BMI calculated from parental self-reported weight and height as follows: "underweight" (BMI<18.5kg/m^2), "healthy weight" (≥18.5 to <25kg/m^2), "overweight" (≥25 to <30kg/m^2) or "obese" (≥30kg/m^2), except for South Asian adults where "overweight" is ≥23 to <27.5kg/m^2 and "obese" is ≥27.5kg/m^2. [5]Recorded at the age nine month interview, or the age three interview for the boosted sample.

Table S2 - Multiple Imputation

Multiple imputation was performed to impute values for our outcome of interest (parental concern) and covariates (child and parental BM). Imputations were based on the variables below, which were all shown to be significantly correlated (at the 5% level) with non-measurement of parental concern, height or weight at ages five and 11:

Variables used in multiple imputation[1]	Number of children with missing data[2] n	%[3]
Outcome of interest		
Parental concern[4]	82	0.6
Exposures of interest		
Child's ethnic background[5]	0	-
Covariates		
Child height measurements[6]:		
Age 3	2367	15.7
Age 5	235	1.6
Age 7	2130	14.2
Age 11	2956	19.7
Child weight measurements[6]:		
Age 3	2219	14.8
Age 5	234	1.6
Age 7	2181	14.5
Age 11	3154	21.0
Parental BMI[6,7]	2456	16.3
Sociodemographic factors		
Child's sex[5]	0	-
Child's age in days[4]	0	-
OECD household income quintile[4]	1	-
Diet		
Portions of fruit eaten a day[4]	88	0.6
Reason for controlling child's diet[4]	1777	11.8
Main snack eaten between meals[4]	79	0.5
Main drink between meals[4]	79	0.5
Physical activity		
Mode of transport to and from school[4]	252	1.7
Days a week participates om sports clubs or classes[4]	69	0.5
Average hours of screen time a day[4]	78	0.5

[1]The attrition/non-response weight (for whole of UK-level analyses), a finite population correction factor, a stratum variable and a ward variable to account for clustering, were also included in the multiple imputation model. [2]Total N=15,039. [3]Proportions are unweighted. [4]Recorded at MCS sweep 3 (age five). [5]Obtained from parental report at the first MCS interview. [6]Height and weight values and parental BMI were transformed on the natural logarithmic scale to mitigate violation of the assumption of normal distributions. [7]Parental BMI based on self-reported weight at MCS sweep 3 (age five) and their most recent self-reported height (usually recorded at the first MCS sweep).

Table S3 – Child weight status at age five years by parent weight status

	Parental weight status[1]							
	Underweight		Healthy weight		Overweight		Obese	
	%	95% CI[2]	%	95% CI[2]	%	95% CI[2]	%	95% CI[2]
Child weight status[3]								
Underweight	0.9	0.0,2.0	0.8	0.6,1.1	0.5	0.3,0.8	0.6	0.2,1.0
Healthy weight	90.7	87.0,94.4	86.5	85.5,87.4	78.7	77.1,80.3	70.2	67.9,72.4
Overweight	6.0	2.9,9.1	8.6	7.8,9.4	13.0	11.7,14.3	15.9	14.2,17.7
Obese	2.4	0.6,4.2	4.1	3.5,4.7	7.8	6.7,8.9	13.3	11.8,14.9

[1]Parental weight status was categorised using BMI calculated from parental self-reported weight and height as follows: "underweight" (BMI<18.5kg/m^2), "healthy weight" (≥18.5 to <25kg/m^2), "overweight" (≥25 to <30kg/m^2) or "obese" (≥30kg/m^2), except for South Asian adults where "overweight" is ≥23 to <27.5kg/m^2 and "obese" is ≥27.5kg/m^2. [2]95% confidence interval. [3]Child weight status based on ethnic-adjusted BMI and categorised according to UK90 clinical reference standard.

Table S4 – Adjusted odds of parental concern about future overweight risk at age five years, including interactions between child sex and ethnic background and between child weight status and ethnic background

	With interactions[1] OR (*p*-value)[2]	95% CI[3]
Ethnic background[4]	(0.249)	
White (ref.)	1	
South Asian	**0.72**	**0.53,0.99**
Black	1.00	0.65,1.52
Mixed and Other	1.00	0.67,1.48
Sex	(<0.001)	
Male (ref.)	1	
Female	**1.59**	**1.46,1.74**
Child weight status[5]	(<0.001)	
Underweight	**0.33**	**0.15,0.75**
Healthy weight (ref.)	1	
Overweight	**2.52**	**2.22,2.87**
Obese	**6.75**	**5.55,8.20**
Parental weight status[6]	(<0.001)	
Underweight	**0.68**	**0.48,0.96**
Healthy weight (ref.)	1	
Overweight	**1.35**	**1.19,1.52**
Obese	**1.93**	**1.72,2.18**
Sex x ethnic background	(0.034)	
Female x White (ref.)	1	
Female x South Asian	0.71	0.47,1.06
Female x Black	0.71	0.43,1.15
Female x Mixed and Other	0.68	0.45,1.02
Child weight status x ethnic background	(0.184)	
Underweight x South Asian	-	-
Underweight x Black	0.47	0.06,3.90
Underweight x Mixed and Other	2.93	0.57,15.0
Healthy weight x White (ref.)	1	
Overweight x South Asian	0.79	0.46,1.37
Overweight x Black	0.56	0.15,2.08
Overweight x Mixed and Other	0.99	0.49,2.01
Obese x South Asian	0.74	0.47,1.18
Obese x Black	1.30	0.59,2.86
Obese x Mixed and Other	1.24	0.57,2.69

[1]Mutually adjusting for ethnic background, sex, age five weight status, parental weight status as well as two interaction terms: 1) sex x ethnic background 2) age five weight status x ethnic background. Four broader ethnic groupings were used instead of individual ethnic backgrounds to overcome small cell sizes when including both interaction terms in the model. [2]Odds ratio and p*-value for corresponding Wald test statistic. [3]95% confidence interval. [4]Ethnic background of the child categorised using UK 2011 Census categories. [5]Child weight status based on ethnic-adjusted BMI categorised according to UK90 clinical reference standard. [6]Parental weight status was categorised using BMI calculated from parental self-reported weight and height as follows: "underweight" (BMI<18.5kg/m^2), "healthy weight" (≥18.5 to <25kg/m^2), "overweight" (≥25 to <30kg/m^2) or "obese" (≥30kg/m^2), except for South Asian adults where "overweight" is ≥23 to <27.5kg/m^2 and "obese" is ≥27.5kg/m^2. Cells in bold font indicate the estimate is statistically significantly different to the reference category.*

Table S5 - Sensitivity analyses: univariable and multivariable odds of parental concern about future overweight risk at age five years using complete-cases

	Unadjusted		Adjusted[1]		With interactions[2]		Model with significant interaction[3]	
	OR (*p*-value)[4]	95% CI[5]	OR (*p*-value)[4]	95% CI[5]	OR (*p*-value)[4]	95% CI[5]	OR (*p*-value)[4]	95% CI[5]
Ethnic background[6]	(0.008)		(<0.001)		(0.410)		(0.108)	
White (ref.)	1		1		1		1	
South Asian					0.75	0.53,1.07		
Indian	1.04	0.80,1.35	0.77	0.56,1.06			0.77	0.51,1.16
Pakistani	**0.68**	**0.54,0.87**	**0.50**	**0.37,0.68**			**0.64**	**0.42,0.97**
Bangladeshi	0.76	0.54,1.06	**0.47**	**0.34,0.65**			0.65	0.38,1.12
Black					0.83	0.46,1.49		
Black Caribbean	1.25	0.77,2.01	1.19	0.66,2.15			1.20	0.58,2.48
Black African	**0.65**	**0.49,0.86**	**0.63**	**0.42,0.95**			0.77	0.43,1.38
Other Black	0.90	0.34,2.39	0.87	0.28,2.74			0.64	0.15,2.71
Mixed and Other					0.89	0.56,1.39		
Other Asian	1.15	0.62,2.14	1.18	0.56,2.52			1.82	0.78,4.26
Chinese and Other	0.69	0.41,1.14	0.69	0.39,1.22			0.75	0.26,2.16
Mixed	0.85	0.63,1.14	0.74	0.53,1.05			0.83	0.52,1.33
Sex	(<0.001)		(<0.001)		(<0.001)		(<0.001)	
Male (ref.)	1		1		1		1	
Female	**1.39**	**1.28,1.51**	**1.52**	**1.42,1.70**	**1.60**	**1.46,1.77**	**1.60**	**1.46,1.77**
Child weight status[7]	(<0.001)		(<0.001)		(<0.001)		(<0.001)	
Underweight	**0.33**	**0.17,0.66**	**0.35**	**0.17,0.73**	**0.39**	**0.17,0.89**	**0.35**	**0.17,0.72**
Healthy weight (ref.)	1		1		1		1	
Overweight	**2.56**	**2.28,2.87**	**2.48**	**2.17,2.83**	**2.51**	**2.18,2.90**	**2.49**	**2.18,2.84**
Obese	**6.90**	**5.90,8.08**	**6.46**	**5.39,7.74**	**6.44**	**5.24,7.92**	**6.44**	**5.37,7.73**
Parental weight status[8]	(<0.001)		(<0.001)		(<0.001)		(<0.001)	
Underweight	**0.62**	**0.45,0.87**	**0.67**	**0.47,0.95**	**0.66**	**0.46,0.94**	**0.67**	**0.47,0.95**
Healthy weight (ref.)	1		1		1		1	
Overweight	**1.44**	**1.28,1.62**	**1.34**	**1.18,1.52**	**1.33**	**1.18,1.51**	**1.34**	**1.19,1.52**
Obese	**2.21**	**1.98,2.47**	**1.93**	**1.72,2.17**	**1.92**	**1.71,2.16**	**1.93**	**1.72,2.18**
Sex x ethnic background					(0.228)		(0.444)	
Female x White (ref.)					1		1	
Female x South Asian					0.72	0.47,1.10		
Female x Indian							0.99	0.55,1.80
Female x Pakistani							0.63	0.35,1.14
Female x Bangladeshi							0.56	0.26,1.20
Female x Black					0.96	0.54,1.68		
Female x Black Caribbean							0.98	0.48,2.02
Female x Black African							0.66	0.28,1.57
Female x Other Black							1.72	0.19,15.4
Female x Mixed and Other					0.77	0.50,1.19		
Female x Other Asian							0.47	0.16,1.37
Female x Chinese and other							0.88	0.23,3.37
Female x Mixed							0.81	0.47,1.38
Child weight status x ethnic background					(0.406)			

Underweight x South Asian			-	-	
Underweight x Black			-	-	
Underweight x Mixed and Other			2.39	0.38,15.1	
Healthy weight x White (ref.)			1		
Overweight x South Asian			0.74	0.42,1.32	
Overweight x Black			0.69	0.22,2.19	
Overweight x Mixed and Other			1.23	0.57,2.63	
Obese x South Asian			0.83	0.47,1.47	
Obese x Black			2.86	0.93,8.78	
Obese x Mixed and Other			0.83	0.35,1.99	

[1]Mutually adjusting for ethnic background, sex, age five weight status and parental weight status. [2]Mutually adjusting for ethnic background, sex, age five weight status, parental weight status as well as two interaction terms: 1) sex x ethnic background 2) age five weight status x ethnic background. [3]Mutually adjusting for ethnic background, sex, child weight status, parental weight status, and an interaction between sex and ethnic background. [4]Odds ratio and p-*value for corresponding Wald test statistic. [5]95% confidence interval. [6]Ethnic background of the child categorised using UK 2011 Census categories. [7]Child weight status based on ethnic-adjusted BMI categorised according to UK90 clinical reference standard. [8]Parental weight status was categorised using BMI calculated from parental self-reported weight and height as follows: "underweight" (BMI<18.5kg/m^2), "healthy weight" (≥18.5 to <25kg/m^2), "overweight" (≥25 to <30kg/m^2) or "obese" (≥30kg/m^2), except for South Asian adults where "overweight" is ≥23 to <27.5kg/m^2 and "obese" is ≥27.5kg/m^2. Cells in bold font indicate the estimate is statistically significantly different to the reference category.*

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2-3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	6-7
Objectives	3	State specific objectives, including any prespecified hypotheses	7
Methods			
Study design	4	Present key elements of study design early in the paper	7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	8
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8-10
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	8-10
Bias	9	Describe any efforts to address potential sources of bias	10-11
Study size	10	Explain how the study size was arrived at	8 (and Fig S1)
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8-10
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	10-11
		(*b*) Describe any methods used to examine subgroups and interactions	10-11
		(*c*) Explain how missing data were addressed	11
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	11
		(*e*) Describe any sensitivity analyses	11
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8 (and Fig S1)
		(b) Give reasons for non-participation at each stage	8 (and Fig S1)
		(c) Consider use of a flow diagram	Fig S1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	12 (and Table 1)
		(b) Indicate number of participants with missing data for each variable of interest	10-11
Outcome data	15*	Report numbers of outcome events or summary measures	8
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	13-14 (and Table 5)
		(*b*) Report category boundaries when continuous variables were categorized	10
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	11
Discussion			
Key results	18	Summarise key results with reference to study objectives	14
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	15-16
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	17-20
Generalisability	21	Discuss the generalisability (external validity) of the study results	15-20
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	29

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Does parental concern about their child's future risk of overweight vary by their ethnic background? Cross-sectional analysis of a national cohort study

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Does parental concern about their child's future risk of overweight vary by their ethnic background? Cross-sectional analysis of a national cohort study

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Abstract

Objectives

Children from South Asian ethnic backgrounds are at increased risk of obesity and its associated future health risks, however evidence is lacking as to whether parental concern about their child's future overweight risk varies by ethnic background. We hypothesised that parents of five-year-old children from South Asian backgrounds would be more likely to express such concerns.

Design: Cross-sectional

Setting: United Kingdom

Participants: 15,039 singleton five-year-old Millennium Cohort Study participants (48.9% girls; 86.7% White).

Primary outcome measure: Parent-reported concern (some/none) about future overweight risk.

Methods

We estimated the adjusted odds ratios (aOR) of some parental concern (ranging from a little to very concerned) by child's ethnic background (reference group: White), adjusted for parent and child weight status, and child sex.

Results

Parents of girls from Pakistani (aOR; 95%CI: 0.4; 0.2,0.5), Bangladeshi (0.3; 0.2,0.5), Black African (0.5; 0.3,0.7) and Mixed (0.7; 0.5,0.99) ethnic backgrounds and of boys from Pakistani ethnic backgrounds (0.6; 0.4,0.9) were less likely to report concern about their child's future overweight risk than parents of White girls and boys, respectively. Overweight (2.5; 2.2,2.8) and obesity (6.7; 5.7,7.9) in children, and overweight (1.4; 1.2,1.5) and obesity (1.9; 1.7,2.2) in parents, were associated with increased likelihood of concern.

Conclusions

Parents of children from South Asian ethnic backgrounds express less concern about their child's future overweight risk. Qualitative studies are needed to understand the concerns of parents from different ethnic backgrounds to inform weight-management interventions in ethnically-diverse populations.

Article summary

Strengths and limitations of the study

- We used robust statistical methods to analyse a large, nationally representative cohort of children from diverse ethnic backgrounds, allowing examination of parental concern across ten ethnic groups
- We adjusted for factors known to be associated with increased parental concern, including child weight status, using clinical definitions of overweight and obesity, and applied ethnic-specific BMI adjustments for more accurate assessment of body fatness in children from South Asian and Black backgrounds.
- We were unable to apply adjustments to the BMI of children from Mixed and Other ethnic backgrounds because validated algorithms to adjust BMI among children from these groups are not available.
- Responses to the parental concern question are unlikely to be influenced by the study child weight measurement as weight was recorded after this question was answered and no interpretation or categorisation of BMI was provided to parents. As our study was cross-sectional, we are unable to determine the temporal association between concern and weight status.
- Some children may have been weighed prior to interview at home, or in clinic, schools or other settings and this might have influenced parental concern, however this information was not available.

Abbreviations

BMI – body mass index

UK – United Kingdom

MCS – Millennium Cohort Study

CI – confidence interval

OR – odds ratio

NCMP – National Child Measurement Programme

FMI – fat mass index

Introduction

In England more than a quarter of children currently leave primary school with a body mass index (BMI) indicating they are overweight or obese, at a level needing clinical weight management support.(1) These proportions vary by ethnic background, and, after adjustment to account for ethnic variation in body fat mass, are significantly higher among children from South Asian backgrounds, especially boys.(2) This has important implications for their future health, as children from South Asian backgrounds are known to be biologically more susceptible to the harms of overweight, and are at higher risk of developing type two diabetes and cardiovascular disease in adulthood.(3-5)

It has been suggested that parental concern about their child's current weight status(6) and about their child becoming overweight in the future(7) may be a meaningful predictor of willingness to engage in behaviour change.

Among parents of children whose BMI is in the overweight or obese range, there is evidence of increased parental concern about both their child's present weight status(8-11) and about their child becoming overweight in the future(12) relative to those whose children have a healthy weight BMI. Furthermore, it has been shown that parents express higher levels of this concern about current(13, 14) and future(15, 16) weight status for daughters with overweight or obesity than for sons,(13-16) as well as if they themselves have a BMI categorised as overweight or obese.(12, 16) There is only very limited evidence regarding ethnic variation in parental concern, with lower levels of concern for current childhood overweight reported in one study of parents from Black Somali backgrounds living in Liverpool,(8) and greater concern about future child overweight from another study of parents from Black Afro-Caribbean backgrounds living in London,(17) with others reporting no differences.(12)

However, these findings are based on regional studies with low response rates and consequently small sample sizes. Moreover, none adjusted BMI for ethnicity and few specifically examine parental

concern about future child overweight (as opposed to current child weight status), warranting further investigation.

Across the UK, children's heights and weights are measured on or shortly after entry to primary school at age five years. Following measurement, parents receive a feedback letter informing them of their child's weight status. Given the longitudinal evidence that obesity at the beginning of primary school strongly predicts obesity on leaving primary school,(18, 19) age five may be viewed as an appropriate time to intervene to prevent and tackle obesity. It is therefore important to understand how parental concern about future childhood overweight might relate to weight status at this point in the life course.

We used cross-sectional data from a large ethnically diverse UK-wide cohort study to examine whether parental concern about their child's future risk of overweight, reported when the child was aged five years, varied by ethnic background. Given the high rates of overweight and obesity observed among children from South Asian backgrounds after adjustments for body fat,(2) and having taken parent weight status and child sex into account, we hypothesised that parents of overweight and obese children from South Asian backgrounds would be more concerned about their child becoming overweight in the future relative to parents of overweight and obese children from White backgrounds.

Materials and methods

Study design

We used data from the Millennium Cohort Study (MCS), a prospective nationally representative cohort of children born between September 2000 and January 2002 in the UK, which used a stratified clustered sampling design to over-represent children born in disadvantaged areas, from ethnic minority groups or from Northern Ireland, Scotland and Wales. When the cohort child was aged nine months, 18,552 (68%) of 27,257 families contacted were interviewed at home when

demographic, social and health information was obtained. An additional 692 families were recruited at age three. Further interviews were conducted when children were aged three, five, seven, 11 and 14 years, when height and weight were measured. At age five, 15,246 (85.8%) of 17,770 families eligible for interview were interviewed, providing data for 15,459 children (Figure S1).

Inclusion and exclusion criteria

We included 15,039 of 15,459 singleton children whose parent (natural mother (97.0%), else child's main care-giver, all referred to hereafter as the parent) was interviewed when their child was aged five years, having excluded 418 twins and triplets, as well as two children with extreme height and/or weight measures at age five or missing ethnicity (Figure S1). We extracted information available for these children from their two earlier and two subsequent MCS interviews. Characteristics of those who did and did not participate in the age five interview are given in Table S1; participating children were more likely to be from families in the highest income quintiles and to have more highly educated mothers compared to non-participating children. We weighted all analyses to take account of survey design and to allow for potential ethnic and socioeconomic biases in cohort attrition by age five years.

Main Outcome measure

The main outcome measure was parental concern about their child's future risk of becoming overweight. This was assessed at the age five interview from responses to a question administered by a trained interviewer who asked the parent "How concerned are you about [child's name] becoming overweight in the future?" We followed the methods applied by others(12, 14-16) and derived a binary variable from the five possible responses as follows: parents reporting they were unconcerned (n=10,964), were categorised as "no parental concern", with all other responses (a little concerned (n=2,645), concerned (n=540), fairly concerned (n=390), very concerned (n=418)) categorised as "parental concern". Response to this question was missing for 82 parents.

Main exposure variable

Ethnic background of the child was obtained from parental report at the first MCS interview and categorised using UK 2011 Census categories. Analyses were based on ten individual Census categories, with the exception of some analyses where individual ethnic groups were too small to create 95% confidence intervals (CI) when categories which were grouped as follows: White (Irish, Traveller, Other), South Asian (Indian, Pakistani, Bangladeshi), Black (Black Caribbean, Black African, other Black), Mixed and Other (Other Asian, Chinese, Mixed, Other).(20)

Covariates

We examined two covariates: child weight status and parental weight status. At age five years, trained interviewers in the home measured the child's height and weight: height was recorded to the nearest millimetre using a Leicester Height Measure Stadiometer (Seca Ltd, Birmingham, UK) with the head positioned in the Frankfort plane. Children were weighed barefoot and without outdoor clothing on Tanita HD-305 scales (Tanita, UK Ltd, Middlesex, UK) and weight recorded in kilograms to one decimal place.(21)

To enable comparison with the current English child measurement programme, we used published guidance from Public Health England(22) to assess the quality and range of height and weight measurements. We excluded one child with extreme short stature, and in addition assigned measurements in two children with extreme weight values as missing, as these were assumed erroneous when compared with their earlier or subsequent MCS measurements.

BMI at age five was calculated and adjusted for ethnicity using methods described by Hudda et al. who used similar ethnic categories to those employed in this study.(23) The authors pooled data from four UK studies which used the deuterium dilution method to measure body fat in approximately 2,000 children from White European, South Asian and Black African backgrounds. They derived a height-standardised fat mass index (FMI) to represent body fat and fitted linear

regression models to quantify ethnic differences in BMI-FMI relationships to provide ethnic-specific BMI adjustments. This adjustment entails adding approximately 1.1kg/m^2 to the BMI of children from South Asian backgrounds, and subtracting between -0.12kg/m^2 and -5.52kg/m^2 dependent upon sex, age group and unadjusted BMI to the BMI of children from Black backgrounds to more accurately reflect adiposity in these groups since it has been shown that BMI overestimates and underestimates body fat in children from Black and South Asian backgrounds, respectively. No adjustment is available to apply to children from Mixed or Other ethnic backgrounds.

We categorised the adjusted BMI according to the UK1990 clinical reference standard,(24) into four mutually exclusive groups: "underweight" (BMI<2nd centile), "healthy weight" (≥2nd to <91st centile), "overweight" (≥91st to <98th centile) or "obese" (≥98th centile) based on alignment with sex- and age-specific BMI centiles from the LMS growth tool Excel add-in.(25, 26) We defined those with BMI ≥98th centile or ≥91st to <98th centile as clinically obese and clinically overweight respectively. The UK90 clinical reference standard uses higher thresholds to define overweight and obesity compared to the UK90 population reference standard, indicating the need for clinical support for weight management. These thresholds are used by a variety of health professionals to assess individual children, as opposed to the UK90 population thresholds which are used to monitor population prevalence of overweight and obesity.(24)

Parental BMI was calculated using the parent's self-reported weight (at the age five sweep) and their most recent self-reported height (usually recorded at the first contact sweep). Trained interviewers measured parental heights and weights objectively if they did not know their measurements for self-report. Parental BMI was categorised into four mutually exclusive groups: "underweight" (BMI<18.5kg/m^2), "healthy weight" (≥18.5 to <25kg/m^2), "overweight" (≥25 to <30kg/m^2) or "obese" (≥30kg/m^2). Due to the higher risk of type two diabetes and cardiovascular disease among adults from Asian backgrounds at a BMI lower than 25kg/m^2, lower thresholds for classifying overweight and obesity in South Asian adults were employed, where "overweight" is considered ≥23 to

<27.5kg/m^2 and "obese" as ≥27.5kg/m^2, based on National Institute for Health Care Excellence guidelines.(27)

Statistical methods

Response to the parental concern question was missing for 82 children. All children for whom consent was obtained from a parent or guardian and who could stand unaided had their height and weight measured.(21) Height was missing for 235 and weight was missing for 234 five year-olds (both height and weight were missing for 218 five year-olds). BMI was missing for 2,456 parents. We used multiple imputation to estimate missing data on parental concern, child height and weight at age five, and parental BMI, and built 20 imputed datasets using the weighted iterative chain algorithm,(28) including all variables involved in the analysis steps under the assumption that missingness is at random (Table S2). All analyses were carried out on imputed datasets, and sensitivity analyses on complete-cases.

We used descriptive statistics (proportions and 95% confidence intervals) to assess the prevalence of parental concern overall, and by sex, ethnic background, child weight status and parental weight status. Similarly, we examined associations of child's weight status with parental concern by sex and ethnic background. We used logistic regression to estimate the unadjusted odds of a parent being concerned about their child being overweight in the future by child's ethnic group, sex, weight status and parental weight status (reported as odds ratios [OR]). We then mutually adjusted for child's ethnic background, sex and child and parent weight status. We tested for interactions between the child's ethnic background and sex, and between child's ethnic background and weight status and used Wald test statistics for these interaction terms to inform the final logistic regression model. We derived sex- and ethnic-specific odds ratios by multiplying the interaction term coefficient by the ethnicity coefficient and plotted these in a forest plot.

All analyses and percentages cited were performed in Stata and weighted to take account of survey design and to allow for potential biases in attrition by age five years, using the `svyset` command (Stata/SE 15; Stata Corporation, Texas, USA).

Ethics approval

Approval for MCS was granted by the London Research Ethics Committees(29) and no further approval was required for this secondary analysis.

Patient and public involvement

This research was done without patient or public involvement. Neither were invited to comment on the study design and were not consulted to develop relevant outcomes or interpret results.

Results

Sample characteristics

Of 15,039 children, 48.9% were girls, 86.7% were from White, and 6.1% from South Asian, backgrounds (Table 1). Parental concern about their child becoming overweight in the future was reported by 27.3% of parents (18.6% 'a little concerned', 3.5% 'concerned', 2.6% 'fairly concerned', 2.6% 'very concerned'), and this was more common among parents of girls than of boys (Table 1).

Parental concern

Parental concern was strongly associated with child's BMI status, and was more common among parents of children with overweight or obesity (42.3% and 66.2% respectively) than among parents of children with a healthy weight (22.3%; Table 1). Similarly, parental concern was more likely to be reported by parents with overweight or obesity: 29.9% and 39.7%, respectively, compared to parents with a healthy weight (22.7%; Table 1).

Parental concern was reported significantly less among parents of children from Pakistani (20.9%) and Black African (20.1%) backgrounds, compared to parents of children from White ethnic backgrounds (27.8%; Table 1).

Overweight and obesity prevalence by ethnic background and sex

At age five, the prevalence of overweight and obesity was 11.0% and 6.6%, respectively, with obesity more prevalent among boys (7.5%) than girls (5.7%) (Table 2; parent weight status was positively associated with child weight status, see Table S3).

Within each ethnic group, most five-year-old children were of healthy weight, however children from South Asian backgrounds were more likely to have a BMI in the obese range than children from White backgrounds (Table 2). There were some minor differences by sex, with boys from South Asian backgrounds and girls from Pakistani and Bangladeshi backgrounds more likely to have a BMI in the obese range than those from White backgrounds (Table 2).

Parental concern by ethnic background and sex

Fewer parents of girls from Pakistani, Bangladeshi or Black African backgrounds reported parental concern relative to parents of girls from White backgrounds. These differences were not seen in boys (Table 3).

Parental concern by weight status, ethnic background and sex

Parental concern was reported for 73.4% of girls with obesity compared with 61.0% of boys with obesity (Table 4).

Parental concern was reported by fewer parents of healthy weight, overweight and obese girls from South Asian backgrounds compared to parents of girls from White backgrounds (Table 4). No differences in parental concern by weight status were observed between boys from different ethnic backgrounds (Table 4).

Logistic regression analyses

After mutual adjustment for ethnic background, sex and child and parent weight status, parental concern was significantly less likely among children from Pakistani, Bangladeshi and Black African ethnic backgrounds. Parental concern was more likely among parents of overweight and obese children, or of girls, and among parents who themselves were overweight or obese (Table 5 'Adjusted' model).

As the Wald test statistic for an interaction between sex and ethnic background was significant (Table S4), the final adjusted model included this interaction term (other interactions were not significant and were excluded from the final model, see Table S4). The sex- and ethnic-specific odds accounting for this interaction are shown in Table 5 and Figure 1, using White ethnic background as the reference category.

Parents of boys from Pakistani backgrounds were less likely to be concerned about their child's future risk of being overweight (Figure 1), as were parents of girls from Pakistani, Bangladeshi, Black African, Mixed or Other ethnic backgrounds.

In the final model, parental concern about future childhood overweight was more likely among parents of children with overweight and obesity, and less likely among parents of children considered underweight, compared to parents of children with a healthy weight (Figure 1). Parents who themselves had a BMI in the overweight or obese range were more likely, and those with a BMI considered underweight less likely, to report concern than those with a healthy weight (Figure 1).

Adjusted odds ratios were similar for complete case analyses (with the exception of the interaction between female sex and Bangladeshi ethnic background; Table S5) and for BMI without ethnic-adjustment (data not shown).

Discussion

Principal findings

In this large nationally representative study, we found that parents of children from South Asian backgrounds were less likely to be concerned about their child's future overweight risk, compared to those from White backgrounds. This was particularly so for girls from Pakistani and Bangladeshi backgrounds, and was independent of child and parent weight status. Furthermore, among our total sample of more than 15,000 children, we confirmed associations between parental concern and child sex and weight status reported by others.

Increased understanding of the context in which people from different ethnic backgrounds report parental concern is important to inform the development of interventions to support parents and families to alter the weight trajectories of their children with overweight or obesity. This is especially important for children from South Asian backgrounds, given their higher absolute risk of obesity and greater metabolic sensitivity to its effects. Our findings make a significant contribution to the literature on parental concern. This is to our knowledge the first study to use a UK-wide nationally representative cohort to examine whether parental concern about future risk of overweight in their child varies by ethnic background.

Strengths and limitations

Strengths of our study include analyses based on a large, nationally representative cohort of children from diverse ethnic backgrounds, allowing examination of parental concern across ten ethnic groups. Our findings are generalisable to the UK reflecting the nationally representative nature of the MCS: both the prevalence of overweight and obesity and the proportions of children from each ethnic background at age five in this cohort are similar to that reported from Public Health England's National Child Measurement programme (NCMP) for the 2006/07 academic year, when most children included in this study were aged five years.(30, 31)

We used robust statistical methods including imputation of missing data and use of survey weights to account for survey design and to allow for biases in attrition. We used a clinical definition of overweight and obesity that indicates the need for clinical weight management support, and applied

ethnic-specific BMI adjustment for more accurate assessment of body fatness in children from South Asian and Black ethnic backgrounds. While this method of adjusting children's BMI is not currently employed in the NCMP, which may make comparisons with other studies less straightforward, analyses without ethnic-adjustment produced similar findings.

We were able to adjust for a number of covariates in our analysis including those shown previously to be strongly associated with parental concern, including parental and child weight status (the latter based on objective measurements). Responses to the question eliciting parental concern are unlikely to be influenced by the MCS weight measurement as this question was asked before the child was weighed, and furthermore no interpretation or categorisation of BMI was provided in the feedback to parents.(29)

Although it is possible that some children may have been recently weighed either at home, in clinical care or in school as part of the NCMP, information on the timing of this in relation to the MCS interview, or the feedback given to parents, is unavailable. The MCS interview did not ask parents about their perception of their child's weight status at age five and consequently we were unable to adjust for this in our final model. Furthermore, given the cross-sectional design of this study, we are unable to draw any conclusions about the temporal relationship between parental concern and child weight status. Since the majority of main respondents were natural mothers our findings may not be generalizable to fathers or other parents.

As one in seven children in this study were from Black, South Asian and Other ethnic backgrounds, we were able to examine parental concern across all major ethnic groups; however, absolute numbers for some groups were small, resulting in greater uncertainty for these estimates.

We used lower thresholds for overweight and obesity to categorise BMI in adults from South Asian backgrounds to reflect the higher risk of type two diabetes and cardiovascular disease at lower levels of BMI experienced among these adults.(27) Although parental height and weight were self-reported, this is considered a reliable measure in epidemiological studies.(32, 33) Furthermore, at

present there are no validated algorithms for the adjustment of BMI for children from Mixed and Other ethnic backgrounds so no adjustments were made for these children in our analyses. Although we lacked statistical power to evaluate all subcategories of parental concern, we used the approach others have taken using this instrument and dichotomised parental concern into "concern" or "no concern" in order to produce robust estimates when examining parental concern by sex and ethnic background.(12, 14-16)

Other studies

There are to our knowledge no other published reports examining ethnic variation in parental concerns about their child's future risk of becoming overweight using a UK-wide nationally representative cohort of children. Our finding of less parental concern among parents of girls from Black African backgrounds is similar to that reported for parents from Black Somali backgrounds in Liverpool,(8) but not consistent with those from a regional study which observed greater parental concern among parents from Black Afro-Caribbean backgrounds living in London.(17)

The explanations for our main finding that there is variation by ethnic background in parental reported concern about their child's future risk of becoming overweight warrant further investigation. This finding may reflect differences in awareness of children's weight status or perceptions of childhood weight and size among parents from different ethnic backgrounds. However, it may be more useful to explore the wider context and barriers which children and their families from different ethnic backgrounds face in negotiating healthy or "ideal" weight so that interventions can be considered which reflect the diverse ethnic backgrounds of children with obesity in the UK.

Many parents are unable to identify overweight or obesity in their children,(15, 34, 35) with the majority of parents of children with a BMI in the overweight or obese range underestimating their child's weight status,(12, 36) a finding replicated in numerous high income countries across the world.(35, 37, 38) While there is some evidence that recognition of overweight or obesity is difficult

among adults from South Asian backgrounds,(39) the reasons for this remain unclear and similar studies in children are lacking.

While parental recognition of child overweight or obesity can be helped by presenting them with child age- and sex-specific body images,(40) these have not been tested among parents from different ethnic backgrounds. Furthermore, we did not find any evidence to suggest that parental concern about child future overweight risk among children from different ethnic backgrounds varied by objectively measured child weight status.

Qualitative research provides important contextual information about South Asian parents and their extended families. Pallan et al. have highlighted the importance of intergenerational influences on child diet and perception of their weight status, suggesting that fatness may signal health and that provision of abundant food may symbolise parental/carer affection for the child.(41) This may be important for families relying on grandparents for informal childcare, and multi-generational households where meals are communally prepared and eaten.(41, 42) For example, studies of women from Pakistan living in North West England and an ethnically diverse sample of families in London have both reported that in these groups, familial expectations to maintain traditional home-cooking procedures are obstacles to changing food preparation and eating practices.(42) Similarly, qualitative research involving women from Somalia living in Liverpool found that many women felt restricted in their efforts to live healthier lifestyles by older relatives' perspectives which promote increased weight, although this study did not focus on the influence of the home environment on their child's weight status,(43) highlighting differences between people from different ethnic backgrounds.

While there is evidence that acculturation can alter maternal health behaviours with the adoption of potentially less healthy behaviours by migrants over time,(44) we did not set out to examine structural barriers or acculturation amongst migrants in this study and further research to explore intergenerational variation in parental concern about future childhood overweight is required.

Our finding that a greater proportion of parents of girls compared to parents of boys from White backgrounds were concerned about their child becoming overweight in the future is consistent with findings from other UK studies of predominantly White populations(13-15) and with one from Australia.(16) This may reflect societal expectations of "ideal" body shapes for boys and girls(14) whereby girls are expected to be slight or petite, and boys to be bigger, stronger or more muscular.(45) Findings from a qualitative study interviewing parents of pre-school aged children in America suggest that childhood overweight is normalised through the use of euphemistic terms like 'cute baby fat' or 'podge',(46) and discussions of body size relate to how 'big', 'strong' or 'muscular' the child is.(47) Other studies have suggested that parents do not worry about their child's weight status because they believe their child participates in an appropriate level of physical activity and/or eats a balanced or healthy diet.(47, 48)

Given these accounts, parents from different ethnic backgrounds may experience social contexts where monitoring child weight is not a priority, particularly in environments where higher weight is a signal of wellness, health and affection for the child. Similarly, given that people from ethnic minority backgrounds, particularly from Pakistan and Bangladesh, are more likely than White British people to live in the most deprived areas in England,(49) it is possible parents prioritise providing for their family over parental concern about future childhood overweight, a less immediate concern. This view is supported by literature which suggests that the future may be perceived differently depending upon personal circumstances, such that concepts of 'public health futures' are not applicable to all individuals.(50)

Our finding that concern was reported more often for children with overweight and obesity is consistent with previously published reports.(9, 12-15) Our findings are similar to those of Carnell et al. who used the same question and response scale but did not examine the influence of ethnicity on this association.(12) Parents may be better able to identify their child's weight status at the extreme end of obesity(14, 15) indicating that, to some extent, parents are aware of overweight in their

children. Inability to assess correctly their child's weight may be a barrier to prevention of childhood obesity,(13, 14, 51) since lifestyle changes are not initiated,(36, 52) however Carnell et al. have argued that parental concern is a more sensitive indicator of parental awareness of child weight status than parental identification of a child's weight status.

The temporality of this relationship however remains unclear as our study was cross-sectional. Whilst it seems plausible that parents are more likely to report concern because their children are already overweight, a range of studies, predominantly from Australia(53-55) and the United States(56-60) as well the UK(61) and Sweden,(62) have proposed that parents reporting concern about their child becoming overweight might be more likely to engage in behaviours such as restrictive feeding, where children's food is controlled and limited.

Longitudinal research has suggested that restrictive feeding practices can result in child weight gain. A prospective study of Australian children aged two years suggests restrictive feeding practices lead to obesogenic behaviours such as overeating,(63) whilst in the United States a study of five to seven year-olds showed a positive association between restrictive feeding and additional weight gain among children at risk of obesity.(64) Two further longitudinal studies in the United States showed restrictive feeding practices were associated with increased eating in the absence of hunger among girls aged five to nine years.(65, 66)

With this in mind and given the cross-sectional nature of our study, our findings require careful interpretation: whilst it is possible that parental concern is a response to child overweight, it remains that child overweight could be in part driven by parental concern and associated feeding practices.

Whether parental feeding practices vary by ethnic background is largely unknown,(67) but remains an important research question particularly as it has been suggested that there may be benefits to restrictive feeding for older, more overweight children but less so for younger, healthy weight children who are yet to develop their eating behaviours.(67) One cross-sectional study comparing feeding practices in Germany and Britain found that parents from Black Afro-Caribbean backgrounds

living in Britain were more likely to use restrictive feeding practices than parents from White backgrounds living in either Britain or Germany, and this was associated with higher child BMI.(68) Further research is needed to understand how social context and ethnic backgrounds might influence parents' feeding practices.

Implications for policy and practice

Our study has implications for practice and research. Our cross-sectional analyses confirmed a strong positive association between the child's current weight status and parental concern, suggesting parents of children with a BMI in the overweight and obese range are more likely than other parents to be concerned about their child's future overweight risk. This is important, given the suggestion that appropriate parental concern is vital for effective parental engagement with obesity intervention programmes(7) and positive behaviour change.(6) Further research is needed to determine whether parental concern is associated with healthier weight trajectories, as well as to understand how feedback given to parents about their child's weight status from the NCMP can be appropriately and accurately conveyed to parents from different ethnic backgrounds.

Our study also has implications in particular for targeted interventions aimed at childhood obesity prevention and management. Parents from particular ethnic backgrounds at higher risk of obesity are less likely to express concern about future childhood overweight, particularly so for girls. This needs to be taken into account in developing ethnically sensitive interventions for weight management of children with obesity in multi-ethnic populations. As with all complex interventions, these need to be informed by qualitative studies to elucidate the factors underlying these novel observed differences in rates of parental concern among participants from different ethnic backgrounds, and to aid their interpretation.

Conclusion

In summary, we have found that, in contrast to our original hypothesis and after taking into account child and parental weight status, parents of children from South Asian ethnic backgrounds who are at higher risk of childhood obesity and its adverse consequences are less likely to report concern for their child's future overweight risk, particularly for their daughters. These novel insights are of importance to the UK population, where the highest risk of obesity is observed in individuals and communities from these backgrounds.

Table 1 – Sample characteristics and proportion of parents reporting parental concern

	Sample characteristics[1]		Parental concern	
	%	95% CI[2]	%	95% CI[2]
All	100		27.3	26.3,28.3
Sex				
Boys	51.1	50.2,52.1	24.1	22.8,25.4
Girls	48.9	47.9,49.8	30.7	29.4,31.9
Child weight status[3]				
Healthy weight	81.7	81.0,82.5	22.3	21.3,23.3
Overweight	11.0	10.4,11.6	42.3	39.6,45.1
Obese	6.6	6.1,7.1	66.2	62.9,69.6
Parent weight status[4]				
Underweight	3.1	2.7,3.4	15.4	11.1,19.6
Healthy weight	52.8	51.5,54.0	22.7	21.5,23.9
Overweight	27.2	26.2,28.2	29.9	28.0,31.9
Obese	16.9	16.0,17.8	39.7	37.4,42.0
Ethnic background[5]				
White	86.7	84.3,89.0	27.8	26.8,28.8
South Asian	6.1	4.3,7.8	23.5	20.5,26.5
Indian	*1.8*	*1.3,2.4*	*28.5*	*23.2,33.7*
Pakistani	*3.1*	*1.7,4.6*	*20.9*	*17.0,24.7*
Bangladeshi	*1.1*	*0.5,1.6*	*22.6*	*16.8,28.4*
Black	2.8	1.8,3.8	24.9	19.6,30.1
Black Caribbean	*1.0*	*0.6,1.4*	*32.3*	*21.9,42.7*
Black African	*1.6*	*1.0,2.3*	*20.1*	*15.5,24.7*
Other Black	*0.2*	*0.1,0.2*	*25.7*	*7.3,44.1*
Mixed and Other	4.5	3.8,5.2	24.9	20.0,29.7
Other Asian	*0.6*	*0.3,0.8*	*30.7*	*17.7,43.8*
Chinese and Other	*0.7*	*0.5,0.9*	*20.9*	*12.4,29.3*
Mixed	*3.2*	*2.7,3.7*	*24.7*	*19.2,30.1*

[1]Total N=15,039. [2]95% confidence interval. [3]Child weight status based on ethnic-adjusted BMI and categorised according to UK90 clinical reference standard. [4]Parental weight status was categorised using BMI calculated from parental self-reported weight and height as follows: "underweight" (BMI<18.5kg/m^2), "healthy weight" (≥18.5 to <25kg/m^2), "overweight" (≥25 to <30kg/m^2) or "obese" (≥30kg/m^2), except for South Asian adults where "overweight" is ≥23 to <27.5kg/m^2 and "obese" is ≥27.5kg/m^2. [5]Ethnic background of the child was obtained from parental report at the first MCS interview and categorised using UK 2011 Census categories.

Table 2 – Overweight and obesity[1] prevalence by ethnic background[2] and sex

	Boys				Girls				All			
	Overweight		Obese		Overweight		Obese		Overweight		Obese	
	%	95% CI[3]	%	95% CI[3]	%	95% CI[3]	%	95% CI[3]	%	95% CI[3]	%	95% CI[3]
White	11.7	10.8,12.6	6.9	6.2,7.6	10.1	9.2,11.1	5.4	4.7,6.0	10.9	10.3,11.6	6.1	5.6,6.6
South Asian	12.8	9.5,16.0	15.9	13.0,18.8	16.8	13.3,20.4	10.6	7.4,13.8	14.8	12.8,16.8	13.3	11.1,15.4
Indian	*9.2*	*4.8,13.6*	*17.3*	*10.7,23.9*	*18.3*	*9.8,26.8*	*6.8*	*0.9,12.6*	*13.6*	*9.1,18.1*	*12.2*	*8.1,16.3*
Pakistani	*14.1*	*9.0,19.2*	*14.0*	*10.1,18.0*	*17.7*	*13.5,22.0*	*9.5*	*6.5,12.4*	*15.7*	*13.0,18.8*	*11.8*	*9.4,14.1*
Bangladeshi	*15.3*	*7.8,22.9*	*18.8*	*11.5,26.1*	*12.1*	*6.4,17.9*	*19.7*	*11.1,28.3*	*13.8*	*10.3,17.1*	*19.3*	*14.0,24.5*
Black	5.1	2.0,8.2	8.2	3.6,12.8	6.7	2.4,10.9	5.0	0.0,10.3	5.8	4.1,8.6	6.8	2.5,11.1
Black Caribbean	*4.9*	*0.5,9.4*	*14.8*	*2.7,27.0*	*5.2*	*0.3,10.2*	*2.8*	*0.0,6.0*	*5.1*	*2.4,7.7*	*9.6*	*2.4,16.7*
Black African	*5.8*	*2.4,9.3*	*4.7*	*1.0,8.5*	*8.0*	*1.3,14.8*	*6.7*	*0.0,14.9*	*6.7*	*2.8,11.0*	*5.7*	*1.2,10.1*
Other Black[4]												
Mixed and Other	11.3	7.5,15.1	7.0	3.8,10.3	8.5	4.7,12.2	6.2	3.2,9.3	9.9	7.3,12.4	6.6	4.5,8.8
Other Asian	*3.3*	*0.1,6.5*	*9.0*	*0.0,19.3*	*2.7*	*0.2,5.2*	*1.7*	*0.0,4.0*	*3.1*	*0.9,5.1*	*5.0*	*0.0,10.3*
Chinese and Other	*8.3*	*0.0,17.0*	*5.6*	*0.0,11.5*	*6.5*	*0.4,12.6*	*6.2*	*0.0,13.5*	*7.3*	*2.5,12.2*	*5.9*	*1.2,10.7*
Mixed	*13.1*	*8.4,17.9*	*7.0*	*3.1,10.9*	*10.1*	*5.1,15.0*	*7.1*	*3.1,11.2*	*11.6*	*8.4,14.9*	*7.1*	*4.4,9.8*
Total	11.5	10.7,12.4	7.5	6.8,8.1	10.4	9.5,11.2	5.7	5.1,6.4	11.1	10.4,11.6	6.6	6.1,7.1

[1] Child weight status based on ethnic-adjusted BMI and categorised according to UK90 clinical reference standard.[2]Ethnic background of the child was obtained from parental report at the first MCS interview and categorised using UK 2011 Census categories. [3]95% confidence interval. [4]Overweight and obesity prevalence estimates not stated due to small numbers. Total N=15,039.

Table 3 – Parental concern about future overweight risk at age five years by ethnic background[1], and sex

	Boys		Girls	
	%	95% CI[2]	%	95% CI[2]
White	24.1	22.8,25.4	31.6	30.3,33.0
South Asian				
Indian	25.4	18.2,32.5	31.8	23.1,40.5
Pakistani	21.8	15.4,28.3	19.9	14.6,25.3
Bangladeshi	24.3	15.5,33.1	21.1	13.0,29.1
Black				
Black Caribbean	32.1	20.3,43.9	32.5	19.3,45.8
Black African	19.2	11.4,27.1	21.1	15.6,26.7
Other Black	26.3	3.1,49.5	24.8	0.0,54.0
Mixed and Other				
Other Asian	35.7	19.6,51.8	26.5	9.9,43.2
Chinese and Other	20.2	7.6,32.8	21.5	8.6,34.3
Mixed	23.7	16.2,31.3	25.7	19.3,32.0

[1]Ethnic background of the child was obtained from parental report at the first MCS interview and categorised using UK 2011 Census categories. [2]95% confidence interval. Total N=15,039.

Table 4 – Parental concern about future overweight risk at age five years, by child weight status[1] at age five

	Proportion of parents reporting parental concern									
	White		South Asian		Black		Mixed and Other		All	
	%	95% CI[2]	%	95% CI[2]	%	95% CI[2]	%	95% CI[2]	%	95% CI[2]
All										
Healthy weight	22.8	21.8,23.8	16.9	14.5,19.3	21.5	15.5,27.6	19.5	14.6,24.4	22.3	21.3,23.3
Overweight	43.8	40.8,46.8	28.4	22.1,34.8	30.1	6.9,53.3	39.8	25.3,54.3	42.3	39.5,45.1
Obese	67.8	63.8,71.7	51.8	44.2,59.3	72.8	58.4,87.2	70.4	55.1,85.7	66.2	62.8,69.6
Boys										
Healthy weight	19.6	18.3,21.0	16.8	13.5,20.2	18.1	13.0,23.2	17.6	11.3,23.8	19.3	18.0,20.6
Overweight	34.2	30.1,38.3	25.9	16.4,35.4	46.7	20.4,72.9	46.6	25.9,67.3	34.5	30.8,38.3
Obese	61.4	56.1,66.7	51.4	41.6,61.2	55.6	31.8,79.3	70.7	47.9,93.4	61.0	56.6,65.4
Girls										
Healthy weight	26.0	24.7,27.3	17.0	13.6,20.3	23.6	17.7,29.6	21.3	15.4,27.3	25.3	24.1,26.5
Overweight	55.4	51.2,59.5	30.5	21.6,39.4	37.2	10.2,64.3	30.7	11.7,49.7	51.4	47.2,55.6
Obese	76.3	70.5,82.1	52.3	40.5,64.1	72.9	39.7,100.0	70.1	48.1,92.1	73.4	68.8,78.6

[1]Underweight groups omitted due to small numbers. Child weight status based on ethnic-adjusted BMI and categorised according to UK90 clinical reference standard. [2]95% confidence interval. Total N=15,039.

Table 5 – Unadjusted, adjusted and sex- and ethnic-specific adjusted odds of parental concern about future overweight risk at age five years

	Unadjusted		Adjusted[1]		Model with interaction term[2]		Final model: Sex- and ethnic-specific adjusted odds[3]			
							Boys		Girls	
	OR (*p*-value)[4]	95% CI[5]	OR (*p*-value)[4]	95% CI[5]	OR (*p*-value)[4]	95% CI[5]	OR[4]	95% CI[5]	OR[4]	95% CI[5]
Ethnic background[6]	(0.008)		(<0.001)		(0.057)					
White (ref.)	1		1		1		1		1	
South Asian										
Indian	1.04	0.80,1.35	0.80	0.60,1.09	0.77	0.52,1.14	0.77	0.52,1.14	0.84	0.54,1.30
Pakistani	**0.69**	**0.54,0.87**	**0.46**	**0.34,0.61**	**0.59**	**0.38,0.91**	**0.59**	**0.38,0.91**	**0.36**	**0.24,0.53**
Bangladeshi	0.76	0.54,1.06	**0.43**	**0.31,0.61**	0.62	0.38,1.01	0.62	0.38,1.01	**0.32**	**0.21,0.48**
Black										
Black Caribbean	1.24	0.77,1.99	1.15	0.73,1.80	1.25	0.78,2.00	1.25	0.78,2.00	1.05	0.56,1.94
Black African	**0.66**	**0.49,0.87**	**0.61**	**0.44,0.84**	0.77	0.46,1.28	0.77	0.46,1.28	**0.49**	**0.32,0.74**
Other Black	0.90	0.34,2.36	1.17	0.43,3.20	1.36	0.37,5.04	1.36	0.37,5.04	0.94	0.20,4.48
Mixed and Other										
Other Asian	1.15	0.62,2.14	1.28	0.66,2.48	2.00	0.99,4.05	2.00	0.99,4.05	0.88	0.34,2.27
Chinese and other	0.69	0.41,1.14	0.66	0.39,1.10	0.79	0.33,1.89	0.79	0.33,1.89	0.57	0.28,1.14
Mixed	0.85	0.64,1.14	0.81	0.60,1.09	0.96	0.63,1.46	0.96	0.63,1.46	**0.69**	**0.48,0.99**
Sex	(<0.001)		(<0.001)		(<0.001)					
Male (ref.)	1		1		1					
Female	**1.39**	**1.28,1.51**	**1.52**	**1.40,1.65**	**1.59**	**1.46,1.73**				
Child weight status[7]	(<0.001)		(<0.001)		(<0.001)		**OR[4]**	**95% CI[5]**		
Underweight	**0.32**	**0.16,0.64**	**0.34**	**0.17,0.68**	**0.34**	**0.17,0.68**	**0.34**	**0.17,0.68**		
Healthy weight (ref.)	1		1		1		1			
Overweight	**2.56**	**2.28,2.87**	**2.47**	**2.19,2.78**	**2.47**	**2.20,2.79**	**2.47**	**2.20,2.79**		
Obese	**6.84**	**5.84,8.01**	**6.70**	**5.68,7.90**	**6.71**	**5.68,7.93**	**6.71**	**5.68,7.93**		
Parental weight status[8]	(<0.001)		(<0.001)		(<0.001)					

Underweight	**0.62**	**0.44,0.87**	**0.68**	**0.48,0.96**	**0.68**	**0.48,0.97**	**0.68**	**0.48,0.97**
Healthy weight (ref.)	1		1		1			
Overweight	**1.46**	**1.30,1.63**	**1.35**	**1.20,1.52**	**1.35**	**1.20,1.52**	**1.35**	**1.20,1.52**
Obese	**2.24**	**2.01,2.50**	**1.94**	**1.72,2.19**	**1.94**	**1.72,2.19**	**1.94**	**1.72,2.19**
Sex x ethnic background					(0.087)			
Female x White (ref.)					1			
Female x South Asian								
Female x Indian					1.09	0.61,1.96		
Female x Pakistani					0.61	0.33,1.13		
Female x Bangladeshi					**0.51**	**0.28,0.94**		
Female x Black								
Female x Black Caribbean					0.84	0.46,1.53		
Female x Black African					0.63	0.31,1.28		
Female x Other Black					0.69	0.09,5.28		
Female x Mixed and Other								
Female x Other Asian					0.44	0.17,1.15		
Female x Chinese and Other					0.72	0.22,2.32		
Female x Mixed					0.72	0.44,1.18		

*[1]Mutually adjusting for ethnic background, sex, age five weight status and parental weight status. [2]Mutually adjusting for ethnic background, sex, child weight status, parental weight status, and an interaction between sex and ethnic background. An interaction between child weight status and ethnic background was tested but deemed not statistically significant so was excluded from the final model (see Table S4). [3]Calculated by multiplying the interaction coefficient with ethnicity coefficient in the model with the interaction term. Mutually adjusting for ethnic background, sex, age five weight status and parental weight status. [4]*Odd ratio (and p-*value for corresponding Wald test statistic). [5]95% confidence interval. [6]Ethnic background of the child categorised using UK 2011 Census categories. [7]Child weight status based on ethnic-adjusted BMI categorised according to UK90 clinical reference standard. [8]Parental weight status was categorised using BMI calculated from parental self-reported weight and height as follows: "underweight" (BMI<18.5kg/m^2), "healthy weight" (≥18.5 to <25kg/m^2), "overweight" (≥25 to <30kg/m^2) or "obese" (≥30kg/m^2), except for South Asian adults where "overweight" is ≥23 to <27.5kg/m^2 and "obese" is ≥27.5kg/m^2. Cells in bold font indicate the estimate is statistically significantly different to the reference category.*

Figure 1 – Adjusted odds of parental concern about future childhood overweight[1]

[1] Mutually adjusted for ethnic background, sex, child weight status, parent weight status and an interaction between sex and ethnic background.

Conflicts of interest

The authors declare no conflict of interest.

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Author statement

NF and CD conceptualised and designed the analysis. NF carried out the literature search, conducted and interpreted the analyses, generated tables and figures and drafted the initial manuscript. CD contributed to the interpretation of analyses and reviewed and revised the manuscript. All authors were involved in writing the paper and had final approval of the submitted and published versions.

Data statement

The MCS data for surveys 1-6 can be downloaded from the UK Data Service.

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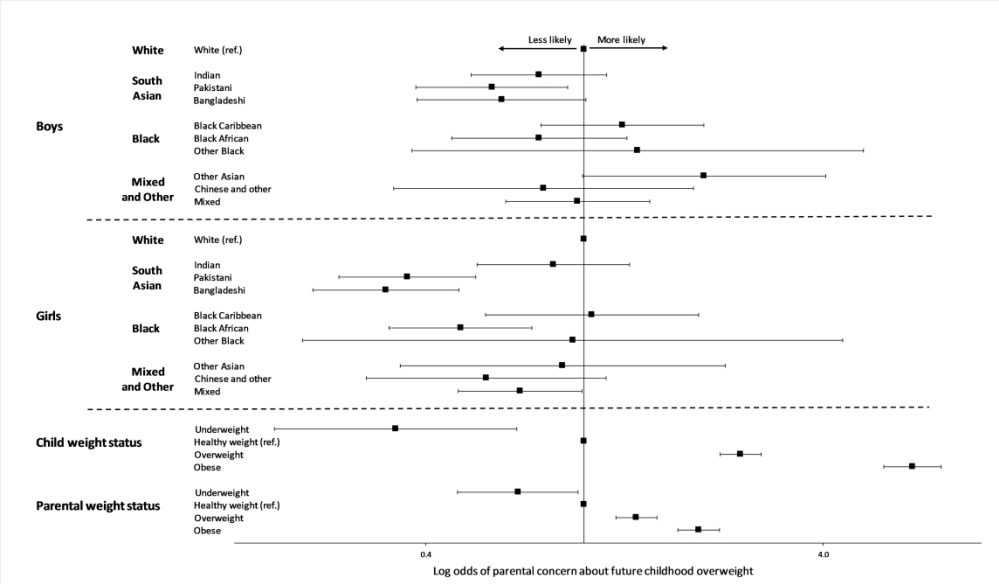

Figure 1 – Adjusted odds of parental concern about future childhood overweight

Does parental concern about their child's future risk of overweight vary by ethnic background? Cross-sectional analysis of a national cohort study

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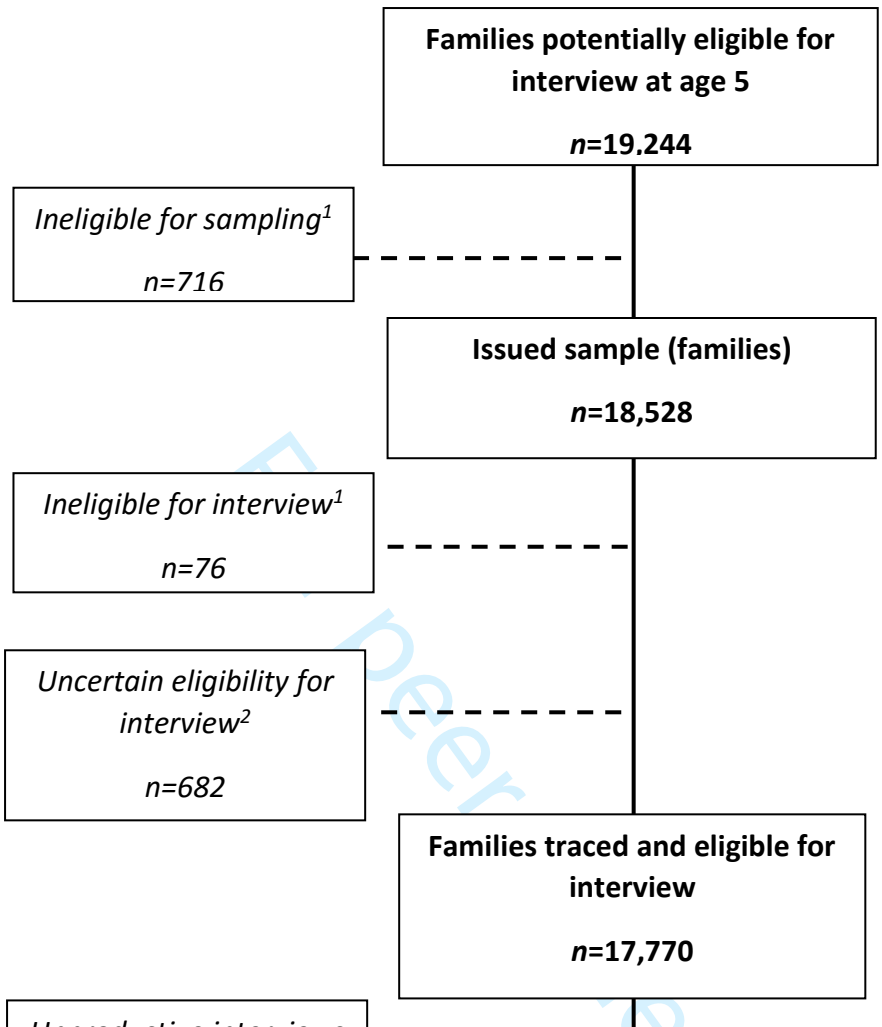
Supplementary material

Figure S1 - Flow chart of study sample



[1]Due to death, emigration, permanent refusal or sensitive family circumstances. [2]Due to untraced movers, outstanding movers or ran out of time to complete sampling. [3]Data for individual children not available prior to the point of productive interview. [4]418 twins/triplets, 1 child with extreme height values, 1 child missing ethnicity.

Table S1 - Sample characteristics of singleton children participating and not participating[1] in MCS at age five

	Singleton children participating at age 5 (n=15,041)		Singleton children not participating at age 5 (n=3,939)	
	n	%[2]	n	%[2]
Child sex				
Male	7708	51.2	2065	52.4
Female	7333	48.8	1874	47.6
Ethnic background[3]				
White	12524	83.3	2990	75.9
South Asian	1361	9.1	474	12.0
Black	505	3.3	213	5.4
Mixed or other	650	4.3	238	6.1
Missing	1	0.0	24	0.6
Parental weight status[4]				
Underweight	541	3.6	156	4.0
Healthy weight	7775	51.7	2018	51.2
Overweight	3591	23.9	880	22.3
Obese	1886	12.5	451	11.5
Missing	1248	8.3	434	11.0
OECD household income quintile[5]				
Lowest	3496	23.2	1326	33.7
2	3306	22.0	977	24.8
3	2852	19.0	685	17.4
4	2761	18.4	479	12.1
Highest	2558	17.0	425	10.8
Missing	68	0.4	47	1.2
Parental highest academic qualification[5]				
Degree or diploma in higher education	3882	25.8	625	15.9
A/AS levels	1441	9.6	296	7.5
GCSEs	6573	43.7	1753	44.5
Other academic qualifications	419	2.8	153	3.9
None	2678	17.8	1072	27.2
Missing	48	0.3	40	1.0

[1] 18,980 singleton children were first recruited/interviewed at either MCS sweep 1 (age nine months) or MCS sweep 2 (age three years). At MCS sweep 3 (age five), 3,939 singleton children did not participate. [2]Proportions are unweighted. [3]Ethnic background of the child was obtained from parental report at the first MCS interview and categorised using UK 2011 Census categories. [4]Parental weight status when the child was aged five years was categorised using BMI calculated from parental self-reported weight and height as follows: "underweight" (BMI<18.5kg/m^2), "healthy weight" (≥18.5 to <25kg/m^2), "overweight" (≥25 to <30kg/m^2) or "obese" (≥30kg/m^2), except for South Asian adults where "overweight" is ≥23 to <27.5kg/m^2 and "obese" is ≥27.5kg/m^2. [5]Recorded at the age nine month interview, or the age three interview for the boosted sample.

Table S2 - Multiple Imputation

Multiple imputation was performed to impute values for our outcome of interest (parental concern) and covariates (child and parental BM). Imputations were based on the variables below, which were all shown to be significantly correlated (at the 5% level) with non-measurement of parental concern, height or weight at ages five and 11:

Variables used in multiple imputation[1]	Number of children with missing data[2] n	%[3]
Outcome of interest		
Parental concern[4]	82	0.6
Exposures of interest		
Child's ethnic background[5]	0	-
Covariates		
Child height measurements[6]:		
Age 3	2367	15.7
Age 5	235	1.6
Age 7	2130	14.2
Age 11	2956	19.7
Child weight measurements[6]:		
Age 3	2219	14.8
Age 5	234	1.6
Age 7	2181	14.5
Age 11	3154	21.0
Parental BMI[6,7]	2456	16.3
Sociodemographic factors		
Child's sex[5]	0	-
Child's age in days[4]	0	-
OECD household income quintile[4]	1	-
Diet		
Portions of fruit eaten a day[4]	88	0.6
Reason for controlling child's diet[4]	1777	11.8
Main snack eaten between meals[4]	79	0.5
Main drink between meals[4]	79	0.5
Physical activity		
Mode of transport to and from school[4]	252	1.7
Days a week participates om sports clubs or classes[4]	69	0.5
Average hours of screen time a day[4]	78	0.5

[1]The attrition/non-response weight (for whole of UK-level analyses), a finite population correction factor, a stratum variable and a ward variable to account for clustering, were also included in the multiple imputation model. [2]Total N=15,039. [3]Proportions are unweighted. [4]Recorded at MCS sweep 3 (age five). [5]Obtained from parental report at the first MCS interview. [6]Height and weight values and parental BMI were transformed on the natural logarithmic scale to mitigate violation of the assumption of normal distributions. [7]Parental BMI based on self-reported weight at MCS sweep 3 (age five) and their most recent self-reported height (usually recorded at the first MCS sweep).

Table S3 – Child weight status at age five years by parent weight status

	Parental weight status[1]							
	Underweight		Healthy weight		Overweight		Obese	
	%	95% CI[2]	%	95% CI[2]	%	95% CI[2]	%	95% CI[2]
Child weight status[3]								
Underweight	0.9	0.0,2.0	0.8	0.6,1.1	0.5	0.3,0.8	0.6	0.2,1.0
Healthy weight	90.7	87.0,94.4	86.5	85.5,87.4	78.7	77.1,80.3	70.2	67.9,72.4
Overweight	6.0	2.9,9.1	8.6	7.8,9.4	13.0	11.7,14.3	15.9	14.2,17.7
Obese	2.4	0.6,4.2	4.1	3.5,4.7	7.8	6.7,8.9	13.3	11.8,14.9

[1]Parental weight status was categorised using BMI calculated from parental self-reported weight and height as follows: "underweight" (BMI<18.5kg/m^2), "healthy weight" (≥18.5 to <25kg/m^2), "overweight" (≥25 to <30kg/m^2) or "obese" (≥30kg/m^2), except for South Asian adults where "overweight" is ≥23 to <27.5kg/m^2 and "obese" is ≥27.5kg/m^2. [2]95% confidence interval. [3]Child weight status based on ethnic-adjusted BMI and categorised according to UK90 clinical reference standard.

Table S4 – Adjusted odds of parental concern about future overweight risk at age five years, including interactions between child sex and ethnic background and between child weight status and ethnic background

	With interactions[1] OR (*p*-value)[2]	95% CI[3]
Ethnic background[4]	(0.249)	
White (ref.)	1	
South Asian	**0.72**	**0.53,0.99**
Black	1.00	0.65,1.52
Mixed and Other	1.00	0.67,1.48
Sex	(<0.001)	
Male (ref.)	1	
Female	**1.59**	**1.46,1.74**
Child weight status[5]	(<0.001)	
Underweight	**0.33**	**0.15,0.75**
Healthy weight (ref.)	1	
Overweight	**2.52**	**2.22,2.87**
Obese	**6.75**	**5.55,8.20**
Parental weight status[6]	(<0.001)	
Underweight	**0.68**	**0.48,0.96**
Healthy weight (ref.)	1	
Overweight	**1.35**	**1.19,1.52**
Obese	**1.93**	**1.72,2.18**
Sex x ethnic background	(0.034)	
Female x White (ref.)	1	
Female x South Asian	0.71	0.47,1.06
Female x Black	0.71	0.43,1.15
Female x Mixed and Other	0.68	0.45,1.02
Child weight status x ethnic background	(0.184)	
Underweight x South Asian	-	-
Underweight x Black	0.47	0.06,3.90
Underweight x Mixed and Other	2.93	0.57,15.0
Healthy weight x White (ref.)	1	
Overweight x South Asian	0.79	0.46,1.37
Overweight x Black	0.56	0.15,2.08
Overweight x Mixed and Other	0.99	0.49,2.01
Obese x South Asian	0.74	0.47,1.18
Obese x Black	1.30	0.59,2.86
Obese x Mixed and Other	1.24	0.57,2.69

[1]Mutually adjusting for ethnic background, sex, age five weight status, parental weight status as well as two interaction terms: 1) sex x ethnic background 2) age five weight status x ethnic background. Four broader ethnic groupings were used instead of individual ethnic backgrounds to overcome small cell sizes when including both interaction terms in the model. [2]Odds ratio and p*-value for corresponding Wald test statistic. [3]95% confidence interval. [4]Ethnic background of the child categorised using UK 2011 Census categories. [5]Child weight status based on ethnic-adjusted BMI categorised according to UK90 clinical reference standard. [6]Parental weight status was categorised using BMI calculated from parental self-reported weight and height as follows: "underweight" (BMI<18.5kg/m^2), "healthy weight" (≥18.5 to <25kg/m^2), "overweight" (≥25 to <30kg/m^2) or "obese" (≥30kg/m^2), except for South Asian adults where "overweight" is ≥23 to <27.5kg/m^2 and "obese" is ≥27.5kg/m^2. Cells in bold font indicate the estimate is statistically significantly different to the reference category.*

Table S5 - Sensitivity analyses: univariable and multivariable odds of parental concern about future overweight risk at age five years using complete-cases

	Unadjusted		Adjusted[1]		With interactions[2]		Model with significant interaction[3]	
	OR (*p*-value)[4]	95% CI[5]	OR (*p*-value)[4]	95% CI[5]	OR (*p*-value)[4]	95% CI[5]	OR (*p*-value)[4]	95% CI[5]
Ethnic background[6]	(0.008)		(<0.001)		(0.410)		(0.108)	
White (ref.)	1		1		1		1	
South Asian					0.75	0.53,1.07		
Indian	1.04	0.80,1.35	0.77	0.56,1.06			0.77	0.51,1.16
Pakistani	**0.68**	**0.54,0.87**	**0.50**	**0.37,0.68**			**0.64**	**0.42,0.97**
Bangladeshi	0.76	0.54,1.06	**0.47**	**0.34,0.65**			0.65	0.38,1.12
Black					0.83	0.46,1.49		
Black Caribbean	1.25	0.77,2.01	1.19	0.66,2.15			1.20	0.58,2.48
Black African	**0.65**	**0.49,0.86**	**0.63**	**0.42,0.95**			0.77	0.43,1.38
Other Black	0.90	0.34,2.39	0.87	0.28,2.74			0.64	0.15,2.71
Mixed and Other					0.89	0.56,1.39		
Other Asian	1.15	0.62,2.14	1.18	0.56,2.52			1.82	0.78,4.26
Chinese and Other	0.69	0.41,1.14	0.69	0.39,1.22			0.75	0.26,2.16
Mixed	0.85	0.63,1.14	0.74	0.53,1.05			0.83	0.52,1.33
Sex	(<0.001)		(<0.001)		(<0.001)		(<0.001)	
Male (ref.)	1		1		1		1	
Female	**1.39**	**1.28,1.51**	**1.52**	**1.42,1.70**	**1.60**	**1.46,1.77**	**1.60**	**1.46,1.77**
Child weight status[7]	(<0.001)		(<0.001)		(<0.001)		(<0.001)	
Underweight	**0.33**	**0.17,0.66**	**0.35**	**0.17,0.73**	**0.39**	**0.17,0.89**	**0.35**	**0.17,0.72**
Healthy weight (ref.)	1		1		1		1	
Overweight	**2.56**	**2.28,2.87**	**2.48**	**2.17,2.83**	**2.51**	**2.18,2.90**	**2.49**	**2.18,2.84**
Obese	**6.90**	**5.90,8.08**	**6.46**	**5.39,7.74**	**6.44**	**5.24,7.92**	**6.44**	**5.37,7.73**
Parental weight status[8]	(<0.001)		(<0.001)		(<0.001)		(<0.001)	
Underweight	**0.62**	**0.45,0.87**	**0.67**	**0.47,0.95**	**0.66**	**0.46,0.94**	**0.67**	**0.47,0.95**
Healthy weight (ref.)	1		1		1		1	
Overweight	**1.44**	**1.28,1.62**	**1.34**	**1.18,1.52**	**1.33**	**1.18,1.51**	**1.34**	**1.19,1.52**
Obese	**2.21**	**1.98,2.47**	**1.93**	**1.72,2.17**	**1.92**	**1.71,2.16**	**1.93**	**1.72,2.18**
Sex x ethnic background					(0.228)		(0.444)	
Female x White (ref.)					1		1	
Female x South Asian					0.72	0.47,1.10		
Female x Indian							0.99	0.55,1.80
Female x Pakistani							0.63	0.35,1.14
Female x Bangladeshi							0.56	0.26,1.20
Female x Black					0.96	0.54,1.68		
Female x Black Caribbean							0.98	0.48,2.02
Female x Black African							0.66	0.28,1.57
Female x Other Black							1.72	0.19,15.4
Female x Mixed and Other					0.77	0.50,1.19		
Female x Other Asian							0.47	0.16,1.37
Female x Chinese and other							0.88	0.23,3.37
Female x Mixed							0.81	0.47,1.38
Child weight status x ethnic background					(0.406)			

Underweight x South Asian			-	-	
Underweight x Black			-	-	
Underweight x Mixed and Other			2.39	0.38,15.1	
Healthy weight x White (ref.)			1		
Overweight x South Asian			0.74	0.42,1.32	
Overweight x Black			0.69	0.22,2.19	
Overweight x Mixed and Other			1.23	0.57,2.63	
Obese x South Asian			0.83	0.47,1.47	
Obese x Black			2.86	0.93,8.78	
Obese x Mixed and Other			0.83	0.35,1.99	

[1]Mutually adjusting for ethnic background, sex, age five weight status and parental weight status. [2]Mutually adjusting for ethnic background, sex, age five weight status, parental weight status as well as two interaction terms: 1) sex x ethnic background 2) age five weight status x ethnic background. [3]Mutually adjusting for ethnic background, sex, child weight status, parental weight status, and an interaction between sex and ethnic background. [4]Odds ratio and p-*value for corresponding Wald test statistic. [5]95% confidence interval. [6]Ethnic background of the child categorised using UK 2011 Census categories. [7]Child weight status based on ethnic-adjusted BMI categorised according to UK90 clinical reference standard. [8]Parental weight status was categorised using BMI calculated from parental self-reported weight and height as follows: "underweight" (BMI<18.5kg/m^2), "healthy weight" (≥18.5 to <25kg/m^2), "overweight" (≥25 to <30kg/m^2) or "obese" (≥30kg/m^2), except for South Asian adults where "overweight" is ≥23 to <27.5kg/m^2 and "obese" is ≥27.5kg/m^2. Cells in bold font indicate the estimate is statistically significantly different to the reference category.*

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2-3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	6-7
Objectives	3	State specific objectives, including any prespecified hypotheses	7
Methods			
Study design	4	Present key elements of study design early in the paper	7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	8
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8-10
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	8-10
Bias	9	Describe any efforts to address potential sources of bias	10-11
Study size	10	Explain how the study size was arrived at	8 (and Fig S1)
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8-10
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	10-11
		(*b*) Describe any methods used to examine subgroups and interactions	10-11
		(*c*) Explain how missing data were addressed	11
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	11
		(*e*) Describe any sensitivity analyses	11
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8 (and Fig S1)
		(b) Give reasons for non-participation at each stage	8 (and Fig S1)
		(c) Consider use of a flow diagram	Fig S1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	12 (and Table 1)
		(b) Indicate number of participants with missing data for each variable of interest	10-11
Outcome data	15*	Report numbers of outcome events or summary measures	8
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	13-14 (and Table 5)
		(*b*) Report category boundaries when continuous variables were categorized	10
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	11
Discussion			
Key results	18	Summarise key results with reference to study objectives	14
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	15-16
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	17-20
Generalisability	21	Discuss the generalisability (external validity) of the study results	15-20
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	29

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.