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Complete List of Authors:	Firman, Nicola; Queen Mary University of London, Centre for Primary Care & Public Health, Barts and the London School of Medicine and Dentistry Boomla, Kambiz; Queen Mary University of London, Centre for Primary Care & Public Health, Barts and the London School of Medicine and Dentistry Hudda, Mohammed; St George's, University of London, Population Health Research Centre Robson, John; Queen Mary University of London, Centre for Primary Care & Public Health, Barts and the London School of Medicine and Dentistry Whincup, Peter; St George's, University of London, Population Health Research Centre Dezateux, Carol; Queen Mary University of London, Centre for Primary Care & Public Health, Barts and the London School of Medicine and Dentistry
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Is child weight status correctly reported to parents? Cross-sectional analysis of National Child Measurement Programme data using ethnic-specific BMI adjustments

Mrs Nicola Firman[1] - Research Assistant in Health Data Science

Dr Kambiz Boomla[1] - Clinical Senior Lecturer

Mr Mohammed T Hudda[2] - Research Fellow in Medical Statistics

Dr John Robson[1] - Clinical Reader in Primary Care Research & Development

Professor Peter Whincup[2] - Professor of Cardiovascular Epidemiology

Professor Carol Dezateux[1] – Professor of Clinical Epidemiology and Health Data Science

[1]Centre for Primary Care & Public Health, Barts and the London School of Medicine and Dentistry, Queen Mary University of London, Yvonne Carter Building, 58 Turner Street, London, E1 2AB, UK

[2]Population Health Research Institute, St George's, University of London, Cranmer Terrace, London, SW17 0RE, UK

Correspondence to: Nicola Firman; nicola.firman@qmul.ac.uk

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Abstract

Background

BMI underestimates and overestimates body fat in children from South Asian and Black ethnic groups, respectively.

Methods

We used cross-sectional NCMP data (2015-17) for 38270 children in three inner-London local authorities: City & Hackney, Newham and Tower Hamlets (41% South Asian, 18.8% Black): 20439 4-5 year-olds (48.9% girls) and 17831 10-11 year-olds (49.1% girls). We estimated the proportion of parents who would have received different information about their child's weight status, and the area-level prevalence of obesity - defined as ≥98th centile - had ethnic-specific BMI adjustments been employed in the English National Child Measurement Programme (NCMP).

Results

Had ethnic-specific adjustment been employed, 19.7% (3112/15830) of parents of children from South Asian backgrounds would have been informed their child was in a heavier weight category, and 19.1% (1381/7217) of parents of children from Black backgrounds would have been informed their child was in a lighter weight category. Ethnic-specific adjustment increased obesity prevalence from 7.9% (95% CI: 7.6,8.3) to 9.1% (8.7,9.5) among 4-5 year-olds and from 17.5% (16.9,18.1) to 18.8% (18.2,19.4) among 10-11 year-olds.

Conclusions

Ethnic-specific adjustment in the NCMP would ensure equitable categorisation of weight status, provide correct information to parents, and support local service provision for families.

Key words

Obesity, ethnicity, children

Background

Childhood obesity is a major public health concern globally(1) and in England, where more than a quarter of children leave primary school affected by overweight or obesity, at a level of severity defined as in need of clinical intervention.(2) Currently, national data suggest that this is highest among: boys; children from Black ethnic groups; and those living in disadvantaged communities, notably in London which has an ethnically diverse childhood population.(3)

Across England childhood obesity is monitored via the National Child Measurement Programme (NCMP) which measures the height and weight of children aged 4-5 and 10-11 years.(4) Body mass index (BMI) and corresponding weight status is calculated for each child. In some local authorities, parents of children who have taken part in the NCMP receive a letter informing them of their child's categorical weight status. This is calculated with reference to the exclusively White British 1990 child growth reference population (UK90), and children are categorised using a clinical reference standard as 'underweight', 'healthy weight', 'overweight' or 'very overweight' using the same age- and sex-specific BMI centile threshold across all ethnic groups.

Childhood obesity is associated with both short- and long-term health consequences including poor metal health, asthma, type 2 diabetes and cardiovascular disease.(5-8) This is particularly important among children from South Asian and Black ethnic backgrounds who are at higher risk of developing type 2 diabetes and cardiovascular disease in adulthood.(9-14) BMI is commonly used as a measure of body fatness, however in children from South Asian and Black ethnic backgrounds it has been shown that BMI underestimates and overestimates body fat respectively.(16, 17) To address this, ethnic-specific BMI adjustments to improve the estimation of body fat in children from South Asian and Black ethnic backgrounds have been developed(18) to enable accurate identification of children at high risk of these adverse health consequences. However these are not currently used in the NCMP. We estimated the proportion of parents who would have received different information about their child's weight status had ethnic-specific adjustments been employed in the NCMP and calculated the prevalence of obesity following ethnic-specific adjustment in inner London Clinical Commissioning Groups (CCGs) with high ethnic diversity.

Methods

Study sample

We used 40151 NCMP records from the 2015-16 and 2016-17 school years from three inner east London CCGs contributing to the Clinical Effectiveness Group (CEG) child health database: City & Hackney, Newham and Tower Hamlets. We removed 45 records which were exact duplicates, retained the most recent measurement of a further 19 children measured on two separate occasions, and excluded children for whom ethnic group was not recorded in either the NCMP or the child's primary care electronic health record (EHR; *n*=1817; Figure S1). The final study sample consisted of 38270 children: 20439 4-5 year-olds and 17831 10-11 year-olds.

Data sources

All children in the first and last years of primary school are invited to participate in the NCMP, which measures the height and weight of 4-5 and 10-11 year-olds attending state-maintained schools in England, on an opt-out basis. Annual data collection is coordinated by local authority public health departments which instruct teams to measure weight and height using protocols produced by Public Health England, specifying weight is measured to the nearest 0.1kg, and height to the nearest 0.1cm without shoes and outdoor clothing.(4)

We linked NCMP records to primary care EHRs based on pseudonymised NHS numbers created using a study-specific encryption key and OpenPseudonymiser software.(19) EHRs were used to ascertain the ethnic background of children with missing or not stated ethnicity in the NCMP data.

Outcome measures

Our main outcomes were the proportion of children whose weight category changed and the change in the prevalence of obesity (defined as BMI centile ≥98th) at CCG level.

We used BMI - as reported in the NCMP - to calculate the CCG and ethnic-specific prevalence of overweight and obesity prior to ethnic-specific adjustments. We then employed ethnic-specific BMI adjustments derived by Hudda et al. using pooled data from four UK studies which measured body fat mass using the deuterium dilution method in approximately 2,000 children from White European, South Asian and Black African backgrounds aged 4-12 years.(18) First, body fat mass was standardised for height to provide a height-independent fat mass index (FMI; kg/m^5). Second, sex-stratified regression models, adjusting for ethnic group and 3-year age groups, were fitted to quantify the ethnic differences in the relationship between BMI (dependent variable) and FMI (independent variable). All potential two-way and three-way interaction terms were included and tested, at the 5% significance level to assess potential effect modifiers for the ethnic differences. Finally, the model coefficients from the best fitting

models were used to derive adjustments needed to harmonise the relationship between BMI and FMI in all three ethnic groups ensuring that adjusted BMI values were associated with fat mass in the same way as in children from White ethnic backgrounds.(18) Results showed BMI should be adjusted by a constant term of +1.12 and +1.07 kg/m^2 in South Asian boys and girls, respectively. However, for children from Black African ethnic backgrounds, ethnic-specific BMI adjustments varied between -0.12 and -5.52 kg/m^2 depending on age group and body fatness. No adjustment is available to apply to children from Mixed or Other ethnic backgrounds.

We categorised BMI for all children before and after ethnic-specific adjustments using the LMS growth tool,(20, 21) based on the UK90 clinical cut-offs which identify children defined as in need of clinical intervention,(22) and which are employed in the NCMP to inform feedback letters sent to parents: underweight (BMI centile<2nd); overweight (BMI centile≥91st); obesity (BMI centile≥98th); and severe obesity (BMI centile≥120% of the 95th centile).(23) As the NCMP does not distinguish between obesity and severe obesity, we combined these categories when looking at information given to parents, but report them separately when looking at ethnic-specific prevalence. In City & Hackney, Newham and Tower Hamlets all parents of children participating in the NCMP receive a letter informing them of their child's categorical weight status.

Ethnicity

Ethnic grouping was based on child ethnicity documented in school records(4) and defined using the National Health Service classification.(24) We used ethnic groupings consistent with those used by Hudda et al.,(18) with four mutually exclusive groups: White ('White British', 'White Irish', or 'any other White background'); Black ('Black African', 'Black Caribbean', or 'any other Black background'); South Asian ('Indian', 'Pakistani', 'Bangladeshi' or 'Sri Lankan'); Mixed and other ('any other ethnic background', 'mixed ethnicity', 'Chinese' or 'Asian other'). Where NCMP ethnic background was missing or 'not stated' (*n*=5103), we used ethnicity as coded in the child's EHR (*n*=3286). We excluded 1817 children for whom an ethnic group code was missing in school and EHRs and examined potential biases in the characteristics of children with and without a record of ethnic group (Table S1).

Proportions of 4-5 and 10-11 year-olds from South Asian ethnic backgrounds were highest in Tower Hamlets and Newham, and lowest in City & Hackney. Equivalent proportions of children from Black ethnic backgrounds were highest in City & Hackney and Newham, and lowest in Tower Hamlets (Table S2).

Statistical methods

We estimated the following descriptive statistics: for each CCG, the change in age-specific prevalence (and 95% confidence interval) of underweight, overweight and obesity after ethnic-specific BMI adjustments for all children and by sex and ethnic background. We report the number and percentage of children in each age group whose weight status changed with ethnic-specific BMI adjustments. Analyses were performed using Stata/SE 15 (StataCorp LP).

Ethics approval

This is a secondary analysis of NCMP data, which is covered by data processing agreements allowing the sharing of de-personalised NCMP data between the CEG, Queen Mary University of London and each local authority public health team. Ethics approval for this study was not required. Patients and the public were not involved in the research.

Results

Population characteristics

We included 20439 4-5 year-olds (48.9% girls) and 17831 10-11 year-olds (49.1% girls) who took part in the NCMP in the 2015-16 and 2016-17 school years (Table 1). More than 40% of children were from South Asian ethnic backgrounds. White, Black, and 'Mixed and Other' ethnic groups each made up approximately one fifth of the children.

Change in NCMP weight status following ethnic-specific BMI adjustment

Across the three CCGs, 1792 4-5 year-olds (1792/8328; 21.5%) and 1320 10-11 year-olds (1320/7502; 17.6%) from South Asian ethnic backgrounds were classified as having a heavier weight status after ethnic-specific BMI adjustment (Table 2). After ethnic-specific BMI adjustment, 15.9% and 14.4% of 4-5 and 10-11 year-olds, respectively, were reclassified from a healthy weight to an overweight status. Similarly, 73.6% and 34.6% of 4-5 and 10-11 year-olds, respectively, were reclassified from an overweight to an obese weight status. Consequently, had ethnic-specific BMI adjustment been applied, parents of approximately one in five children from South Asian ethnic backgrounds (3112/15830) would have received different information about their child's weight status than that provided by the NCMP.

By contrast, 800 4-5 year-olds (800/3767; 21.2%) and 581 10-11 year-olds (581/3450; 16.8%) from Black ethnic backgrounds were classified as having a lighter weight status after ethnic-specific BMI adjustment

(Table2). After ethnic-specific BMI adjustment, 100% and 52.5% of 4-5 and 10-11 year-olds, respectively, were reclassified from an overweight to a healthy weight status. Similarly, 46.6% and 31.9% of 4-5 and 0-11 year-olds, respectively, were reclassified from an obese to an overweight status. Additionally, 17.1% of 4-5 year-olds were reclassified from an obese to a healthy weight status. Consequently, had ethnic-specific BMI adjustment been applied, parents of approximately one in five children from Black ethnic backgrounds (1381/7217) would have received different information about their child's weight status than that provided by the NCMP.

Change in obesity prevalence following ethnic-specific BMI adjustment

Prior to ethnic-specific BMI adjustment, 7.9% of 4-5 year-olds and 17.5% of 10-11 year-olds had a BMI considered to indicate obesity or severe obesity. Equivalent figures after ethnic-specific adjustment were 9.1% of 4-5 year-olds and 18.8% of 10-11 year-olds (Table 3).

Within each CCG, changes in the prevalences of obesity (including severe obesity) after applying ethnic-specific BMI adjustments varied according to their ethnic composition. In Tower Hamlets prevalences increased by 3.1% at age 4-5 years and 3.7% at age 10-11 years, reflecting the high proportion of children from South Asian ethnic backgrounds in this area (Table 3). Similar increases were observed in overweight prevalence. In Newham the prevalences of obesity (including severe obesity) increased by 1.2% at age 4-5 and by 1.3% at age 10-11, whereas in City & Hackney they decreased by 1.4% at age 4-5 and by 1.8% at age 10-11, reflecting the higher proportion of children from Black ethnic backgrounds in this area. See Table S3 for a cross-tabulation of unadjusted and adjusted weight status by CCG.

Estimates of the prevalences of overweight, obesity and severe obesity increased by 7.2%, 4.2% and 1.5% at age 4-5 and by 2.9%, 3.1% and 3.0% at age 10-11 among children from South Asian ethnic backgrounds, respectively, after ethnic-specific BMI adjustments were applied. Conversely, the prevalences of overweight, obesity and severe obesity decreased by 7.0%, 4.5% and 2.0% at age 4-5 and by 2.9%, 1.6% and 4.9% at age 10-11 among children from Black ethnic backgrounds, respectively (Table S4). After the application of ethnic-specific BMI adjustments, the estimated combined prevalences of obesity and severe obesity among 4-5 year-olds from South Asian and Black ethnic backgrounds, respectively, were 13.3% and 3.8% compared to 7.1% of 4-5 year-olds from White ethnic backgrounds. Equivalent figures at age 10-11 were 23.3% and 13.5%; compared to 16.0% of 10-11 year-olds from White ethnic backgrounds (Tables S4 and S5).

Discussion

Main findings of this study

We found that one fifth of 4-5 and 10-11 year-olds from South Asian and Black ethnic groups participating in the NCMP over a two-year period in City & Hackney, Newham and Tower Hamlets would have been classified in heavier and lighter weight status categories, respectively, had the NCMP taken ethnic background into account. We showed that area-level estimates of obesity prevalence at ages 4-5 and 10-11 years changed in inner London CCGs with high ethnic diversity, with increases and decreases determined by the proportion of children from South Asian and Black ethnic backgrounds respectively.

What is already known on this topic

The observed increased and decreased prevalence of overweight and obesity among children from South Asian and Black ethnic backgrounds, respectively, at ages 4-5 and 10-11 years has been shown in other UK studies using alternative methods for measuring body fat in children of all ages,(16, 17, 25, 26) and in previous analysis of NCMP data using BMI adjustments.(27, 28)

What this study adds

Our analysis has highlighted how application of ethnic-specific BMI adjustments to local authority NCMP data alters the estimated number of children affected by obesity and therefore the provision of child obesity services required.

Moreover, our findings illustrate the scale of misclassification of weight status due to failure to take ethnic background into account in the NCMP. Currently, without ethnic-specific BMI adjustment, the NCMP parental feedback letters provide discriminatory information about children's weight status, which disproportionately affects children from South Asian and Black ethnic backgrounds, potentially falsely reassuring the former and stigmatising the latter.

A high proportion of parents would have been given different information about their child's weight status had their child's ethnic background been taken into account. For many parents of South Asian children, this would have changed their child's weight status from healthy to overweight or from overweight to obese. It is possible that these parents are inappropriately reassured by the current NCMP information and may not seek advice about tackling childhood overweight and obesity.

This is of particular concern given the high ethnic-adjusted prevalence of overweight and obesity/severe obesity among South Asian children leaving primary school. In Tower Hamlets, 68.6% of 10-11 year-olds participating in the NCMP are from South Asian ethnic backgrounds, representing a missed opportunity

for intervention given the increased longer-term risks of type 2 diabetes and cardiovascular disease among these children, and highlighting an important public health obesity challenge, which should be a priority for action.

Conversely, fewer parents of children from Black ethnic backgrounds would have received information informing them that their child was overweight or obese. Application of ethnic-specific BMI adjustments would limit the number of inappropriate overweight letters which are currently sent to parents of children from Black ethnic backgrounds who would be considered a healthy weight had their ethnic background been taken into account.

Qualitative research has revealed a range of negative parental reactions to NCMP feedback letters,(29-33) any changes to letters, and ways in which these could be improved. Hence, any changes to letters as a consequence of deploying ethnic-specific BMI adjustment would need to take account of this wider literature, and be co-produced with parents and families.

Strengths and limitations of the study

Linking NCMP and EHRs enabled us to record an ethnic group for two thirds of children with missing or not stated ethnic background in the NCMP, resulting in 95% of children in our study population with complete ethnicity recording. We used NCMP data collected using standardised protocols and quality control procedures from three CCGs with high participation rates (approximately 90%).

We applied validated ethnic-specific BMI adjustments derived from an independent study which used the reference deuterium dilution method, an accurate, safe and minimally invasive method which measures total body water and fat mass with an error of <1%.(28, 34) The algorithms were derived from a pooled data resource including large numbers of UK children from South Asian and Black African ethnic backgrounds, as well as reference populations of White European children, allowing reasonably precise quantification of ethnic differences in the BMI–fat mass index (FMI) relationship in three main ethnic groups across a wide age range across which a single FMI could be applied, which included both the younger and older age groups of the NCMP.(18) The distribution of underweight, healthy weight, overweight and obesity in these children were consistent with those of children in NCMP populations, suggesting that the adjustments should be applicable to NCMP data.(18)

The adjustments are based on equivalent total body fatness, though it could be argued that basing adjustment on equivalent diabetes risk of other health outcomes (which would be likely to increase the size of adjustment) could be more valid.(18) Furthermore, the confidence intervals reported around the

obesity prevalence estimates after application of BMI adjustments may be unduly narrow, making no allowance for error in the adjustment factor. Underweight prevalence estimates are likely to be less precise than those of overweight estimates due to the small number of younger children with lower BMI values in the sample used to derive the ethnic-specific BMI adjustments, as well as the relatively small number of children considered underweight in this study.

Ethnic-specific adjustments were made to the BMI of children from South Asian and Black ethnic backgrounds, accounting for 76.4% of children in this study, however similar adjustments are not available for children from other ethnic minority groups, particularly for those from Mixed and Other ethnic groups who comprised almost one fifth of our study population. We excluded children with no record of their ethnic group: while this was more likely in 10-11 year olds and in Newham, there were no systematic differences by weight status. We were not able to include children attending private and/or faith schools, which do not participate in the NCMP. This omission was particularly relevant in City & Hackney, where approximately one quarter of all school-aged children attend such schools but would have had little effect in Newham and Tower Hamlets.(35) Our findings may not be generalisable to these children, who tend to be more socioeconomically advantaged than those attending state-maintained schools. We did not have information about the small number of children who opt out of the NCMP.

Implications for policy, practice and future research

Local authorities with high ethnic diversity may wish to consider using BMI adjustments to classify individuals more accurately and to get a more accurate assessment of local overweight and obesity prevalence. Ethnic-specific adjustment of BMI enables more meaningful, standardised comparisons of overweight and obesity prevalence between local authorities, and is essential to support clinical service planning for children and their families.

Whilst there is conflicting evidence to suggest that improved parental awareness of child overweight status leads to behaviour change,(33, 36, 37) a study of parents of children participating in the NCMP showed that one month after finding out their child was overweight or obese, over half reported increased physical activity, reduced sedentary time and improved diet.(38) Application of ethnic-specific BMI adjustment in the NCMP feedback letters would improve the accuracy of information given to parents about their child's weight status with the potential to incite appropriate healthy behaviour change. National surveillance programmes elsewhere in the UK may also wish to update their policy to

enable better comparisons between settings and equity for children from these ethnic backgrounds. Our findings are likely to be relevant to other countries with similarly high ethnic diversity.

Future research should focus on understanding the health outcomes associated with ethnic-adjusted BMI and obesity. We have shown that ethnic-specific BMI adjustments change the information received about child weight status in a significant proportion of parents of children from South Asian and Black ethnic groups. Ethnic-specific adjustment enables CCG estimates of prevalence of childhood overweight and obesity to reflect the ethnic composition of their child population. Our findings support the implementation of ethnic-specific adjustments in the NCMP to ensure equitable categorisation of children's weight status, to enable standardised childhood obesity prevalence comparisons and to support local service planning and provision.

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Declarations

Ethics approval and consent to participate

This is a secondary analysis of NCMP data, which is covered by data processing agreements allowing the sharing of de-personalised NCMP data between the research institution (Clinical Effectiveness Group, Queen Mary University of London) and each local authority public health team. Ethics approval for this study was not required. Patients and the public were not involved in the research.

Availability of data and material

The data that support the findings of this study are available from local authority public health departments but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of respective local authority public health departments.

Competing interests

The authors declare no conflict of interest.

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Authors' contributions

CD obtained funding for the study. NF and CD conceptualised, designed and interpreted the analyses. NF carried out the literature search, conducted the analyses, generated tables and figures and drafted the initial manuscript. All authors 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 manuscript. The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

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Table 1 – Sample characteristics

	Age 4-5			Age 10-11			Total	
	Boys	**Girls**	**All**	**Boys**	**Girls**	**All**	**N**	
	***n*=10,436**	***n*=10,003**	***n*=20,439**	***n*=9,071**	***n*=8,760**	***n*=17,831**	***n*=38,270**	**%**
Age[1] mean (SD)[2]	5.0 (0.33)	5.0 (0.33)	5.0 (0.33)	10.9 (0.38)	10.9 (0.38)	10.9 (0.38)		
Ethnic background[3] n (%)								
White	2438 (23.4)	2280 (22.8)	4718 (23.1)	1769 (19.5)	1617 (18.5)	3386 (19.0)	8104	21.2
Mixed and Other	1862 (17.8)	1764 (17.6)	3626 (17.7)	1776 (19.5)	1717 (19.5)	3493 (19.6)	7119	18.6
South Asian	4246 (40.7)	4082 (40.8)	8328 (40.8)	3815 (42.1)	3687 (42.1)	7502 (42.1)	15830	41.4
Black	1890 (18.1)	1877 (18.8)	3767 (18.4)	1711 (18.9)	1739 (19.9)	3450 (19.4)	7217	18.9
CCG[4] n (%)								
City & Hackney	2795 (26.8)	2624 (26.2)	5419 (26.5)	2323 (25.6)	2218 (25.3)	4541 (25.5)	9960	26.0
Newham	4402 (42.2)	4359 (43.6)	8761 (42.9)	3839 (42.3)	3650 (41.7)	7489 (42.0)	16250	42.5
Tower Hamlets	3239 (31.0)	3020 (30.2)	6259 (30.6)	2909 (32.1)	2892 (33.0)	5801 (32.5)	12060	31.5

[1]Age in years. [2]Mean (standard deviation). [3]Child ethnic background from the school record or supplemented from the child's electronic health record if missing or 'not stated' in the school record. [4]Clinical Commissioning Group.

Table 2 – Tabulation of unadjusted and adjusted weight status for children from South Asian and Black ethnic backgrounds, by ethnic background and age group (row percentages)

		Ethnic-adjusted weight status[2]									
		Underweight		Healthy weight		Overweight		Obese[3]		Total	
		n	%	n	%	n	%	n	%	n	%
		South Asian (*n*=15830)									
Unadjusted weight status[1]	**Age 4-5**										
	Underweight	26	9.6	244	90.4					270	100
	Healthy weight			5,705	84.1	1,075	15.9			6780	100
	Overweight					170	26.4	473	73.6	643	100
	Obese[3]							635	100.0	635	100
	Total	26	0.3	5949	71.4	1245	15.0	1108	13.3	8328	100
	Age 10-11										
	Underweight	34	15.1	191	84.9					225	100
	Healthy weight			3,998	85.6	675	14.4			4673	100
	Overweight					857	65.4	454	34.6	1311	100
	Obese[3]							1293	100.0	1293	100
	Total	34	0.5	4189	55.8	1532	20.4	1747	23.3	7502	100
		Black (*n*=7217)									
Unadjusted weight status[1]	**Age 4-5**										
	Underweight	49	100							49	100
	Healthy weight	109	3.8	2778	96.2					2887	100
	Overweight			445	100.0					445	100
	Obese[3]			66	17.1	180	46.6	140	36.3	386	100
	Total	158	4.2	3289	87.3	180	4.8	140	3.7	3767	100
	Age 10-11										
	Underweight	32	100							32	100
	Healthy weight	40	1.9	2077	98.1					2117	100
	Overweight			321	52.5	291	47.5			612	100
	Obese[3]					220	31.9	469	68.1	689	100
	Total	72	2.1	2398	69.5	511	14.8	469	13.6	3450	100

[1]Child unadjusted weight status based on NCMP recorded BMI and categorised according to UK90 clinical reference standard. [2]Child adjusted weight status based on ethnic-specific adjusted BMI and categorised according to UK90 clinical reference standard. [3]Obese including severely obese. Cells highlighted in green indicate when the ethnic-adjusted weight status was the same as unadjusted weight status. Cells highlighted in peach indicate where ethnic-adjusted weight status differed to the unadjusted weight status.

Table 3 - Prevalence of clinical underweight, overweight and obesity among 4-5 and 10-11 year-olds before and after ethnic-specific BMI adjustment, by CCG[1] and sex

	Boys				Girls				All			
	Unadjusted[2]		Adjusted[3]		Unadjusted[2]		Adjusted[3]		Unadjusted[2]		Adjusted[3]	
	n	% (95% CI[4])	*n*	% (95% CI[4])	*n*	% (95% CI[4])	*n*	% (95% CI[4])	*n*	% (95% CI[4])	*n*	% (95% CI[4])
Age 4-5												
City & Hackney												
Underweight	47	1.7 (1.3,2.2)	78	2.8 (2.2,3.5)	23	0.9 (0.6,1.3)	33	1.3 (0.9,1.8)	70	1.3 (1.0,1.6)	111	2.0 (1.7,2.5)
Overweight	273	9.8 (8.7,10.9)	239	8.6 (7.6,9.6)	248	9.5 (8.4,10.6)	212	8.1 (7.1,9.2)	521	9.6 (8.9,10.4)	451	8.3 (7.6,9.1)
Obese[5]	254	9.1 (8.1,10.2)	217	7.8 (6.8,8.8)	180	6.9 (6.0,7.9)	143	5.4 (4.6,6.4)	434	8.0 (7.3,8.8)	360	6.6 (6.0,7.3)
Newham												
Underweight	125	2.8 (2.4,3.4)	69	1.6 (1.2,2.0)	76	1.7 (1.4,2.2)	42	1.0 (0.7,1.3)	201	2.3 (2.0,2.6)	111	1.3 (1.1,1.5)
Overweight	408	9.3 (8.4,10.2)	495	11.2 (10.3,12.2)	405	9.3 (8.5,10.2)	448	10.3 (9.4,11.2)	813	9.3 (8.7,9.9)	943	10.8 (10.1,11.4)
Obese[5]	390	8.9 (8.1,9.7)	444	10.1 (9.2,11.0)	308	7.1 (6.3,7.9)	360	8.3 (7.5,9.1)	698	8.0 (7.4,8.6)	804	9.2 (8.6,9.8)
Tower Hamlets												
Underweight	88	2.7 (2.2,3.3)	35	1.1 (0.8,1.5)	50	1.7 (1.3,2.2)	17	0.6 (0.4,0.9)	138	2.2 (1.9,2.6)	52	0.8 (0.6,1.1)
Overweight	283	8.7 (7.8,9.8)	451	13.9 (12.8,15.2)	259	8.6 (7.6,9.6)	368	12.2 (11.1,13.4)	542	8.7 (8.0,9.4)	819	13.1 (12.3,13.9)
Obese[5]	270	8.3 (7.4,9.3)	383	11.8 (10.8,13.0)	222	7.4 (6.5,8.3)	304	10.1 (9.0,11.2)	492	7.9 (7.2,8.6)	687	11.0 (10.2,11.8)
All												
Underweight	260	2.5 (2.2,2.8)	182	1.7 (1.5,2.0)	149	1.5 (1.3,1.7)	92	0.9 (0.8,1.1)	409	2.0 (1.8,2.2)	274	1.3 (1.2,1.5)
Overweight	964	9.2 (8.7,9.8)	1185	11.4 (10.8,12.0)	912	9.1 (8.6,9.7)	1028	10.3 (9.7,10.9)	1876	9.2 (8.8,9.6)	2213	10.8 (10.4,11.3)
Obese[5]	914	8.8 (8.2,9.3)	1044	10.0 (9.4,10.6)	710	7.1 (6.6,7.6)	807	8.1 (7.5,8.6)	1624	7.9 (7.6,8.3)	1851	9.1 (8.7,9.5)

Age 10-11												
City & Hackney												
Underweight	15	0.6 (0.4,1.1)	16	0.7 (0.4,1.1)	30	1.4 (0.9,1.9)	32	1.4 (1.0,2.0)	45	1.0 (0.7,1.3)	48	1.1 (0.8,1.4)
Overweight	353	15.2 (13.8,16.7)	350	15.1 (13.7,16.6)	353	15.9 (14.5,17.5)	340	15.3 (13.9,16.9)	706	15.5 (14.5,16.6)	690	15.2 (14.2,16.3)
Obese[5]	469	20.2 (18.6,21.9)	425	18.3 (16.8,19.9)	375	16.9 (15.4,18.5)	337	15.2 (13.8,16.8)	844	18.6 (17.5,19.7)	762	16.8 (15.7,17.9)
Newham												
Underweight	78	2.0 (1.6,2.5)	47	1.2 (0.9,1.6)	100	2.7 (2.3,3.3)	66	1.8 (1.4,2.3)	178	2.4 (2.1,2.7)	113	1.5 (1.3,1.8)
Overweight	676	17.6 (16.4,18.8)	688	17.9 (16.7,19.2)	611	16.7 (15.6,18.0)	642	17.6 (16.4,18.9)	1287	17.2 (16.3,18.1)	1330	17.8 (16.9,18.6)
Obese[5]	798	20.8 (19.5,22.1)	866	22.6 (21.3,23.9)	505	13.8 (12.8,15.0)	536	14.7 (13.6,15.9)	1303	17.4 (16.6,18.3)	1402	18.7 (17.9,19.6)
Tower Hamlets												
Underweight	50	1.7 (1.3,2.3)	18	0.6 (0.4,1.0)	76	2.6 (2.1,3.3)	19	0.7 (0.4,1.0)	126	2.2 (1.8,2.6)	37	0.6 (0.5,0.9)
Overweight	510	17.5 (16.2,19.0)	571	19.6 (18.2,21.1)	491	17.0 (15.7,18.4)	523	18.1 (16.7,19.5)	1001	17.3 (16.3,18.3)	1094	18.9 (17.9,19.9)
Obese[5]	574	19.7 (18.3,21.2)	686	23.6 (22.1,25.2)	398	13.8 (12.6,15.1)	503	17.4 (16.1,18.8)	972	16.8 (15.8,17.7)	1189	20.5 (19.5,21.6)
All												
Underweight	143	1.6 (1.3,1.9)	81	0.9 (0.7,1.1)	206	2.4 (2.1,2.7)	117	1.3 (1.1,1.6)	349	2.0 (1.8,2.2)	198	1.1 (1.0,1.3)
Overweight	1539	17.0 (16.2,17.8)	1609	17.7 (17.0,18.5)	1455	16.6 (15.8,17.4)	1505	17.2 (16.4,18.0)	2994	16.8 (16.2,17.3)	3114	17.5 (16.9,18.0)
Obese[5]	1841	20.3 (19.5,21.1)	1977	21.8 (21.0,22.7)	1278	14.6 (13.9,15.3)	1376	15.7 (15.0,16.5)	3119	17.5 (16.9,18.1)	3353	18.8 (18.2,19.4)

[1]Clinical Commissioning Group. [2]Child unadjusted weight status based on NCMP recorded BMI and categorised according to UK90 clinical reference standard.
[3]Child adjusted weight status based on ethnic-specific adjusted BMI and categorised according to UK90 clinical reference standard. [4]95% confidence interval.
[5]Obese including severely obese.

Is child weight status correctly reported to parents? Analysis of National Child Measurement Programme data using ethnic-specific BMI adjustments

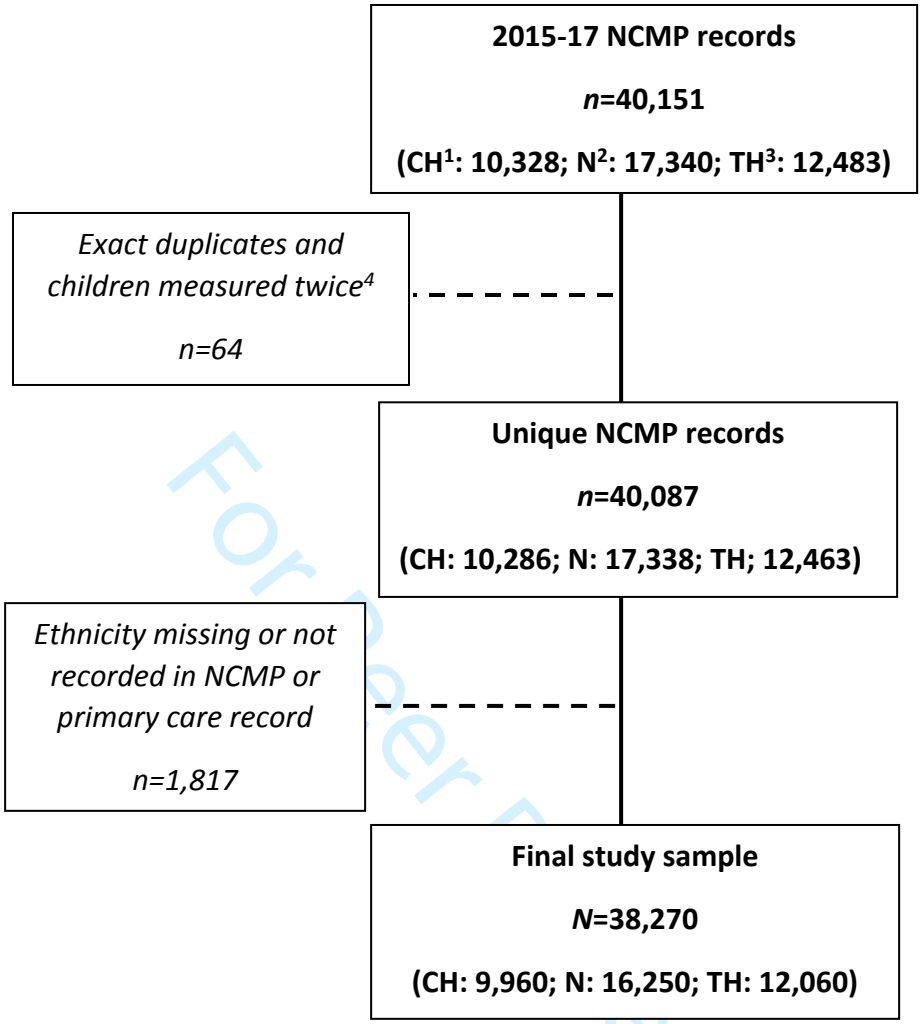
Mrs Nicola Firman[1] - Research Assistant in Health Data Science
Dr Kambiz Boomla[1] - Clinical Senior Lecturer
Mr Mohammed T Hudda[2] - Research Fellow in Medical Statistics
Dr John Robson[1] - Clinical Reader in Primary Care Research & Development
Professor Peter Whincup[2] - Professor of Cardiovascular Epidemiology
Professor Carol Dezateux[1] – Professor of Clinical Epidemiology and Health Data Science

[1]Centre for Primary Care & Public Health, Barts and the London School of Medicine and Dentistry, Queen Mary University of London, Yvonne Carter Building, 58 Turner Street, London, E1 2AB, UK

[2]Population Health Research Institute, St George's, University of London, Cranmer Terrace, London, SW17 0RE, UK

Correspondence to: Nicola Firman; nicola.firman@qmul.ac.uk

Figure S1: Study sample



[1]City & Hackney. [2]Newham. [3]Tower Hamlets. [4]Includes 45 exact duplicates and 19 repeat measurements where only most recent measurement retained.

Table S1: Sample characteristics of children with and without ethnicity recording, after linkage to electronic health records.

	Ethnicity (*n*=38,270)		Missing ethnicity (*n*=1,817)	
	n	**%**	***n***	**%**
Sex				
Male	19507	51.0	903	49.7
Female	18763	49.0	914	50.3
Age group				
Age 4-5 years	20439	53.4	661	36.4
Age 10-11 years	17831	46.6	1156	63.6
CCG[1]				
City & Hackney	9960	26.0	326	17.9
Newham	16250	42.5	1088	59.9
Tower Hamlets	12060	31.5	403	22.2
Unadjusted weight status[2]				
Underweight	758	2.0	34	1.9
Healthy weight	27899	72.9	1296	71.3
Overweight	4870	12.7	249	13.7
Obese	2957	7.7	145	8.0
Severely obese	1786	4.7	93	5.1

[1]Clinical Commissioning Group. [2]Child unadjusted weight status based on NCMP recorded BMI and categorised according to UK90 clinical reference standard. Severely obese defined as BMI≥120% of the 95th centile.

Table S2: Ethnic distribution by CCG[1] (row percentages)

	White		Mixed and Other		South Asian		Black		Total	
	n	% (95% CI[2])	*n*	% (95% CI[2])	n	% (95% CI[2])	*n*	% (95% CI[2])	*N*	%
City & Hackney										
Reception	2047	37.7 (36.4,39.0)	1200	22.1 (21.1,23.3)	537	9.9 (9.1,10.7)	1635	30.2 (29.0,31.5)	5419	100
Year 6	1351	29.7 (28.4,31.1)	1308	29.0 (27.7,30.3)	441	9.7 (8.9,10.6)	1441	31.6 (30.3,33.0)	4541	100
Newham										
Reception	1630	18.6 (17.8,19.4)	1728	20.1 (19.3,21.0)	3831	43.4 (42.3,44.4)	1572	17.9 (17.1,18.7)	8761	100
Year 6	1277	17.1 (16.2,17.9)	1677	21.3 (20.4,22.2)	3082	42.2 (41.1,43.3)	1453	19.4 (18.5,20.3)	7489	100
Tower Hamlets										
Reception	1041	16.6 (15.7,17.6)	698	11.2 (10.4,12.0)	3960	63.3 (62.1,64.5)	560	8.9 (8.3,9.7)	6259	100
Year 6	758	13.1 (12.2,14.0)	508	8.8 (8.1,9.5)	3979	68.6 (67.4,69.8)	556	9.6 (8.8,10.4)	5801	100
Total	8104	21.2	7119	18.6	15830	41.4	7217	18.8	38270	100

[1]Clinical Commissioning Group. [2]95% confidence interval.

Table S3: Cross-tabulation of unadjusted weight status and ethnic-adjusted weight status, by CCG[1] and age group

		Adjusted[3]									
		Age 4-5					Age 10-11				
		Underweight	Healthy weight	Overweight	Obese[4]	Total	Underweight	Healthy weight	Overweight	Obese[4]	Total
Unadjusted[2]	**City & Hackney**										
	Underweight	61	9	0	0	70	38	7	0	0	45
	Healthy weight	50	4270	74	0	4394	10	2899	37	0	2946
	Overweight	0	185	298	38	521	0	135	550	21	706
	Obese[3]	0	33	79	322	434	0	0	103	741	844
	Total	111	4497	451	360	5419	48	3041	690	762	4541
	Newham										
	Underweight	74	127	0	0	201	87	91	0	0	178
	Healthy weight	37	6553	459	0	7049	26	4415	280	0	4721
	Overweight	0	195	409	209	813	0	138	968	181	1287
	Obese[3]	0	28	75	595	698	0	0	82	1221	1303
	Total	111	6903	943	804	8761	113	4644	1330	1402	7489
	Tower Hamlets										
	Underweight	30	108	0	0	138	33	93	0	0	126
	Healthy weight	22	4523	542	0	5087	4	3340	358	0	3702
	Overweight	0	65	251	226	542	0	48	701	252	1001
	Obese[3]	0	5	26	461	492	0	0	35	937	972
	Total	52	4701	819	687	6259	37	3481	1094	1189	5801

[1]Clinical Commissioning Group. [2]Child unadjusted weight status based on NCMP recorded BMI and categorised according to UK90 clinical reference standard. [3]Child adjusted weight status based on ethnic-specific adjusted BMI and categorised according to UK90 clinical reference standard. [4]Obese including severely obese. Cells highlighted in blue indicate where the NCMP weight status overestimates weight status compared to after ethnic-specific BMI adjustment. Conversely, cells highlighted in peach indicate where the NCMP underestimates weight status.

Table S4: Prevalence of clinical underweight, overweight and obesity among South Asian and Black children before and after ethnic-specific BMI adjustment, by age group and sex

	Age 4-5				Age 10-11			
	Unadjusted[1]		Adjusted[2]		Unadjusted[1]		Adjusted[2]	
	n	% (95% CI[3])	*n*	% (95% CI[3])	*n*	% (95% CI[3])	*n*	% (95% CI[3])
SOUTH ASIAN								
Boys								
Underweight	169	4.0 (3.4,4.6)	17	0.4 (0.2,0.6)	95	2.5 (2.0,3.0)	17	0.4 (0.3,0.7)
Overweight	305	7.2 (6.4,8.0)	658	15.5 (14.4,16.6)	683	17.9 (16.7,19.2)	808	21.2 (19.9,22.5)
Obese	279	6.6 (5.9,7.4)	483	11.4 (10.5,12.4)	493	12.9 (11.9,14.0)	601	15.8 (14.6,16.9)
Severely obese	93	2.2 (1.8,2.7)	157	3.7 (3.2,4.3)	316	8.3 (7.4,9.2)	456	12.0 (11.0,13.0)
Girls								
Underweight	101	2.5 (2.0,3.0)	9	0.2 (0.1,0.4)	130	3.5 (3.0,4.2)	17	0.5 (0.3,0.7)
Overweight	338	8.3 (7.5,9.2)	587	14.4 (13.3,15.5)	628	17.0 (15.9,18.3)	724	19.6 (18.4,21.0)
Obese	219	5.4 (4.7,6.1)	366	9.0 (8.1,9.9)	294	8.0 (7.1,8.9)	416	11.3 (10.3,12.3)
Severely obese	44	1.1 (0.8,1.4)	102	2.5 (2.1,3.0)	190	5.2 (4.5,5.9)	274	7.4 (6.6,8.3)
All								
Underweight	270	3.2 (2.9,3.6)	26	0.3 (0.2,0.5)	225	3.0 (2.6,3.4)	34	0.5 (0.3,0.6)
Overweight	643	7.7 (7.2,8.3)	1245	14.9 (14.2,15.7)	1311	17.5 (16.6,18.4)	1532	20.4 (19.5,21.3)
Obese	498	6.0 (5.5,6.5)	849	10.2 (9.6,10.9)	787	10.5 (9.8,11.2)	1017	13.6 (12.8,14.4)
Severely obese	137	1.6 (1.4,1.9)	259	3.1 (2.8,3.5)	506	6.7 (6.2,7.3)	730	9.7 (9.1,10.4)
BLACK								
Boys								
Underweight	35	1.9 (1.3,2.6)	109	5.8 (4.8,6.9)	8	0.5 (0.2,0.9)	24	1.4 (0.9,2.1)
Overweight	222	11.7 (10.4,13.3)	90	4.8 (3.9,5.8)	300	17.5 (15.8,19.4)	245	14.3 (12.7,16.1)
Obese	166	8.8 (7.6,10.1)	62	3.3 (2.6,4.2)	173	10.1 (8.8,11.6)	151	8.8 (7.6,10.3)
Severely obese	43	2.3 (1.7,3.1)	9	0.5 (0.2,0.9)	191	11.2 (9.8,12.7)	101	5.9 (4.9,7.1)
Girls								
Underweight	14	0.7 (0.4,1.3)	49	2.6 (2.0,3.4)	24	1.4 (0.9,2.1)	48	2.8 (2.1,3.6)
Overweight	223	11.9 (10.5,13.4)	90	4.8 (3.9,5.9)	312	17.9 (16.2,19.8)	266	15.3 (13.7,17.1)

Obese	123	6.6 (5.5,7.8)	57	3.0 (2.3,3.9)	161	9.3 (8.0,10.7)	130	7.5 (6.3,8.8)
Severely obese	54	2.9 (2.2,3.7)	12	0.6 (0.4,1.1)	164	9.4 (8.1,10.9)	87	5.0 (4.1,6.1)
All								
Underweight	49	1.3 (1.0,1.7)	158	4.2 (3.6,4.9)	32	0.9 (0.7,1.3)	72	2.1 (1.7,2.6)
Overweight	445	11.8 (10.8,12.9)	180	4.8 (4.1,5.5)	612	17.7 (16.5,19.1)	511	14.8 (13.7,16.0)
Obese	289	7.7 (6.9,8.6)	119	3.2 (2.6,3.8)	334	9.7 (8.7,10.7)	281	8.1 (7.3,9.1)
Severely obese	97	2.6 (2.1,3.1)	21	0.6 (0.4,0.9)	355	10.3 (9.3,11.3)	188	5.4 (4.7,6.3)

[1]Child unadjusted weight status based on NCMP recorded BMI and categorised according to UK90 clinical reference standard. [2]Child adjusted weight status based on ethnic-specific adjusted BMI and categorised according to UK90 clinical reference standard. [3]95% confidence interval.

Table S5: Prevalence (95% Confidence interval) of clinical underweight, overweight and obesity among White children, by age group and sex

	Age 4-5		Age 10-11	
	n	% (95% CI[1])	*n*	% (95% CI[1])
Boys				
Underweight	29	1.2 (0.8,1.7)	23	1.3 (0.9,1.9)
Overweight	255	10.5 (9.3,11.7)	273	15.4 (13.8,17.2)
Obese	147	6.0 (5.2,7.0)	150	8.5 (7.3,9.9)
Severely obese	40	1.6 (1.2,2.2)	189	10.7 (9.3,12.2)
Girls				
Underweight	20	0.9 (0.6,1.4)	27	1.7 (1.1,2.4)
Overweight	200	8.8 (7.7,10.0)	236	14.6 (13.0,16.4)
Obese	106	4.6 (3.9,5.6)	116	7.2 (6.0,8.5)
Severely obese	40	1.8 (1.3,2.4)	86	5.3 (4.3,6.5)
All				
Underweight	49	1.0 (0.8,1.4)	50	1.5 (1.1,1.9)
Overweight	455	9.6 (8.8,10.5)	509	15.0 (13.9,16.3)
Obese	253	5.4 (4.8,6.0)	266	7.9 (7.0,8.8)
Severely obese	80	1.7 (1.4,2.1)	275	8.1 (7.2,9.1)

[1]*95% confidence interval.*

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
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	3	State specific objectives, including any prespecified hypotheses	3
Methods			
Study design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	4
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4-5
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	4-5
Bias	9	Describe any efforts to address potential sources of bias	5 (and Table S1)
Study size	10	Explain how the study size was arrived at	4-5 (and Figure S1)
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	4-5
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	6
		(*b*) Describe any methods used to examine subgroups and interactions	4-6
		(*c*) Explain how missing data were addressed	4-6
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	n/a
		(*e*) Describe any sensitivity analyses	n/a
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	4-6 (and Figure S1)
		(b) Give reasons for non-participation at each stage	4-6 (and Figure S1)
		(c) Consider use of a flow diagram	Figure S1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	6
		(b) Indicate number of participants with missing data for each variable of interest	n/a
Outcome data	15*	Report numbers of outcome events or summary measures	6
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	6-7
		(*b*) Report category boundaries when continuous variables were categorized	5
		(*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	n/a
Discussion			
Key results	18	Summarise key results with reference to study objectives	8
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	9-10
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	10
Generalisability	21	Discuss the generalisability (external validity) of the study results	8-11
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	12

*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.