

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

Nicola Firman¹, Kambiz Boomla¹, Mohammed T. Hudda², John Robson¹, Peter Whincup², Carol Dezateux¹

¹Centre for Primary Care & Public Health, Barts and the London School of Medicine and Dentistry, Queen Mary University of London, London E1 2AB, UK

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

Address correspondence to Nicola Firman, E-mail: nicola.firman@qmul.ac.uk.

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 38 270 children in three inner-London local authorities: City & Hackney, Newham and Tower Hamlets (41% South Asian, 18.8% Black): 20 439 4–5 year-olds (48.9% girls) and 17 831 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 ≥ 98 th 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% (3112/15 830) of parents of children from South Asian backgrounds would have been informed that their child was in a heavier weight category, and 19.1% (1381/7217) of parents of children from Black backgrounds would have been informed that 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) amongst 4–5 year-olds and from 17.5% (16.9, 18.1) to 18.8% (18.2, 19.4) amongst 10–11 year-olds.

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

Keywords children, ethnicity, obesity

Background

Childhood obesity is a major public health concern globally¹ 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 amongst 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 categorized 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.

Nicola Firman, Research Assistant in Health Data Science

Kambiz Boomla, Clinical Senior Lecturer

Mohammed T. Hudda, Research Fellow in Medical Statistics

John Robson, Clinical Reader in Primary Care Research & Development

Peter Whincup, Professor of Cardiovascular Epidemiology

Carol Dezateux, Professor of Clinical Epidemiology and Health Data Science

Childhood obesity is associated with both short- and long-term health consequences including poor mental health, asthma, type 2 diabetes and cardiovascular disease.^{5–8} This is particularly important amongst 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.^{15, 16} 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 developed¹⁷ 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 that 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 40 151 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 38 270 children: 20 439 4–5 year-olds and 17 831 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 0.1 kg and height to the nearest 0.1 cm without shoes and outdoor clothing.⁴

We linked NCMP records to primary care EHRs based on pseudonymized NHS numbers created using a study-specific encryption key and OpenPseudonymiser software.¹⁸ 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 ≥ 98 th) 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 2000 children from White European, South Asian and Black African backgrounds aged 4–12 years.¹⁷ First, body fat mass was standardized 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 harmonize 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.¹⁷ Results showed that 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 categorized BMI for all children before and after ethnic-specific adjustments using the LMS growth tool,^{19, 20} based on the UK90 clinical cut-offs which identify children defined as in need of clinical intervention,²¹ and which are employed in the NCMP to inform feedback letters sent to parents: underweight (BMI centile < 2 nd), overweight (BMI centile ≥ 91 st), obesity (BMI centile ≥ 98 th) and severe obesity (BMI centile $\geq 120\%$ of the 95th centile).²² 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 records⁴ and defined using the National Health Service classification.²³ We used ethnic groupings consistent with those used by Hudda *et al.*,¹⁷ 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-personalized 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 20 439 4–5 year-olds (48.9% girls) and 17 831 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 (3112/15 830) 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 (Table 2). 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 10–11 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).

Table 1 Sample characteristics

	Age 4–5			Age 10–11			Total	
	Boys	Girls	All	Boys	Girls	All	N	
	<i>n</i> = 10 436	<i>n</i> = 10 003	<i>n</i> = 20 439	<i>n</i> = 9071	<i>n</i> = 8760	<i>n</i> = 17 831	<i>n</i> = 38 270	%
Age mean (SD) ^{a,b}	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 <i>n</i> (%) ^c								
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)	15 830	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 <i>n</i> (%) ^d								
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)	16 250	42.5
Tower Hamlets	3239 (31.0)	3020 (30.2)	6259 (30.6)	2909 (32.1)	2892 (33.0)	5801 (32.5)	12 060	31.5

^aAge in years.

^bMean (standard deviation).

^cChild ethnic background from the school record or supplemented from the child's electronic health record if missing or 'not stated' in the school record.

^dClinical Commissioning Group.

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 amongst 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 amongst 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 amongst 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 2-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 amongst 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^{15, 16, 24, 25} and in previous analysis of NCMP data using BMI adjustments.^{26, 27}

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 ^b									
		Underweight		Healthy weight		Overweight		Obese ^c		Total	
		n	%	n	%	n	%	n	%	n	%
South Asian (n = 15 830)											
Unadjusted weight status ^a	Age 4–5										
	Underweight	26	9.6	244	90.4					270	100
	Healthy weight			5705	84.1	1075	15.9			6780	100
	Overweight					170	26.4	473	73.6	643	100
	Obese ^c							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			3998	85.6	675	14.4			4673	100
	Overweight					857	65.4	454	34.6	1311	100
	Obese ^c							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 ^a	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 ^c			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 ^c					220	31.9	469	68.1	689	100
	Total	72	2.1	2398	69.5	511	14.8	469	13.6	3450	100

^aChild unadjusted weight status based on NCMP recorded BMI and categorized according to UK90 clinical reference standard.

^bChild adjusted weight status based on ethnic-specific adjusted BMI and categorized according to UK90 clinical reference standard.

^cObese 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.

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 stigmatizing 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.

Table 3 Prevalence of clinical underweight, overweight and obesity amongst 4–5 and 10–11 year-olds before and after ethnic-specific BMI adjustment, by CCG^a and sex

	Boys				Girls				All			
	Unadjusted ^b		Adjusted ^c		Unadjusted ^b		Adjusted ^c		Unadjusted ^b		Adjusted ^c	
	<i>n</i>	% (95% CI) ^d	<i>n</i>	% (95% CI) ^d	<i>n</i>	% (95% CI) ^d	<i>n</i>	% (95% CI) ^d	<i>n</i>	% (95% CI) ^d	<i>n</i>	% (95% CI) ^d
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 ^e	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 ^e	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 ^e	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 ^e	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 ^e	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 ^e	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 ^e	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)

Continued

Table 3 Continued

	Boys				Girls				All			
	Unadjusted ^b		Adjusted ^c		Unadjusted ^b		Adjusted ^c		Unadjusted ^b		Adjusted ^c	
	n	% (95% CI) ^d	n	% (95% CI) ^d	n	% (95% CI) ^d	n	% (95% CI) ^d	n	% (95% CI) ^d	n	% (95% CI) ^d
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 ^e	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)

^aClinical Commissioning Group.

^bChild unadjusted weight status based on NCMP recorded BMI and categorized according to UK90 clinical reference standard.

^cChild adjusted weight status based on ethnic-specific adjusted BMI and categorized according to UK90 clinical reference standard.

^d95% confidence interval.

^eObese including severely obese.

This is of particular concern given the high ethnic-adjusted prevalence of overweight and obesity/severe obesity amongst 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 amongst 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,^{28–32} 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 standardized 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%.^{27, 33} The algorithms were derived from a pooled data resource including a large number 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.¹⁷ The distribution of underweight, healthy weight, overweight and obesity in these children was consistent with those of children in NCMP populations, suggesting that the adjustments should be applicable to NCMP data.¹⁷

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.¹⁷ 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.³⁴ Our findings may not be generalizable 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, standardized 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,^{32, 35, 36} a study of parents of children participating in the NCMP showed that 1 month after finding out their child was overweight or obese, over half reported increased physical activity, reduced sedentary

time and improved diet.³⁷ 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 categorization of children's weight status, to enable standardized childhood obesity prevalence comparisons and to support local service planning and provision.

Acknowledgments

The authors are grateful to the local authority public health teams for providing pseudonymized NCMP data; school nurses and NCMP data collection teams; NCMP participants; and colleagues at the Clinical Effectiveness Group for extracting ethnicity data from primary care electronic health records.

Funding

This research was in part funded by a grant from Barts Charity ref: MGU0419. This work was supported by Health Data Research UK (award reference: GPPB1C2), which is funded by the UK Medical Research Council, Engineering and Physical Sciences Research Council, Economic and Social Research Council, Department of Health and Social Care (England), Chief Scientist Office of the Scottish Government Health and Social Care Directorates, Health and Social Care Research and Development Division (Welsh Government), Public Health Agency (Northern Ireland), British Heart Foundation and Wellcome. MH has been supported by a project grant and a PhD studentship from the British Heart Foundation (Grant refs: PG/15/19/31336 & FS/17/76/33286).

Supplementary data

Supplementary data are available at the *Journal of Public Health* online.

Conflict of interest

The authors declare no conflict of interest.

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-personalized 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 licence 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.

Authors' contributions

CD obtained funding for the study. NF and CD conceptualized, 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.

References

- 1 World Health Organisation. Childhood overweight and obesity, 2019. <https://www.who.int/dietphysicalactivity/childhood/en/> [January 2019, date last accessed].
- 2 NHS Digital. National Child Measurement Programme, 2016–17, 2017. <https://digital.nhs.uk/data-and-information/publications/statistical/national-child-measurement-programme/national-child->

[measurement-programme-england-2016-17](https://digital.nhs.uk/data-and-information/publications/statistical/national-child-measurement-programme-england-2016-17) [October 2018, date last accessed].

- 3 Public Health England. NCMP and child obesity profile, 2018. <https://fingertips.phe.org.uk/profile/national-child-measurement-programme/data#page/7/gid/8000011/pat/6/par/E12000007/at/102/are/E09000030/iid/90323/age/201/sex/4/nn/nn-1-E09000030> [November 2018, date last accessed].
- 4 Public Health England. *National Child Measurement Programme Operational Guidance 2018*. London, England: Public Health England, 2018.
- 5 Reilly JJ, Methven E, McDowell ZC *et al*. Health consequences of obesity. *Arch Dis Child* 2003;**88**:748–52.
- 6 Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: International survey. *BMJ* 2000;**320**:1240–3.
- 7 Tirosch A, Shai I, Afek A *et al*. Adolescent BMI trajectory and risk of diabetes versus coronary disease. *N Engl J Med* 2011;**364**:1315–25.
- 8 Owen CG, Whincup PH, Orfei L *et al*. Is body mass index before middle age related to coronary heart disease risk in later life? Evidence from observational studies. *Int J Obes* 2009;**33**:866–77.
- 9 Nightingale CM, Rudnicka AR, Owen CG *et al*. Influence of adiposity on insulin resistance and glycemia markers among United Kingdom children of South Asian, Black African-Caribbean, and White European origin: child heart and health study in England. *Diabetes Care* 2013;**36**:1712–9.
- 10 NHS Digital. *Health Survey for England 2004: The health of ethnic minorities*. NHS Digital website: NHS Digital, 2006. <https://digital.nhs.uk/catalogue/PUB01209> [January 2018, date last accessed].
- 11 Woodfield J. Increased type 2 diabetes rates in UK children, study reveals, 2018. <https://www.diabetes.co.uk/news/2018/mar/increase-d-type-2-diabetes-rates-in-uk-children-study-reveals-95710741.html> [November 2018, date last accessed].
- 12 Candler TP, Mahmoud O, Lynn RM *et al*. Continuing rise of type 2 diabetes incidence in children and young people in the UK. *Diabet Med* 2018;**35**:737–44.
- 13 Whincup PH, Gilg JA, Papacosta O *et al*. Early evidence of ethnic differences in cardiovascular risk: Cross sectional comparison of British south Asian and white children. *Br Med J* 2002;**324**:635.
- 14 Whincup PH, Nightingale CM, Owen CG *et al*. Early emergence of ethnic differences in type 2 diabetes precursors in the UK: The child heart and health study in England (CHASE study). *PLoS Med* 2010;**7**:e1000263.
- 15 Nightingale CM, Rudnicka AR, Owen CG *et al*. Patterns of body size and adiposity among UK children of south Asian, black African-Caribbean and white European origin: child heart and health study in England (CHASE study). *Int J Epidemiol* 2011;**40**:33–44.
- 16 Nightingale CM, Rudnicka AR, Owen CG *et al*. Are ethnic and gender specific equations needed to derive fat free mass from bioelectrical impedance in children of South Asian, Black African-Caribbean and white European origin? Results of the assessment of body composition in children study. *PLoS One* 2013;**8**:e76426.
- 17 Hudda MT, Nightingale CM, Donin AS *et al*. Body mass index adjustments to increase the validity of body fatness assessment in UK black African and south Asian children. *Int J Obes* 2017;**41**:1048–55.

- 18 Hippisley-Cox J. *OpenPseudonymiser*. University of Nottingham, 2011.
- 19 Cole TJ, Freeman JV, Preece MA. Body mass index reference curves for the UK, 1990. *Arch Dis Child* 1995;**73**:25–9.
- 20 Pan H, Cole TJ. *LMSgrowth Microsoft Excel add-in to access references based on the LMS method*, 2012.
- 21 Scientific Advisory Committee on Nutrition. *Royal College of Paediatrics and Child Health. Consideration of issues around the use of BMI centile thresholds for defining underweight, overweight and obesity in children aged 2-8 years in the UK*, 2012.
- 22 Flegal KM, Wei R, Ogden CL *et al*. Characterizing extreme values of body mass index-for-age by using the 2000 Centers for Disease Control and Prevention growth charts. *Am J Clin Nutr* 2009;**90**: 1314–20.
- 23 NHS. Ethnic category code, 2018. https://www.datadictionary.nhs.uk/data_dictionary/attributes/e/end/ethnic_category_code_de.asp [March 2018, date last accessed].
- 24 Lee S, Bountziouka V, Lum S *et al*. Ethnic variability in body size, proportions and composition in children aged 5 to 11 years: Is ethnic-specific calibration of bioelectrical impedance required? *PLoS One* 2014;**9**:e113883.
- 25 Shaw NJ, Crabtree NJ, Kibirige MS, Fordham JN. Ethnic and gender differences in body fat in British schoolchildren as measured by DXA. *Arch Dis Child* 2007;**92**:872–5.
- 26 Hudda MT, Nightingale CM, Donin AS *et al*. Patterns of childhood body mass index (BMI), overweight and obesity in South Asian and black participants in the English national child measurement programme: effect of applying BMI adjustments standardising for ethnic differences in BMI-body fatness associations. *Int J Obes* 2017;**42**:662–70.
- 27 Deurenberg P, Yap M. The assessment of obesity: methods for measuring body fat and global prevalence of obesity. *Best Pract Res Clin En* 1999;**13**:1–11.
- 28 Gainsbury A, Dowling S. A little bit offended and slightly patronised': parents' experiences of National Child Measurement Programme feedback. *Public Health Nutr* 2018;**21**:2884–92.
- 29 Gillison F, Beck F, Lewitt J. Exploring the basis for parents' negative reactions to being informed that their child is overweight. *Public Health Nutr* 2014;**17**:987–97.
- 30 Nyanzi LA, Summerbell CD, Ells L *et al*. Parental response to a letter reporting child overweight measured as part of a routine national programme in England: results from interviews with parents. *BMC Public Health* 16 846 (2016) doi: 10.1186/s12889-016-34.
- 31 Kovacs BE, Gillison FB, Barnett JC. Is children's weight a public health or a private family issue? A qualitative analysis of online discussion about National Child Measurement Programme feedback in England. *BMC Public Health* 2018;**18**:1295.
- 32 Mooney A, Statham J, Boddy J, Smith M. *The National Child Measurement Programme: early experiences of routine feedback to parents of children's height and weight*, 2010.
- 33 Wells JC, Fuller NJ, Dewit O *et al*. Four-component model of body composition in children: Density and hydration of fat-free mass and comparison with simpler models. *Am J Clin Nutr* 1999;**69**:904–12.
- 34 Shepherd J. Education in England: Pupils by race, poverty and language for every local authority. *The Guardian* 2011;
- 35 Parkinson KN, Reilly JJ, Basterfield L *et al*. Mothers' perceptions of child weight status and the subsequent weight gain of their children: a population-based longitudinal study. *Int J Obes* 2017;**41**:801–6.
- 36 Falconer CL, Park MH, Croker H *et al*. The benefits and harms of providing parents with weight feedback as part of the national child measurement programme: A prospective cohort study. *BMC Public Health* 2014;**14**:549.
- 37 Park MH, Falconer CL, Croker H *et al*. Predictors of health-related behaviour change in parents of overweight children in England. *Prev Med* 2014;**62**:20–4.