Public Health England

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Changes in the weight status of children between the first and final years of primary school

A longitudinal analysis of data from the National Child Measurement Programme in four local authorities in England between 2006/07 and 2014/15

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Executive summary

We examined how weight status tracks in individual children during primary school using the National Child Measurement Programme (NCMP) data from four local authorities.

The participating authorities had a larger than the national average proportion of children from deprived and Black and Asian ethnic communities. The data is therefore not nationally representative.

Purpose of the study

The NCMP was established to help improve understanding of obesity prevalence and trends in children across England and to inform the planning and delivery of services for children.

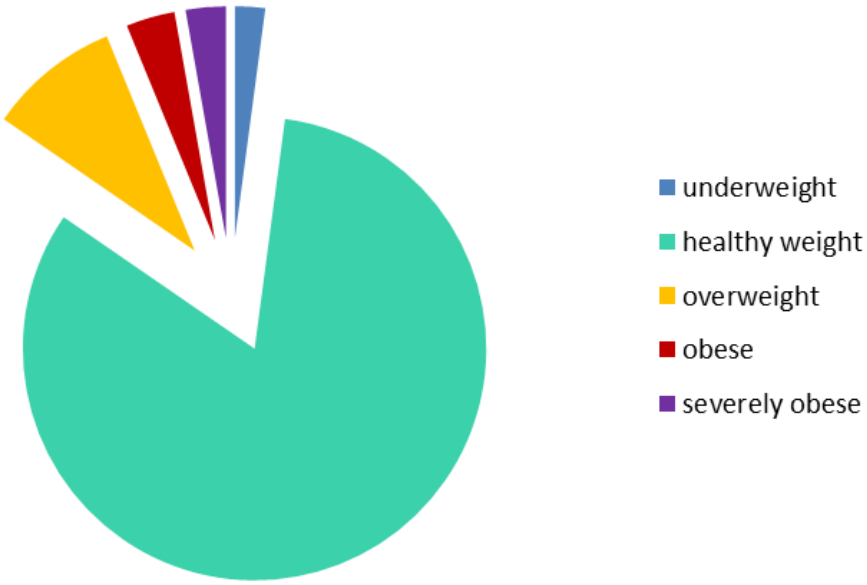
To date, analysis of NCMP data has shown that the prevalence of obesity doubles between Reception and Year 6, and is higher in children from certain black and minority ethnic groups and those from the most deprived areas. It is therefore important to know:

- How does weight status change during primary school?
- Do obese children in Reception remain obese at Year 6?
- What are the socio-demographic characteristics of the children who become obese (≥98th centile) during primary school?
- What are the socio-demographic characteristics of the children who remain obese throughout primary school?
- What are the socio-demographic characteristics of children who start school overweight (≥91st to <98th centile) or obese and grow into a healthy weight during primary school?

Tracking the weight status of individual children can help to answer these questions; however, such tracking is currently only possible using locally provided data, since nationally linked data will not be available until 2019.

What we found

We tracked the weight status of 722 underweight (<2nd centile), 28,092 healthy weight (2nd to <91st centile) and 3,128 overweight (≥91st centile to <98th), 1,143 obese (≥98th to <99.6th centile)) and 963 severely obese (≥99.6th centile) Reception children from four local authorities in England:



We predicted the chances of girls and boys remaining or changing weight status in Year 6 based on their weight status in Reception, and found that:

- For children who are overweight in Reception, 31% will remain overweight, around 30% will become obese, and 13% severely obese by Year 6.
- For children who are obese (excluding severely obese) in reception, 36% of girls and 37% of boys will remain obese in Year 6, and a further 28% of girls and 33% of boys will develop severe obesity.
- Most children who are severely obese in Reception will remain severely obese in Year 6 (62% of girls, 57% of boys).
- Most children who are a healthy weight in Reception will remain a healthy weight by Year 6 (77% girls, 73% boys). However, 7% of girls and 9% of boys who are a healthy weight in Reception will become obese (including severe obesity) by Year 6. Although a small percentage, this represents a large number of children.
- These results suggest that the doubling in obesity prevalence between Reception and Year 6 is driven by the numbers of overweight and healthy weight Reception children that become obese by Year 6.
- Most children (68% of girls, 77% of boys) who are underweight in Reception will gain a healthy weight by Year 6.
- A small number of children with excess weight will return to a healthy weight: around 27% of overweight, just over 10% of obese, and fewer than 5% of severely obesechildren in Reception will return to a healthy weight by Year 6.
- These findings align with a similar study conducted in a nationally representative cohort of children taking part in the Millennium Cohort Study.

Summary diagram: Changes in weight status during primary school

PREDICTED WEIGHT STATUS IN YEAR 6

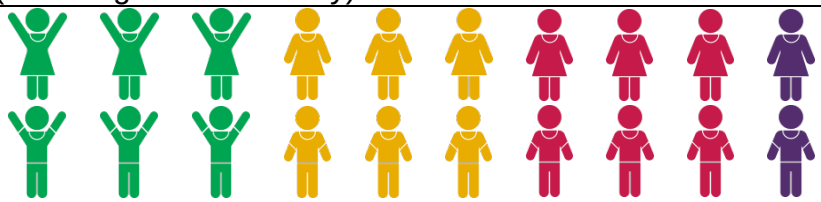
Of the 2% of boys and girls who were UNDERWEIGHT in Reception

Most will gain a healthy weight but around a third of girls and a fifth of boys will remain underweight

Of the 83% of boys and girls who were HEALTHY WEIGHT in Reception

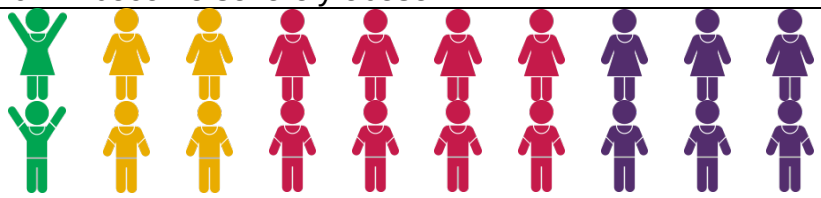
Most will remain a healthy weight, but more than 1 in 10 will become overweight and around 1 in 10 will become obese (including severe obesity)

Of the 9% of boys and girls who were OVERWEIGHT in Reception



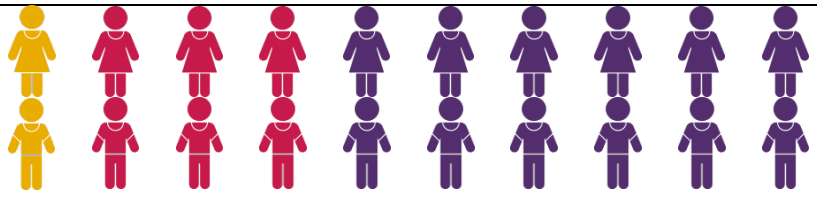
Just under a third will gain a healthy weight, just under a third will remain overweight, just under a third will become obese and 1 in 10 will become severely obese

Of the 3% of boys and girls who were OBESE (but not severely obese) in Reception



Around a third will reduce their weight status to healthy or over-weight, while more than two thirds will remain obese or become severely obese

Of the 3% of boys and girls who were SEVERELY OBESE in Reception



Most will remain severely obese, however around a third will reduce their weight status to become obese and 1 in 10 will become overweight

Underweight; Healthy weight, Overweight, Obese, Severely Obese. Predicted weight status is calculated using UK90 clinical cut points, shown for boys and girls separately, and % rounded to nearest 10%.

The impact of socio-demographics

All children irrespective of socioeconomic status are at risk of maintaining or developing obesity; however, this risk is greatest in children from the most deprived neighbourhoods, who are more likely to become or remain obese than their most affluent counterparts.

All children irrespective of their ethnicity are at risk of becoming obese during primary school; however, healthy weight children from Asian and black ethnic groups, have a higher likelihood of becoming obese in Year 6 when compared with their white counterparts.

Children from the most deprived neighbourhoods may be less likely than their more affluent counterparts to return to a healthy weight status in Year 6.

Practice considerations

These results show that for most children, unhealthy excess weight (≥91st centile) tracks from Reception to Year 6, and therefore needs to be recognised and acted upon by parents, health services, educators and the wider community. It may be useful to use this report's findings to communicate these risks.

The findings help make the case for:

- wide-scale preschool and school-age primary and secondary prevention programmes to increase the numbers of children starting and leaving primary school with a healthy weight
- appropriate services to reduce the burden of excess weight for those children who are already obese, and prevent the continuity of unhealthy excess weight into later life

The risk of becoming or retaining an unhealthy weight is higher for children from more deprived families and certain BME populations. Therefore, localities should consider working closely with families from these groups to help ensure that services meet their population needs. It is important to note that movement from an unhealthy to a healthy weight is seen in a minority of children. These children warrant further investigation because they could provide valuable insights into what individual, environmental and psychosocial changes supported their transition.

In view of the tracking and development of severe obesity during primary school, localities may wish to review their service provision, since these children are likely to require specialist services.

Glossary

BMI:	Body Mass Index
BME:	Black and minority ethnic
IMD:	Index of Multiple Deprivation
NCMP:	National Child Measurement Programme
UK90:	UK 1990 growth reference

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Background

About the National Child Measurement Programme

The NCMP began in 2006 and provides detailed trend data on children's weight status. The data are used by national and local government to inform action to tackle child obesity. Set up as a surveillance programme, the NCMP national report has UK National Statistics status and is one of the mandatory public health functions of local authorities. The data are internationally recognised as a world-class source of public health intelligence. Additionally, the programme provides an opportunity to engage with children and families about the importance of healthy weight.

The importance of tracking weight status during primary school

National cohort analyses of the NCMP data have shown that the prevalence of obesity approximately doubles during primary school and is associated with socio-demographic factors. For instance, prevalence is higher in certain black and minority ethnic (BME) populations and in children from more deprived areas (PHE, 2014). These analyses raise several important questions, which to date have not been explored using NCMP data.

- How does weight status track during primary school?
- Do obese children in Reception remain obese by Year 6?
- What are the socio-demographic characteristics of the children who become obese throughout primary school?
- What are the socio-demographic characteristics of the children who remain obese throughout primary school?
- What are the socio-demographic characteristics of children who start school overweight or obese and grow into a healthy weight during primary school?

Longitudinal tracking analysis would help to answer these questions by exploring how the weight status of individual children changes over time.

Until 2013, linking of children's Reception and Year 6 NCMP results was not possible because the data collected was anonymised when submitted for national analysis. Subsequent changes to legislation (Local Authority Regulations, 2013) have provided the opportunity to submit person identifiable data such as an NHS identifier with each child's NCMP record. However, longitudinal linkage of NCMP data at the national level will not be possible until 2019 when Reception-year

children, whose NHS number was included in 2013/14, will reach Year 6 and be re-measured.

In the 2014/15 NCMP data collection, 56 out of 150 local authorities did not submit an NHS number for any of the children they measured (HSCIC, 2015). In the 2015/16 NCMP data, this had fallen to 42 out of 150 submitting local authorities (NHS Digital, 2016). The geographical coverage of any future national tracking analyses will be limited until coverage of this information improves. PHE is examining the models that are used in areas successfully submitting NHS numbers for all children measured with a view to sharing practice with areas not doing so.

Until geographically complete national analyses are possible, tracking analysis can only be done using locally held data, where the data has been stored alongside a suitable identifier such as an NHS number (for example in areas that have opted to store their NCMP data on their electronic child health systems). This local arrangement will facilitate the linkage of Reception and Year 6 measurements providing that appropriate governance arrangements are in place.

Previous childhood overweight and obesity tracking studies

The earliest English tracking analysis was done in Hull (Porter 2007), using data extracted from the local child health information system to link measurements from children aged 4–5 (recorded in 1999–2001) to data at ages 10–11 (recorded in 2005–2007). The study pre-dated the start of the NCMP, and showed that around half the overweight children in Reception became obese by Year 6. Additionally, 59% of boys and 77% of girls who were obese in Reception remained obese by Year 6. However, this analysis, tracked only the prevalence of overweight and obesity (defined using population monitoring not clinical cut points), and did not monitor underweight or healthy weight trends.

A later study in Southampton (King, 2011), also obtained data from local child health information systems for children measured in two cohorts: 1999/00 and 2005/06; and 2004/05 and 2010/11. An odds ratio analysis showed that the odds of overweight Reception children becoming obese in Year 6 were 4.71 times (4.05 to 5.49) greater than the odds of healthy weight children becoming obese. The odds of obese children remaining obese at Year 6 were 16.20 times (13.68 to 19.17) greater than the odds of healthy weight children becoming obese. Odds ratios can, however, be difficult to interpret and do not quantify individual prediction error. This analysis also used population monitoring cut points to define overweight and obesity.

Another study in South Gloucestershire (Pearce, 2015) used NCMP data and logistic regression to track BMI percentiles from Reception to Year 6 (measured in

2006/07 and 2012/13). The study reported that the odds of overweight children (between the 85th and 94th centile) in Reception becoming obese (greater than or equal to the 95th centile) at Year 6 were 13.38 (8.00 to 22.38) times greater than children who were between the 2nd to 49th percentile in Reception. Using population monitoring thresholds for overweight and obesity this study also demonstrated that 68% of children who were obese at reception remained obese in Year 6, and 78.4% of those who were a healthy weight in reception remained so in Year 6.

The most recent tracking analysis was conducted using the Millennium Cohort Study (MCS) data (Mead, 2016), and used ordinal regression to derive the predicted probability of an 11-year-old child becoming underweight, healthy weight, overweight, obese or severely obese from their weight status at age 5. This study showed that the chances of becoming obese (including severely obese) at age 11 were 5.7% (95% CI: 5.2% to 6.2%) for a healthy weight 5-year-old and 32.3% (29.8% to 34.8%) for an overweight 5-year-old. The chance of an obese 5-year-old remaining obese was 68.1% (63.8% to 72.5%), and a severely obese 5-year-old had a 50.3% (43.1% to 57.4%) chance of remaining severely obese by age 11.

Although the study did not find any substantial difference between boys and girls, the most affluent obese 5-year-old boys did have a lower probability of remaining obese by age 11 then their more deprived counter parts, an association that was not seen in girls. This study used clinical cut points to categorise weight status[1] (>/=91st centile for overweight and >/=98th centile for obese), and the results derive from the MCS which is a cohort study not a population census. The measurement times do, however, broadly align with children who may have also taken part in the very first NCMP Reception measures and subsequent Year 6 follow up. The study provides a robust and easily interpreted methodology that could be applied to other longitudinal datasets, such as the NCMP.

[1] Clinical thresholds for overweight and obesity: >/=91st and >/=98th
Population thresholds for overweight an obesity: >/=85th centile and >/=95th

Aim and objectives

This study aimed to collate NCMP data from a purposive[2] sample of local authorities that were able to provide anonymised linked extracts from their local child health systems (2006/07-2014/15). These datasets were analysed individually and collectively to address the following objectives:

- to provide prognostic information on the likelihood of an individual child developing or retaining an unhealthy weight (<2nd centile or ≥91st centile) status during primary school
- to increase understanding of the relationship between unhealthy weight status, change in weight status during primary school, and socio-demographic inequalities, particularly sex, deprivation, and ethnicity
- to improve understanding of child growth trajectories, which may help inform the development of appropriate services for populations identified as highest risk

Methods

We followed the method described by Mead et al, 2016, and used ordinal logistic regression to predict weight status at age 10–11 years based on six potential determinants: weight status at age 4–5 years; sex; ethnicity; deprivation; local authority, and year of first measurement. We made the following adaptations:

- a multinomial logit model was used as an alternative to a generalised logit model in sensitivity analysis because of estimation (convergence) issues with the latter
- we did not do a multiple imputation of missing Year 6 weight status because the NCMP strives to be an exhaustive sample of children in state-maintained schools and has very high rates of participation (HSCIC 2013, HSCIC 2014, HSCIC 2015). The missing data in this analysis is thus largely due to problems with data linkage rather than absenteeism or opt out on the day of measurement. The proportion of potentially informative missing data was considered to be very low

A detailed analytical protocol is provided in Appendix 1.

[2] A purposive sample is a non-probability sample, that is, a population selected to meet the objective of the study. Purposive sampling can also be referred to as judgmental, selective, or subjective sampling.

The four local authorities were selected because (i) they had data suitable for linkage and had agreed to share their data within the timeframe of the analysis; and (ii) they provided a collective population ranging in ethnicity and socioeconomic status. Data was collated for the most recent three cohorts that could be linked (2006/07, 2007/08, 2008/9 to 2012/13, 2013/14, 2014/15). Pupil participation rates for these periods, where data were provided, were higher than the national values. For all local authorities participation was lowest in 2006/07 in Reception children (The Information Centre, 2008). Participation data are provided in Table 1.

All results were analysed using the clinical cut points for underweight (<2nd centile), healthy weight (2 to <91st centile), overweight (91st centile and over); obese (98th centile and over) and severely obese (99.6th centile and over) of the UK90 growth reference (Cole, 1995). The decision to use clinical cut points was made because the data tracks individual children, and the output may be a useful resource for parents, who will have received feedback on their child's weight status defined using the clinical cut points. Socioeconomic status was classified using the Index of Multiple Deprivation (IMD) (2015).[3] Ethnic group was allocated using the NHS ethnicity coding scheme.[4] As numbers for many of the individual ethnic groups were too small to analyse individually, these were aggregated to summary ethnic groups for analysis as shown in Table 1.

Statistical significance of effect was assessed throughout the results using 95% confidence intervals, with significance noted only when confidence intervals do not overlap. This is a conservative approach; it is possible in some cases for confidence intervals to overlap even when a significant difference is shown in a statistical test.

Table 1: Summary ethnic groups (as used in the analysis)

NHS Ethnicity Code	Summary ethnic group used in analysis
A British B Irish C Any other White background	White
H Indian J Pakistani K Bangladeshi L Any other Asian background F White and Asian	Asian
M Caribbean N African D White and Black Caribbean E White and Black African P Any other Black background	Black
R Chinese G Any other mixed background	Other

[3] https://www.gov.uk/government/statistics/english-indices-of-deprivation-2015
[4] http://www.datadictionary.nhs.uk/data_dictionary/attributes/e/end/ethnic_category_code_de.asp

S Any other ethnic group Z Not stated Not matched Missing	

Results were analysed in Excel 2010 and Stata SE version 13. LMS Growth was used to calculate the BMI centiles.[5]

Results

Four local authorities were able to provide data. Results have been aggregated for this report.

Characteristics of participating children

Data was successfully extracted and linked for 34,048 children across four local authorities. Descriptive statistics which compare weight status at age 4–5 years and age 10–11 years by sex, deprivation and ethnicity are shown in Appendix 2. The participant characteristics are shown in Table 2, and show significant differences in sample sizes, with the overall dataset predominated by the largest local authority (LA1). Summary data for England for 2014/15 has been included in Table 2 and highlights differences between the sample population and the average population characteristics for children measured nationally. When divided by the Index of Multiple Deprivation, all local authorities (apart from LA4) have substantially more participants residing in the most deprived quintiles, with fewest in the most affluent quintiles, a characteristic that is much higher than the England average. Ethnicity data was not provided for LA4, and proportion of participants from different BME groups varied across the remaining local authorities, with the greatest ethnic diversity in LA1&2. Overall the sample contained a higher proportion of children from black and Asian groups when compared to the national average.

Prevalence of obesity (defined using clinical cut points) also varied across the localities, with the highest and lowest prevalence of both Reception and Year 6 obesity in LA2 and LA4, respectively. Data was returned for all three baseline years for LA1–3, but only 2006/07 for LA4. Of all the data returned, complete matched data was only available for 67%, 49%, 78% and 99% of data for LA1–4, respectively. In view of the variation in matching rates, a sensitivity analysis was undertaken to examine the impact of the local authority with the lowest matching rate, this analysis (Appendix 3) showed the that this authority did not substantially influence the overall findings and therefore remained in the analysis.

[5] http://www.healthforallchildren.com/shop-base/shop/software/lmsgrowth/

Table 2: Participant characteristics compared to England and overall participation rates

	n (%)*					England overall % (2014/15)
	Birmingham (LA1)	**Luton (LA2)**	**Walsall (LA3)**	**South Gloucestershire (LA4)**	**Overall**	
Sex						
Male	11,877 (50.6)	921 (54.2)	3,554 (50.6)	959 (52.0)	17,311 (50.8)	51.1
Female	11,604 (49.4)	779 (45.8)	3,468 (49.4)	886 (48.0)	16,737 (49.2)	48.9
IMD quintile age 4-5 years						
Most deprived 1	15,715 (66.9)	530 (31.2)	3,701 (52.7)	34 (1.8)	19,980 (58.7)	25.4
2	3,044 (13.0)	671 (39.5)	1,175 (16.7)	228 (12.4)	5,118 (15.0)	20.7
3	2,394 (10.2)	225 (13.2)	757 (10.8)	357 (19.4)	3,733 (11.0)	18.2
4	1,047 (4.5)	180 (10.6)	711 (10.1)	409 (22.2)	2,347 (6.9)	17.1
Least deprived 5	779 (3.3)	72 (4.2)	656 (9.3)	789 (42.8)	2,296 (6.7)	18.3
Missing	502 (2.1)	22 (1.3)	22 (0.3)	28 (1.5)	574 (1.7)	0.3
Ethnicity						
White	9,565 (40.7)	513 (30.2)	4,857 (69.2)	-	14,935 (43.9)	62.3
Asian	9,814 (41.8)	679 (39.9)	1,757 (25.0)	-	12,250 (36.0)	9.5
Black	2,907 (12.4)	174 (10.2)	291 (4.1)	-	3,372 (9.9)	6.2
Other inc. missing	1,195 (5.1)	334 (19.7)	117 (1.7)	1,845 (100.0)	3,491 (10.3)	22
Year						
2006/07	7,333 (31.2)	302 (17.8)	2,171 (30.9)	1,845 (100.0)	11,651 (34.2)	-
2007/08	8,389 (35.7)	866 (50.9)	2,302 (32.8)	-	11,557 (33.9)	-
2008/09	7,759 (33.0)	532 (31.3)	2,549 (36.3)	-	10,840 (31.8)	-
Clinical weight status age 4-5 years						
Underweight	544 (2.3)	23 (1.4)	135 (1.9)	20 (1.1)	722 (2.1)	1
Healthy weight	19,348 (82.4)	1,256 (73.9)	5,909 (84.2)	1,579 (85.6)	28,092 (82.5)	84.8
Overweight	2,127 (9.1)	219 (12.9)	612 (8.7)	170 (9.2)	3,128 (9.2)	9.3
Obese (not inc. severe)	773 (3.3)	104 (6.1)	212 (3.0)	54 (2.9)	1,143 (3.4)	2.9
Severely obese	689 (2.9)	98 (5.8)	154 (2.2)	22 (1.2)	963 (2.8)	2.1
Clinical weight status age 10-11 years						
Underweight	460 (2.0)	43 (2.5)	130 (1.9)	19 (1.0)	652 (1.9)	1.4
Healthy weight	15,555 (66.3)	906 (53.3)	4,785 (68.1)	1,397 (75.7)	22,643 (66.5)	72.8
Overweight	3,935 (16.8)	407 (23.9)	1,085 (15.5)	269 (14.6)	5,696 (16.7)	14.4
Obese (not inc. severe)	2,237 (9.5)	224 (13.2)	649 (9.2)	119 (6.5)	3,229 (9.5)	7.7
Severely obese	1,294 (5.5)	120 (7.1)	373 (5.3)	41 (2.2)	1,828 (5.4)	3.7
Missing Data						
Complete cases	23,481 (66.6)	1,700 (49.3)	7,022 (77.5)	1,845 (99.0)	34,048 (68.6)	-
Incomplete cases	11,775 (33.4)	1,746 (50.7)	2,038 (22.5)	18 (1.0)	15,577 (31.4)	-
Participation rate (%)						
Reception 2006/07	87	78	92	88	-	83
Reception 2007/08	92	91	95	-	-	89
Reception 2008/09	92	94	98	-	-	91
Year 6 2011/12	95	99	97	92	-	92
Year 6 2012/13	95	99	98	-	-	93
Year 6 2013/14	96	100	97	-	-	94

* percentages may not sum to 100 due to rounding. †'Other inc missing' ethnic group includes children who were missing ethnicity data as well as children from other BME groups (e.g. Chinese) which were too small assess in their own category. Weight status categories used the following clinical cut points: <2nd centile underweight; 2-90th centile healthy weight; 91-97th centile overweight; 98-99.5th centile obese; 99.6th and over for severely obese.

Predicted weight status in Year 6 by weight status in Reception

All data is presented graphically, but corresponding data tables can be found in Appendix 4.

Figure 1 shows the modelled weight status for Year 6 boys and girls based on their weight status in Reception (i.e. the chances of remaining or changing weight status). This data shows that most (77% boys and 68% girls) underweight children in Reception will gain a healthy weight by Year 6. The chance of an underweight Reception child becoming overweight or obese by Year 6 was less than 2%. However, around a fifth of boys and a third of girls will remain underweight by Year 6 (these sex differences were statisically significant). It is, however, important to note that underweight children represent a very small proportion of all children in Reception (2.1%, n=722 in this sample).

For healthy weight children in Reception (this was the vast majority: 82.5% of all children sampled, n=28,092), most (73% of boys and 77% of girls) will remain a healthy weight in Year 6. Less than 10% (9% of boys and 7% of girls) of healthy weight Reception children will become obese (including severe obesity), and less than 2% will become underweight by Year 6. Healthy weight boys were statistically significantly more likely than their female counterparts to gain excess weight by Year 6.

However, for the overweight children in Reception (9.2%, n=3,128 in this sample), approximately 30% will remain overweight, whilst almost 30% will become obese and a further 13% will become severely obese. Around 27% of these children will return to a healthy weight.

For those obese but not severely obese Reception children (3.4%, n=1,143 in this sample), just over a third will remain obese and around a third will develop severe obesity by the time they reach Year 6. The percentage of obese Reception children who will become overweight or healthy weight will be around 20% and 10%, respectively. For the severely obese Reception children (2.8%, n=963 children in this sample), most will remain severely obese (57% boys and 62% girls). A further 29% of boys and 27% of girls who are severely obese in Reception will become obese, and the remaining small proportion will transition to overweight (under 10%) or healthy weight (under 5%).

Predicted weight status by socio-demographics

Figure 2 presents the predictive chance of a child in Reception becoming obese by Year 6 according to their sex and Index of Multiple Deprivation (IMD). This data shows that the risk of obesity increases for all children, however, the risk is higher in children from the most deprived fifth of the population. There is a general trend for this risk to be higher in boys than girls (although the only statistically significant difference between sexes within IMD was seen in the healthy weight children, this may be due to the larger number analysed). A similar impact of deprivation was also observed for severe obesity (Figure 3), although the trend for remaining severely obese was higher in girls rather than boys.

The chance of a Reception child becoming obese by ethnic group and sex is shown in Figure 4. Although fewer than 10% of all healthy weight children become obese, those with a healthy weight in Reception from Asian and black groups are significantly more likely to become obese than are their white counterparts. This was also observed for overweight Asian and black Reception children (although this relationship was only statistically significant for black children).

Figure 5 shows the socio-demographic breakdown for the small proportion of obese and overweight Reception children who returned to a healthy weight by Year 6. The overall trends show that the likelihood of returning to healthy weight status was less for children from black and Asian ethnic groups than children from other ethnicities, and less for those from the most deprived neighbourhoods than those from more affluent areas. The relationship between deprivation and reduced chances of gaining a healthy weight status was statistically significant for all groups.

Figure 1: The predicted percentage chances of a 10-11 year old boy or girl being underweight, healthy weight, overweight and obese based on their weight status at age 4-5 years (error bars indicate 95% confidence intervals)

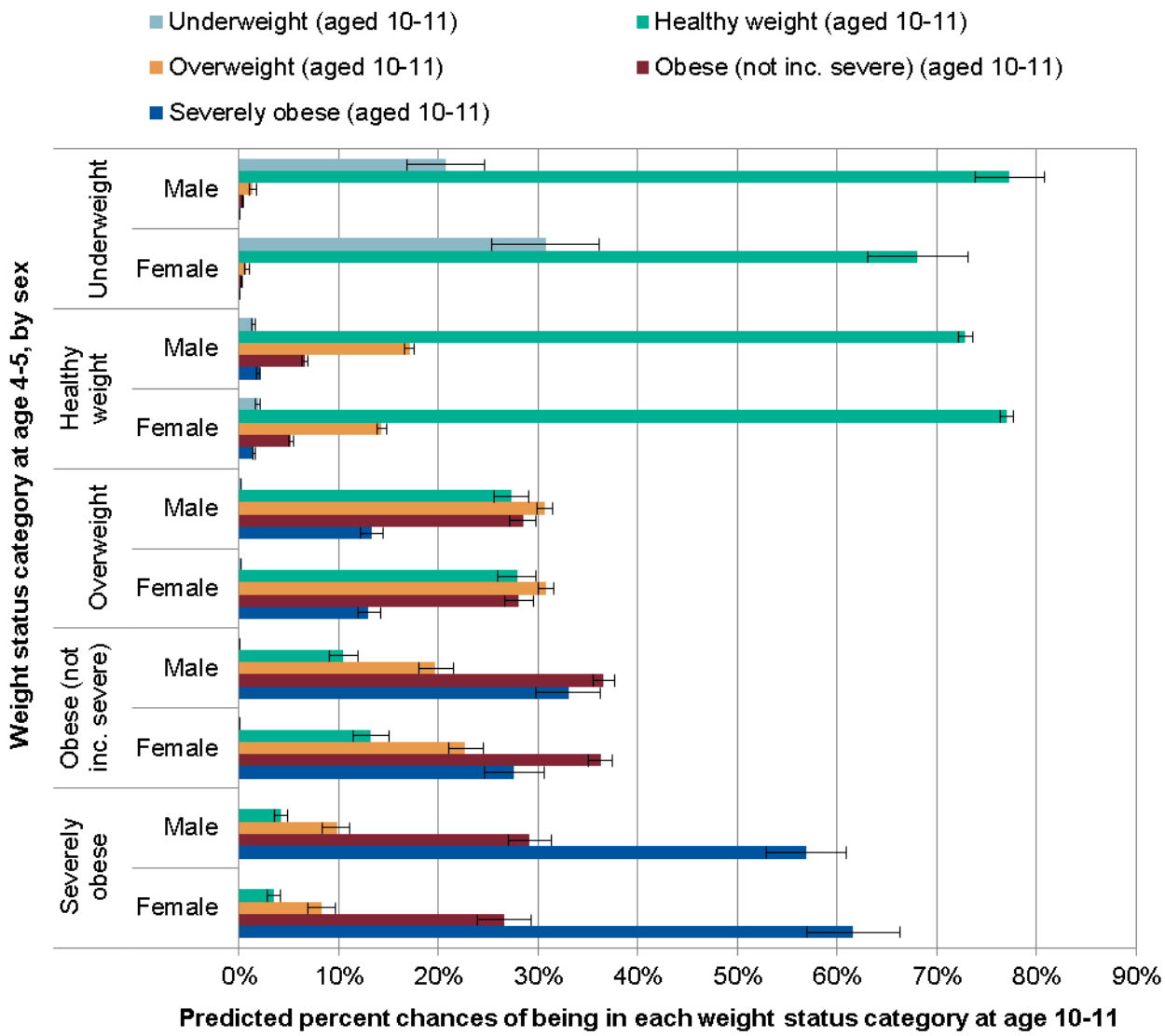


Figure 2: The predicted percentage chances of most and least deprived boys and girls being obese at age 10-11 years, based on their weight status and the residence Index of Multiple Deprivation (IMD) score at age 4-5 years (error bars indicate 95% confidence intervals)

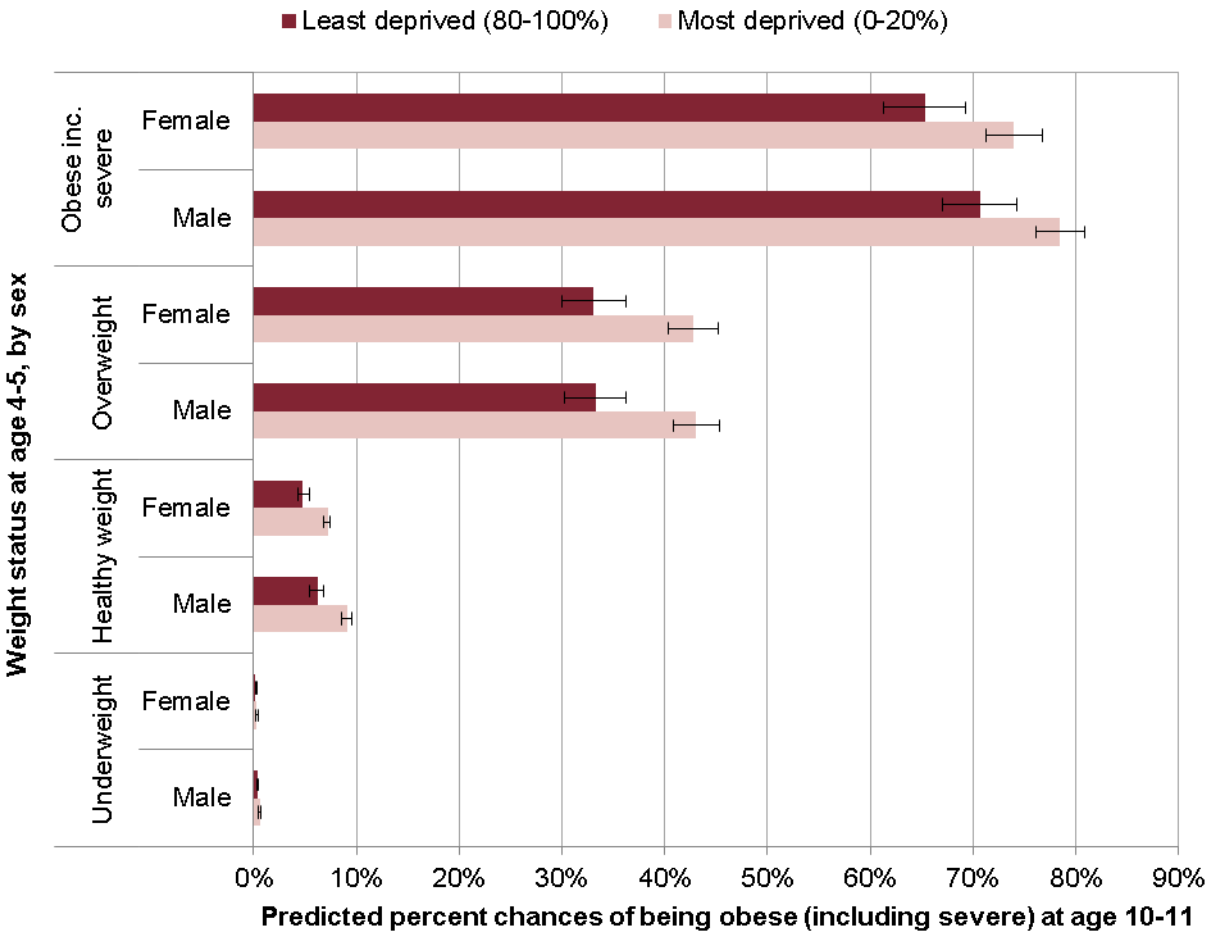


Figure 3: The predicted percentage chances of a most and least deprived child being severely obese at age 10-11 years based on their weight status at age 4-5 years, by sex (error bars indicate 95% confidence intervals)

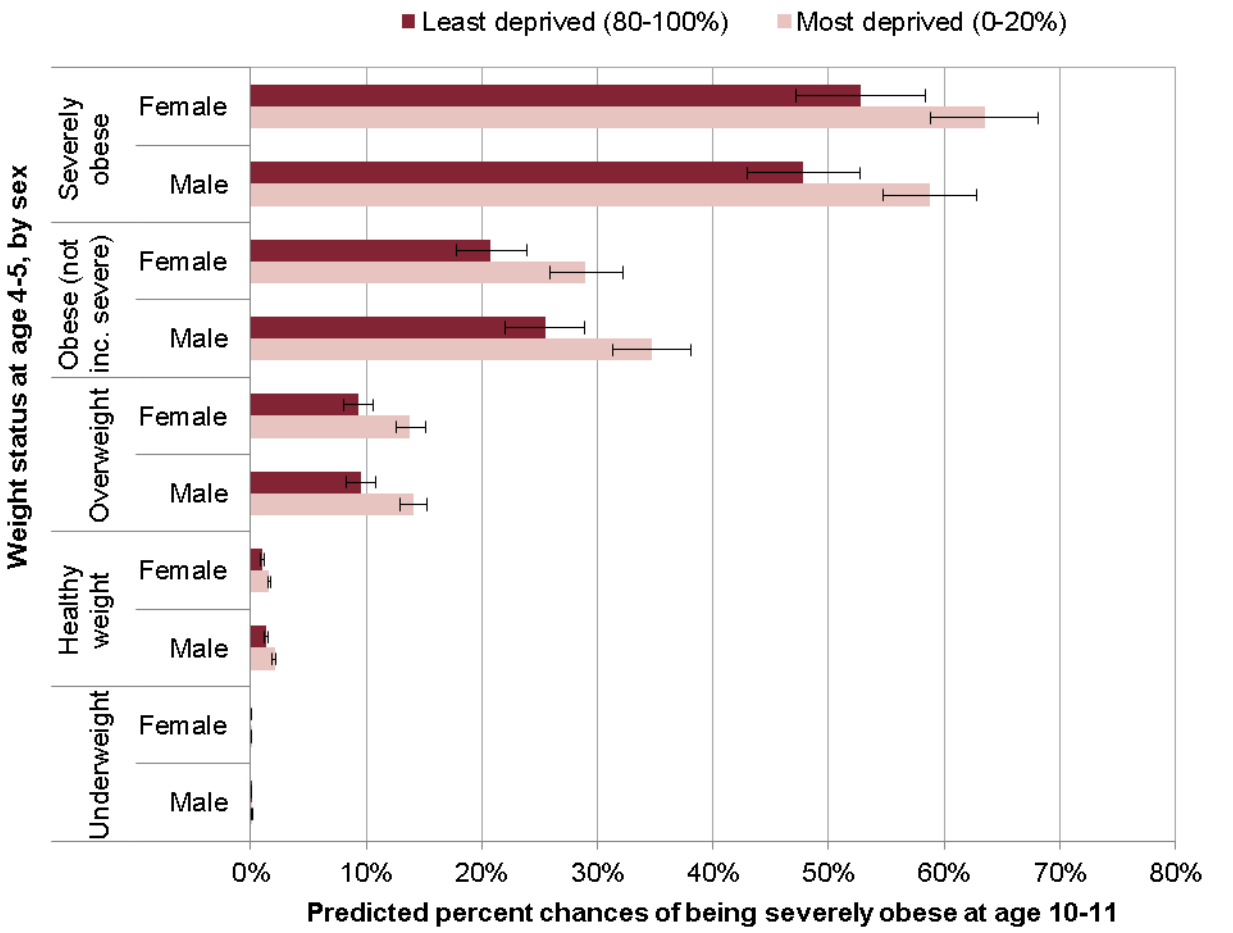


Figure 4: The predicted percentage chances of a child being obese at age 10-11 years based on their weight status at age 4-5 year by sex and ethnicity (error bars indicate 95% confidence intervals)

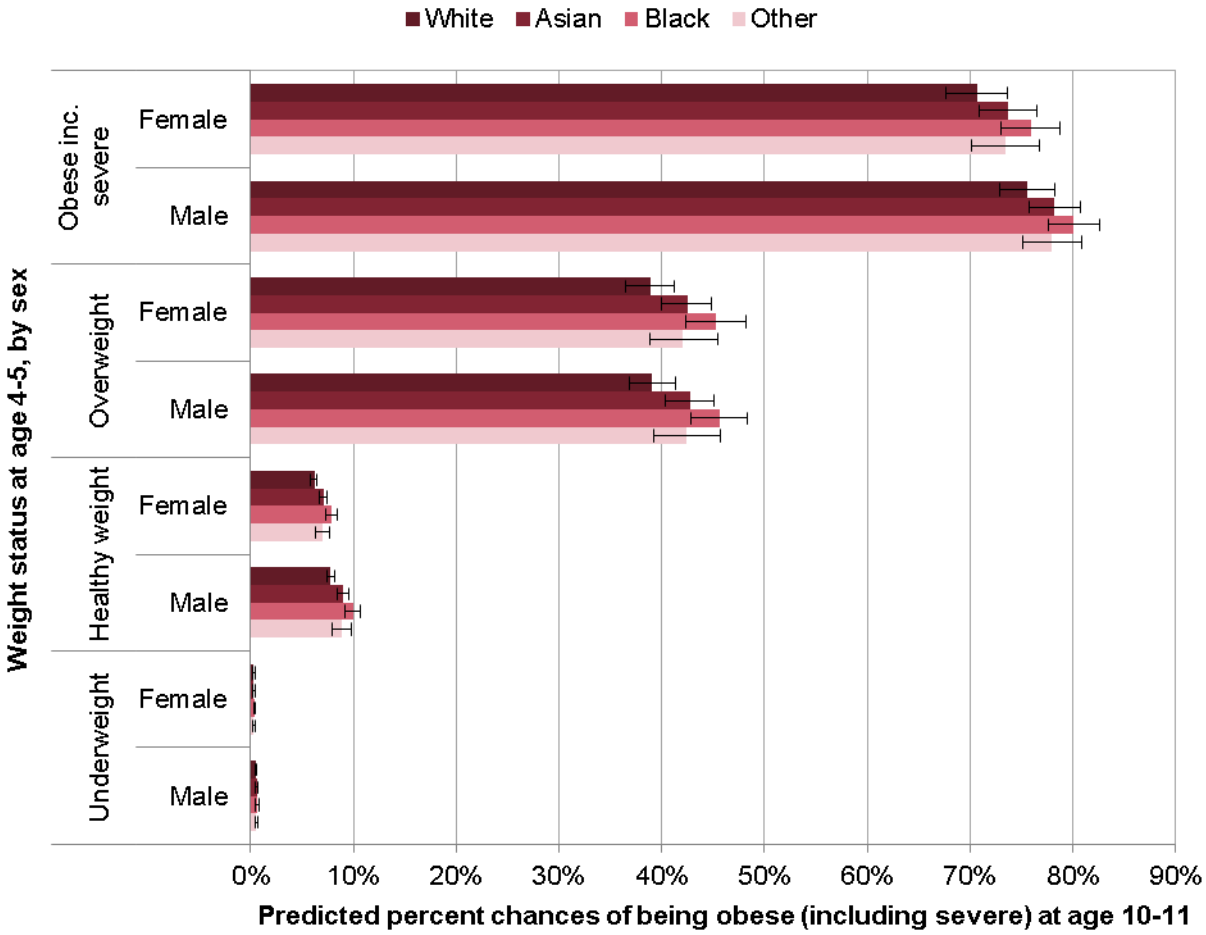
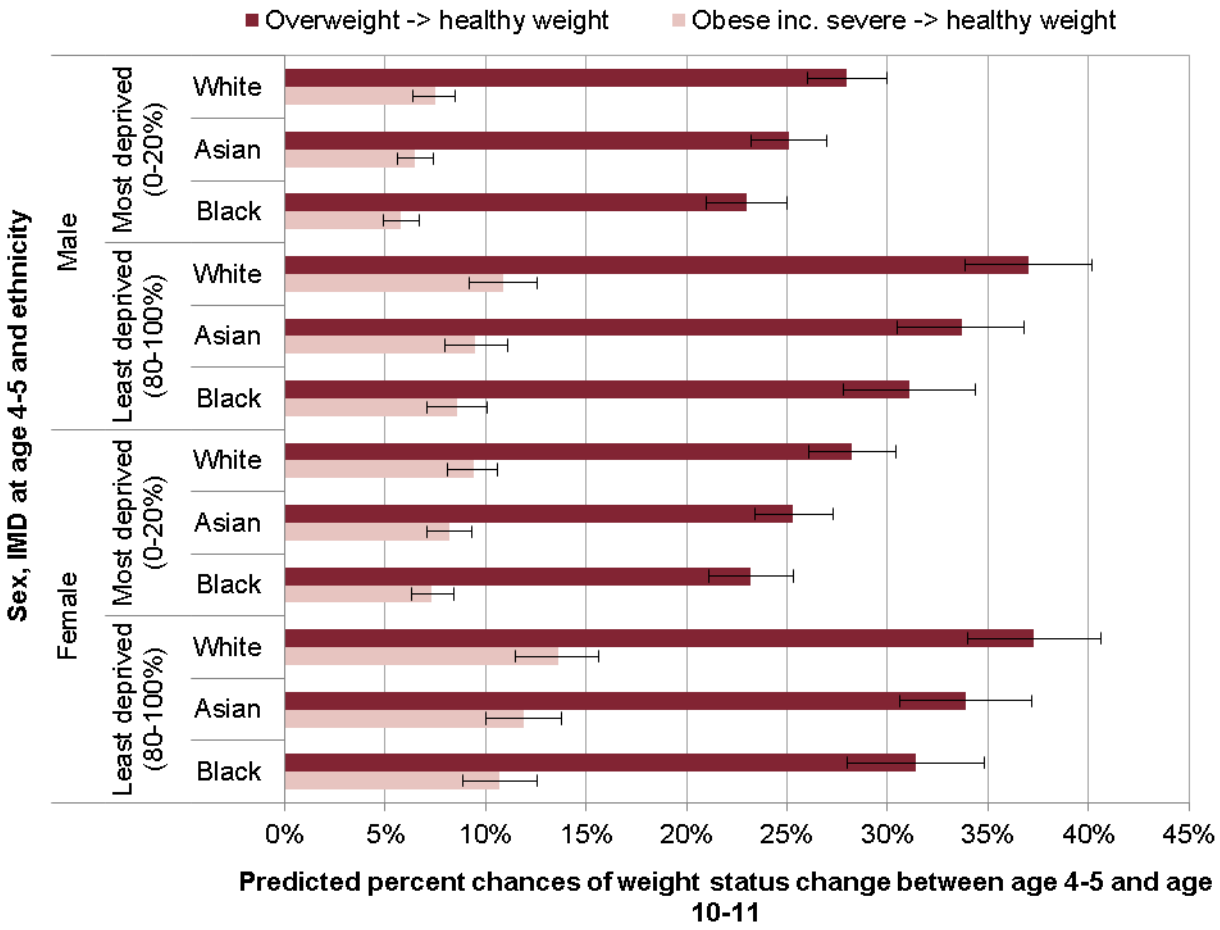


Figure 5: Predicted chances of improving weight status between age 4-5 and age 10-11 years, by sex, Index of Multiple Deprivation (IMD) and ethnicity (error bars indicate 95% confidence intervals)



Discussion

This study is currently the largest tracking study undertaken in England using NCMP data. The findings therefore provide an important benchmark for future national and local tracking analyses, and new insight into how weight status tracks during primary school. Unlike previous tracking studies discussed earlier, this study uses a sufficient sample size to examine the effect of ethnicity, underweight and severe obesity, defined using the UK90 clinical cut points (Cole, 1995).

Comparing the findings with previous studies

Although different tracking methodologies were used, results from previous studies (Pearce et al, 2015, King, 2011 and Porter, 2007) align with the findings in this report to suggest that overweight and obesity is likely to persist or worsen between Reception and Year 6.

The only previous study to have undertaken tracking analyses using ordinal regression methodology was Mead (2016), who examined weight status tracking of children participating in the UK MCS. The sample size of this NCMP study was almost three times the size of the MCS study, which allowed for more detailed subgroup analyses by ethnicity and underweight, which were not possible due to small numbers in the MCS. In terms of participant demographics, while both studies analysed equal proportions of boys and girls, this study had significantly more participants (59%) who resided in the most deprived quintile compared to just 26% in the MCS. The measurement years were also slightly earlier in the MCS, starting in 2005. In terms of baseline weight status in Reception, values were comparable for underweight (1.1% MCS *vs* 2.1% NCMP), healthy weight (82.4% *vs* 82.5%), overweight (10.3% *vs* 9.2%) and obesity (6.2% *vs* 6.2%). In terms of tracking outcomes, the figures were comparable between the nationally representative Mead study and the case studies presented in this report. The Mead study reported that the chances of a healthy, overweight and obese Reception child becoming or remaining obese (including severe obesity) by Year 6 were 6%, 32% and 68% respectively. This compares with 7.7% (95%CI 7.4-8.0), 41.3% (95%CI 39.7-42.9) and 74.9% (95%CI 73.1-76.8) identified in this NCMP study, which shows a substantially higher chance of an overweight and obese child becoming or remaining obese in Year 6 when compared with the MCS. Most children in both the MCS and NCMP who were underweight or healthy weight achieved or retained a healthy weight by Year 6. In the MCS, a severely obese Reception aged child had a 50.3% (43.1%-57.4%) chance of remaining severely obese, which compared with a 59.2% (95%CI 56.1-62.3) chance for comparable children in the NCMP. When analysed by IMD, the NCMP data showed a more consistent trend than the MCS study towards higher obesity

development or retention in more deprived children, which may be attributable to the larger sample size and greater proportion of deprived children within the dataset.

Limitations of the study

The main limitations are:

- data are aggregated from three different baseline years and, although participation rates are generally high, participation rates between years did vary. Additionally, one local authority was only able to provide data for one linked measurement year
- data are aggregated from four purposively selected local authorities and, therefore, does not provide a nationally representative population. This sample also over represented children from the most deprived quintiles, which may explain the small differences between the most and least deprived groups in obesity tracking
- only three local authorities used the data linkage protocol described in this report; LA 4 used a different linkage methodology
- one local authority was unable to provide ethnicity data, therefore these children were all categorised in the 'other inc. missing' category (includes children with missing ethnicity data as well those from other BME groups (eg Chinese) which were too small to assess in their own category)
- due to small numbers we had to create very broad ethnic groups. While they provide a very important insight into possible differences for BME populations, it is important to acknowledge that the individual ethnic groups within each broad category may have different obesity profiles to the average for the broad category
- overall, 574 children were missing data on IMD

Although this is the largest tracking study undertaken in England, a larger, more nationally representative sample size would have strengthened the analysis. This may have helped reduce the size of the confidence intervals where smaller numbers of children were available (such as underweight and severe obesity), and improved the strength of ethnicity analyses (for example, larger numbers may have facilitated examination of more defined ethnicity categories). However, despite interest from a number of local authorities, participation from several local authorities was restricted by insufficient staff to extract link and clean data, insufficient time to undertake the data extraction, the lack of suitable identifiers on locally stored data (to enable linkage) and/or local governance issues.

Consideration:
The possibly of a second wave of analysis should be scoped, to include additional data from those localities who needed additional time and capacity to source the data. This

would further strengthen the evidence base and provide more local areas with information to inform service provision.

Practical considerations for these findings

If children enter primary school with a healthy weight, most will retain this healthy weight status until the end of primary school, yet an overweight child is more likely to remain overweight or develop obesity, and an obese child is more likely to remain obese or develop severe obesity.

Although only a small proportion of healthy weight children become obese, they represent a large number. The combination of healthy and overweight children who become obese by Year 6 is driving the doubling in obesity prevalence.

Considerations:
These results provide support in making the case for providing healthy weight programmes and support before Reception year to help reduce the life course burden of overweight and obesity.

The findings provide support in making the case for the provision of wide scale primary and secondary prevention programmes to prevent the large numbers of healthy and overweight children gaining excess weight during their primary school years.

The findings also support the case for appropriate treatment interventions to manage children who have already gained an unhealthy weight.

These results show that unhealthy excess weight is likely to track from Reception to Year 6, and therefore needs to be recognised and acted upon by parents, health services, educators and the wider community.. It may be useful to use these findings to communicate these risks, and dispel common myths around young children having ‘puppy fat’ that they will grow out of (Jones 2011).

Socio-demographic equalities may exist that need to be explored and addressed.

Consideration:
Localities may consider working with families from different socio-economic and ethnic backgrounds to understand the barriers and facilitators to weight management both in term of access to and uptake of treatment programmes, and possible family and wider environmental influences. These insights may help to develop interventions that are tailored to the needs of higher risk children.

Only a small number of overweight and obese children return to a healthy weight in Year 6. However, fewer children from Black and Asian groups, and those from more deprived neighbourhoods are returning to a healthy weight status.

Considerations:
Localities may wish to investigate whether inequalities exist in terms of access to, participation or success in weight management during primary school aged years.

Children who do return to healthy weight warrant further investigation as they could provide valuable insights into what individual, environmental and psychosocial changes may have supported their transition to a healthy weight.

Severely obese Reception children are likely to remain severely obese in Year 6, and around a third of obese, and a tenth of overweight Reception children will develop severe obesity.

Consideration:
Localities may wish to review their service provision for severely obese children, who are more likely to have obesity related co-morbidities (Ells 2015) and may therefore require more specialised services.

Research considerations

The findings from this report suggest several evidence gaps that would benefit from future research, these include:

- a qualitative research programme to explore the barriers and facilitators to weight management, particularly within more deprived families and those from black and minority ethnic groups
- a qualitative research programme with families of children who have transitioned from an unhealthy to a healthy weight during primary school. This research should explore the individual family and wider environment to establish whether there are particular attributes that supported this positive change that could be applied to others
- research to determine the most effective weight management interventions for primary school age children. This research should specifically examine targeted and tailored interventions for more deprived children, those from different BME communities and those suffering from more severe forms of obesity (including children with complex needs)
- future tracking analysis may benefit from examining BMI-z score as a continuous measure to help further explore socio-demographic relationships

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Appendix 1: Analytical protocol

Guidance on undertaking local level tracking analyses

How to analyse local data

It is possible to undertake tracking analysis locally if:

- your local NCMP data are stored alongside a suitable identifier (such as NHS number) on a local database (such as the child health information system)
- you have sufficient years data (at least 6) to facilitate linkage between Reception and Year 6
- you have permission from the data controller to undertake the analysis
- you have the required analytical and statistical expertise and software to undertake the analysis documented in this protocol

Step 1: Data cleaning and linkage

This data linkage protocol should ensure that an appropriate robust and standard methodology is applied when linking NCMP child data between different years, and that the data linkage can be replicated successfully by different users. Data linkage must take place on a secure computer and should be completed by an individual who has the correct permissions in their organisation to see identifiable data, and has completed appropriate information governance training as determined by their organisation.

This data linkage protocol assumes a good working knowledge of Excel. Where a formula is suggested, the variables to be used as part of that formula are stated; the relevant spreadsheet cells should be selected. Formulas provided are only suggestions, and users attempting matching may prefer to use alternatives. An accompanying Excel spreadsheet, named *DummyData.xlsx* containing false data is provided; this shows how the formulae throughout this protocol work.

Data linkage can only take place if the dataset has suitable identifiers. Data quality may limit the possibility of data linkage.

Download the data from the local system

1. Download NCMP data from the local system:

- data for Reception children are required for the years 2006/07, 2007/08, and 2008/09
- data for Year 6 children are required for the years 2012/13, 2013/14, and 2014/15

Data values that are blanks or null should be included in this download, as this will give an indicator of data quality and possible sample bias.

2. For all the years of data downloaded, for both Reception and Year 6 data, the following fields of data will be required:

    1. Year of NCMP
    2. School Year (Year 6 or Reception)
    3. Child NHS number (if available)
    4. Pupil reference number (if available, required for the de-duplication of the data)
    5. Child forename
    6. Child surname
    7. Sex of child
    8. Date of Birth
    9. Postcode of child
    10. Ethnicity
    11. Height in cm
    12. Weight in kg
    13. School URN (or equivalent school identifier, required for the de-duplication of the data)
    14. Date of measurement (to later calculate age at measurement in months)

    Please note that these fields may be named differently in local datasets, and careful consideration should be given to ensure the correct data are downloaded.

3. Each year of data download should be on a separate Excel worksheet, and clearly labelled with the year of data.

    Check: Have the correct data been downloaded for the correct children, for the correct years?
    Check: Is each year of data in a separate worksheet?

Initial data cleaning and preparation

4. Before any data linkage is completed, some initial data cleaning must be completed. The following steps must be applied for each year of data:

Ensure consistent formatting of all data items

Creating a pivot table of all entries in a column, can be a quick way to detect problems in the data for the following data variables:

5. Date of Birth must contain a valid date in the format dd/mm/yyyy. Data for Reception children should only consider 4-5 year olds, and data for Year 6 children should only consider 10-11 year olds. Remove data for children that fall outside the defined age range:

    - for Reception children in 2006/07 data, the date of birth should be between 01/09/2001 and 31/08/2002

- for Reception children in 2007/08 data, the date of birth should be between 01/09/2002 and 31/08/2003
- for Reception children in 2008/09 data, the date of birth should be between 01/09/2003 and 31/08/2004
- for children in Year 6 in 2012/13 data, the date of birth should be between 01/09/2001 and 31/08/2002
- for children in Year 6 in 2013/14 data, the date of birth should be between 01/09/2002 and 31/08/2003
- for children in Year 6 in 2014/15 data, the date of birth should be between 01/09/2003 and 31/08/2004

Check: Filter the data and check the dates of birth fall within the specified timeframe for a particular year of data, remove any rows where date is incorrect.

6. For the purposes of matching, the separate components of Date of Birth (DOB) need to be individual fields. Label 3 new columns as DOB day, DOB month, and DOB year:

   - In column DOB day use the DAY function in Excel to get the day date from the Date of Birth field: =DAY(DateOfBirth)
   - In column DOB month use the MONTH function in Excel to get the month date from the Date of Birth field: =MONTH(DateOfBirth])
   - In column DOB year use the YEAR function in Excel to get the year from the Date of Birth field: =YEAR(DateOfBirth)

   Check: Has the formula been applied to all rows of data?
   Check: Does each year of data have additional columns of DOB day, DOB month, and DOB year?

7. Sex of child should be coded as ‘M’ for male and ‘F for female. This should be applied to all years of data:

   - if the data set has ‘Male’ and ‘Female’ as values for sex, highlight the column containing sex description and use the find and replace function (Press ‘Ctrl’ and ‘F’ together to open the find and replace window). First replace ‘Female’ with ‘F’ and then ‘Male’ with M. Ensure that ‘Female’ is changed first to prevent it changing to ‘FeM’
   - if the data set has numerical values for sex (for example 1 and 2), highlight the column containing sex description and use the find and replace function, to replace the numbers with ‘M’ and ‘F’, as appropriate

   Check: Filter the data and check that sex is coded as ‘F’ or ‘M’ for each year of data

8. Child postcodes should be consistent in format for each year to facilitate matching. As the postcode will be required to assign an IMD 2015 deprivation decile to a child, the postcode

should be formatted in the same manner as the provided postcode to IMD lookup. To ensure that the postcode is consistent for matching purposes create a new field Postcode1:

- in column Postcode1, use the formula =SUBSTITUTE(ChildPostcode," “,””). This removes all spaces from the cell. Postcode1 should be used in matching

9. To enable an IMD decile to be assigned, the Postcode should be the same format as the provided Postcode-IMD lookup. Label a new column PostcodeIMD:

    - in all valid postcodes, the second part of a postcode is always 3 digits. The following formula determines the length of the created field Postcode1 and concatenates to format it into an appropriate 7 digit code: =IF(LEN(Postcode1)=7,Postcode1,IF(LEN(Postcode1)=6,(LEFT(Postcode1,3))&" "&(RIGHT(Postcode1,3)),IF(LEN(Postcode1)=5,(LEFT(Postcode1,2))&" "&(RIGHT(Postcode1,3)),"Invalid")))

    Check: Has the formula been completed for all cells?

10. Date of measurement must contain a valid date in the format dd/mm/yyyy; Date of measurement must fall within the academic year of data collection. Delete rows of data where the date of measurement is not valid:

    - date of measurement should be between 01/09/2006 and 31/08/2007, for the NCMP data collection year of 2006/07
    - date of measurement should be between 01/09/2007 and 31/08/2008, for the NCMP data collection year of 2007/08
    - date of measurement should be between 01/09/2008 and 31/08/2009, for the NCMP data collection year of 2008/09
    - date of measurement should be between 01/09/2012 and 31/08/2013, for the NCMP data collection year of 2012/13
    - date of measurement should be between 01/09/2013 and 31/08/2014, for the NCMP data collection year of 2013/14
    - date of measurement should be between 01/09/2014 and 31/08/2015, for the NCMP data collection year of 2014/15

    Check: Filter the dates and ensure spread of dates of measurement is within the specified timeframe for the data year.

11. Create a flag for the day of the week the date of measurement falls, this will draw attention to any measurements taken on a weekend, and could indicate possible data quality issues:

    - create a new column titled “Day of Measurement”, use the TEXT function to get the day of the week the measurement was taken:

=TEXT(DateOfMeasurement,”ddd”). For example, this will return Tue for the date 01/03/2016

12. NHS numbers need to be consistently formatted, and should be defined as data type numeric, with no decimal places:

    - select the cells that contain NHS numbers and format cells to ensure data is defined as numeric

    Check: Have data for every year been formatted?

13. To complete matching, a series of matching keys need to be created for every year of data, as specified in Figure1. MatchKey1 and MatchKey2 take into consideration if the NHS number is missing or invalid. For ease, using the look up function, the MatchKeys should be inserted into the beginning of the data, as demonstrated in the provided DummyData Excel File:

    - MatchKey1 NHS number and date of birth: =IF(NHSNumber="","N/A",IF(LEN(NHSNumber)<>10,"N/A", CONCATENATE(NHSNumber,DateOfBirth)))
    - MatchKey2 NHS number and partial date of birth and name: =IF(NHSNumber="","N/A",IF(LEN(NHSNumber)<>10,"N/A", CONCATENATE(NHSNumber,MonthOfBirth,YearOfBirth,LEFT(TRIM(surname,3)), LEFT(TRIM(forename,1)))
    - MatchKey3 partial date of birth, name and postcode (using created field Postcode1): =CONCATENATE(MonthOfBirth,YearOfBirth,surname,LEFT(TRIM(forename,2)), Postcode1)
    - MatchKey4 partial date of birth, and name: =CONCATENATE(MonthOfBirth,YearOfBirth,surname,forename)
    - MatchKey5 date of birth, and name: =CONCATENATE(DateofBirth,surname,forename)

    Check: Have match keys been calculated for every year of data?

Remove duplicate rows

14. Data must be de-duplicated (removing multiple rows of data that seem to be for the same child). Duplicates within a year are records within one school with the same pupil reference number, or NHS number or first name, surname, sex and DOB. To check for duplicates, each in a new column, create 3 de-duplicate IDs (as before these consider if the NHS number is invalid):

    - label an empty column as DeDupe1, and use the CONCATENATE function: =IF(NHSNumber="","N/A",IF(LEN(NHSNumber)<>10,"N/A", CONCATENATE(URN,NHSnumber). Sort the data on DeDupe1, and in an

empty column calculate a 0/1 flag if DeDupe1 is repeated. Delete any rows that have been flagged as a duplicate

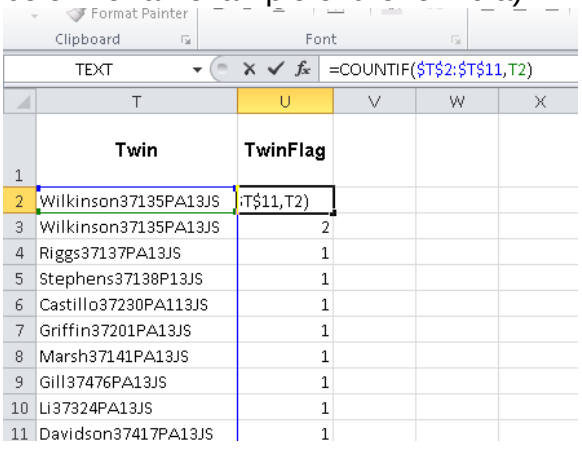
- label an empty column as DeDupe2, and use the CONCATENATE function: =CONCATENATE(URN,PupilReferenceNumber). Sort the data on DeDupe2, and in an empty column calculate a 0/1 flag if DeDupe2 is repeated. Delete any rows that have been flagged as a duplicate
- label an empty column as DeDupe3, and use the CONCATENATE function: =CONCATENATE(URN,firstname,surname,sex,DateofBirth). Sort the data on DeDupe3, and in an empty column calculate a 0/1 flag if DeDupe3 is repeated. Delete any rows that have been flagged as a duplicate

Check: Has each year of data been de-duplicated?

Flag twins in the dataset

15. Data for twins should be flagged, label an empty column as 'Twin' and use the CONCATENATE function to identify children with the same date of birth, surname and postcode:

- in the column titled Twin, use the formula =CONCATENATE(surname,DateofBirth,Postcode1)
- title another column as TwinFlag, and use the COUNTIF function to count the number of duplicate values in the Twin column: =COUNTIF(TwinArray,Twin). Cells with values greater than 1 are indicative of multiple births (see picture below for an example of the formula)



Check: Has each year of data been checked for twins?
Check: Has the initial data cleaning been completed successfully?

Calculate the age at measurement

16. For both Year 6 and Reception data for each child, calculate the age at date measured in days. In two new columns, labelled ReceptionAge and Year6Age, provide the age at measurement:

- in column ReceptionAge, calculate the age at date measured in days, for Reception data, using the function DATEDIF: =DATEDIF(DateOfBirth,ReceptionDateOfMeasurement,"d")
- in column Year6Age, calculate the age at date measured in days, for Year 6 data, using the function DATEDIF: =DATEDIF(DateOfBirth,Year6DateOfMeasurement,"d")

Check: Has the formula been applied successfully to all rows of data?

Data linking processes

17. Ideally, data will be linked using NHS number and date of birth (MatchKey1). If this is not possible, linkage can take place using a combination of pseudo-identifiers such as name, date of birth, and postcode (MatchKeys 3,4,5). When a match has been identified, record the MatchKey used.

18. The following links between data years in different worksheets should be completed:

- children in Reception in 2006/07 should be linked to children in Year 6 in 2012/13
- children in Reception in 2007/08 should be linked to children in Year 6 in 2013/14
- children in Reception in 2008/09 should be linked to children in Year 6 in 2014/15

Check: Are the correct years trying to be linked?

Check: Is each child only matched once?

Automatic matching for data linkage

19. A flowchart for matching is given in Figure 1, this is the MIDAS method for matching used by the HSCIC.

20. Create a series of Match columns in the Reception data. In the Reception year data for 2006/07, in a new column titled Match1, use the COUNTIF function to calculate the number of matches against MatchKey1 in the Year 6 2012/13 data:

- =COUNTIF(Year6MatchKey1Array,YearRMatchKey1)
- if MatchKey1 is in both Reception data and the corresponding Year 6 data, and there are not multiple matches the value in the Match1 column will be 1, and this should be considered a good match
- if there is only 1 match then use VLOOKUP to append all the required Year 6 data details to the Year R child record using MatchKey1. For example using MatchKey1, for height, the formula would be:

=if(Match1=1,VLOOKUP(YearRMatchKey1,Year6MatchKey1Array,Year6Height,16)

Complete this step for each of the required data fields until all the Year 6 data is adjacent to the Reception child data

- if the value in the Match column is 0, there has been no match.

21. In the Reception year data for 2006/07, in a new column titled Match2, use the COUNTIF function to calculate the number of matches against MatchKey2 in the Year 6 2012/13 data:

- =COUNTIF(Year6MatchKey2Array,YearRMatchKey2)
- if MatchKey2 is in both Reception data and the corresponding Year 6 data, and there are no multiple matches, the value in the Match2 column will be 1, and this should be considered a match
- if the value in Match2 column is 0, there has been no match. If the value is greater than 1, there have been multiple matches
- if there is only 1 match then use VLOOKUP to append all the required Year 6 data details to the Year R child record using the MatchKey2. For example using MatchKey2, for height, the formula would be:

=if(Match2=1,VLOOKUP(YearRMatchKey2,Year6MatchKey2Array,Year6Height,15)

22. If there is no match using MatchKey2, proceed to use MatchKey3. In the Reception year data for 2006/07, in a new column titled Match3, use the COUNTIF function to calculate the number of matches against MatchKey3 in the Year 6 2012/13 data:

- =COUNTIF(Year6MatchKey3Array,YearRMatchKey3)
- if MatchKey3 is in both Reception data and the corresponding Year 6 data, and there are no multiple matches, the value in the Match3 column will be 1, and this should be considered a match
- if there is only 1 match then use VLOOKUP to append all the required Year 6 data details to the Year R child record using the MatchKey3. For example using MatchKey3, for height, the formula would be: =if(Match3=1,VLOOKUP(YearRMatchKey3,Year6MatchKey3Array,Year6Height, 14)
- if the value in Match3 column is 0, there has been no match. If the value is greater than 1, there have been multiple matches

23. If there is no match using MatchKey3, proceed to use MatchKey4. In the Reception year data for 2006/07, in a new column titled Match4, use the COUNTIF function to calculate the number of matches against MatchKey4 in the Year 6 2012/13 data:

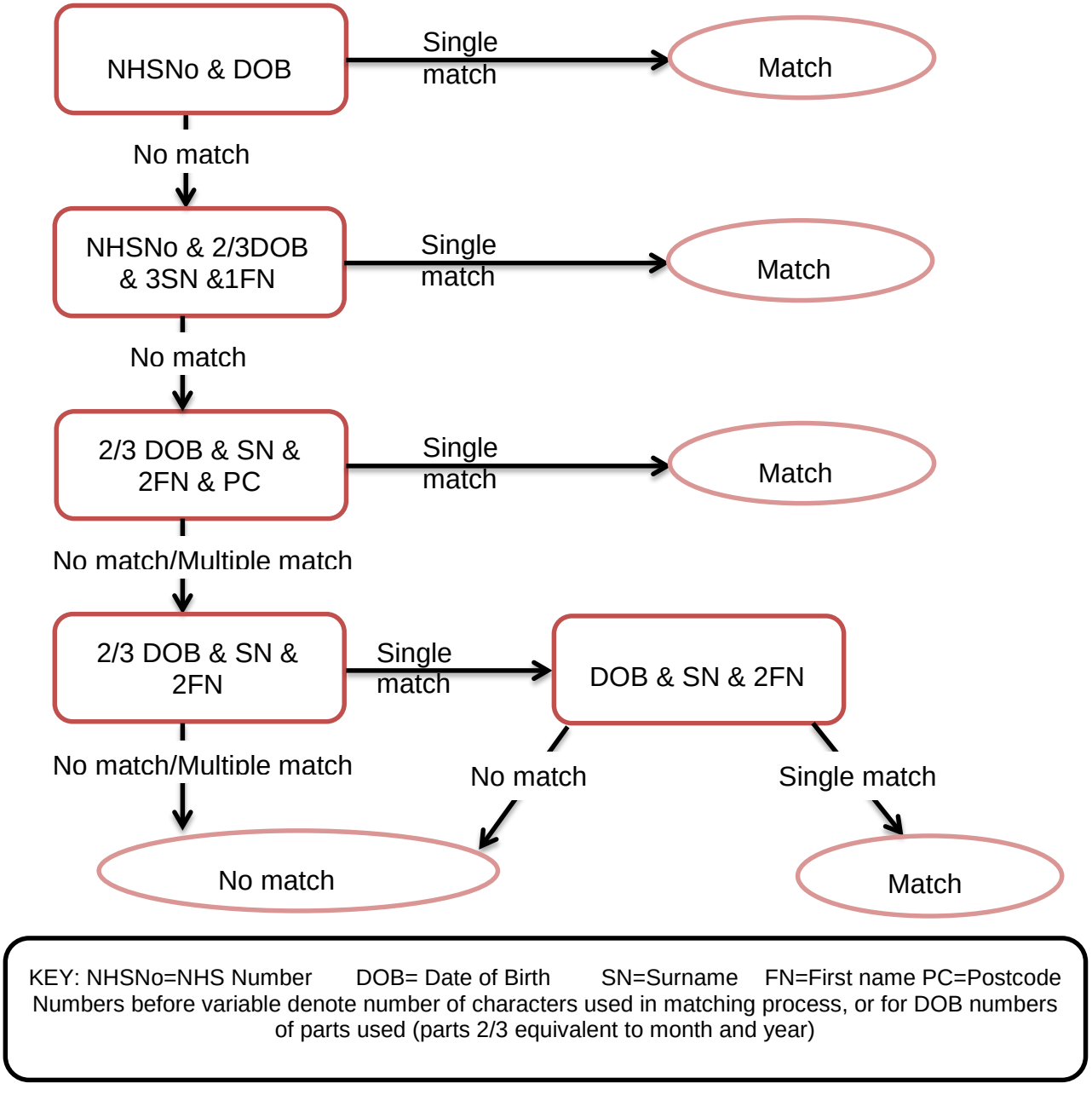
- =COUNTIF(Year6MatchKey4Array,YearRMatchKey4)
- if MatchKey4 is in both Reception data and the corresponding Year 6 data, and there are no multiple matches, the value in the Match4 column will be 1, and this should be considered a match
- if there is only 1 match, use MatchKey5 to confirm the match using the COUNTIF function: =COUNTIF(Year6MatchKey5Array,YearRMatchKey5)
- if there is only 1 match then use VLOOKUP to append all the required Year 6 data details to the Year R child record using the MatchKey5. For example using MatchKey4 and MatchKey5, for height, the formula would be:

=if(Match4=1,if(Match5=1,VLOOKUP(YearRMatchKey3,Year6MatchKey3Array,Year 6Height,12),"NoMatch"))

- if the value in Match5 column is 0, there has been no match. If the value is greater than 1, there have been multiple matches and no further matching can take place

24. Complete steps 20-23 for the remaining years data, matching the Reception year data for 2007/08, to the Year 6 2013/14 data, and the Reception year data for 2008/09, to the Year 6 2014/15 data, following the steps in the flowchart in Figure 1.

Figure 1: Matching Flowchart



After linking the data

25. Once the data have been linked, there should be one row of data per child containing data from when the child was in Reception, and where a child was successfully matched, the data from when the child was in Year 6. Ensure that each column is clearly labelled as data for either Reception or Year 6 data. Data for children from Reception that have not been matched to Year 6 children, should still be included in the dataset, for PHE to assess the proportion of children matched.

Creating a unique identifier

26. With one row of data per child, assign an ID number, as assigned by PHE. For each of the local authorities involved in this study the coding will be 7 digits long, consisting of a letter and 6 numbers. For example:

Local authority 1: A100000 – A150000
Local authority 2: B200000 – B250000
The allocation of consecutive numbers, with excess numbers to allow for extra children, should prevent any overlapping of numbers between the local authorities involved. The addition of the letter at the beginning will add an additional item to differentiate by.

Check: Have the correct identifiers been applied for the local authority?

Assigning an IMD deprivation decile

27. Once the data have been linked, the postcode to IMD lookup should be used to assign a 2015 IMD decile. This should be applied for both Year 6 and Reception Year data for each child. In a new column titled ChildIMDDecile:

- use the VLOOKUP function to assign an IMD decile using the newly created PostcodeIMD field and the supplied lookup:

=VLOOKUP(PostcodeIMD,IMDLOOKUParray,[column of IMD decile],FALSE)

Check: Has the lookup been applied to all rows, for Reception data and Year 6 data?
Check: Have all data been successfully assigned an IMD decile? Filter the data to investigate those that do not return an IMD decile – is there a valid postcode?

Apply ethnicity coding

28. Ethnicity code should be aligned with the NHS system for coding as follows:

A=White British
B=White Irish
C=Any other White background
D=Mixed White and Black Caribbean
E=Mixed White and Black African
F=Mixed White and Asian
G=Any other mixed background
H= Asian or Asian British Indian
J= Asian or Asian British Pakistani

K= Asian or Asian British Bangladeshi
L=Any other Asian or Asian British background
M= Black or Black British Caribbean
N= Black or Black British African
P=Any other Black background
R= Chinese
S= Any other ethnic group
Z= Not stated

This should be done at source; however, if it is not possible for the local authority to complete this, the authority should notify PHE of the classification system used.

Remove un-needed data fields

29. Remove data fields that are not required by PHE in order to anonymise the data, in line with the ICO Anonymisation Code of Practice.[6] The final dataset to send to PHE should contain only the 24 fields specified below:

1. Assigned Unique Reference Number of child
2. Reception Year of NCMP
3. Reception sex of child
4. Reception IMD decile of child
5. Reception Ethnicity of child,
6. Reception height in cm
7. Reception weight in kg
8. Reception age at measurement in days
9. Reception Day of measurement
10. Reception Twin flag
11. Match1
12. Match2
13. Match3
14. Match4

(Match Flags indicate the stage at which a child's data were matched, and illustrate the quality of the match achieved.)

15. Match5
16. Year 6 Year of NCMP
17. Year 6 sex of child
18. Year 6 IMD decile of child
19. Year 6 Ethnicity of child,
20. Year 6 height in cm
21. Year 6 weight in kg
22. Year 6 age at measurement in days
23. Year 6 Day of measurement
24. Year 6 Twin flag

[6] Information Commissioner's Office. Anonymisation: managing data protection risk code of practice. Available from https://ico.org.uk/for-organisations/guide-to-data-protection/anonymisation/

Check: Does the dataset contain three sets of matched data?
Check: Are data for all Reception children, regardless of match status included?
Check: Does each matched dataset contain the variables listed above?
Check: Have all the identifiable data been removed?

Step 2: Preparing cleaned, linked data for analysis

When BMI is measured in the NCMP it is converted into BMI z scores or centiles, which are then used to generate weight status categories. We propose these categories should be used as an outcome variable when predicting future weight status. Hence, we suggested the use of ordinal logistic regression to predict whether a child is likely to move to, or remain at, an unhealthy weight status.

To prepare the data for analysis:

- Raw BMI at baseline and follow up needs to be converted into a BMI z score then centile using the LMS Microsoft Excel add-in, which can be downloaded freely online [http://www.healthforallchildren.com/shop-base/shop/software/lmsgrowth/], and the UK1990 growth reference should be selected. To calculate these centiles, the child's age and sex are also required.
- The weight status categories then need to be generated based on the UK1990 clinical cut points, which are: *<2nd centile=underweight; ≥2nd centile, but <91st centile=normal weight; ≥91st centile but <98th centile=overweight; ≥98th centile= obese*. The categories should be numbered e.g. underweight=0, normal weight=1, overweight=2, obese=3.
- The clinical cut points should be used if as you are assessing individual children. A separate column can also be generated to include the cut off for severely obesity (≥99.6th centile), e.g. severely obese=4.
- The level of deprivation should be defined by IMD scores which can be grouped into categories. Quintiles were chosen instead of deciles to achieve a larger sample size in each category. By using four quintiles to divide the data into fifths, it allows the comparison of the most (1st) and least deprived children (5th).

NB: Data was deemed incomplete (and therefore not analysed) if Year 6 data was missing (insufficient data available to assign a BMI centile) or any of Reception or Year 6 height or weights were deemed abnormal. Heights and weights were considered abnormal if Reception height or weight was greater than or equal to Year 6 height and weight, or if height and weight were too small or too large in comparison with the RCPCH growth charts. A conservative approach was taken and children were only excluded from analysis on this basis if their height was less than 70 cm (Reception) or 100 cm (Year 6 respectively) or greater than 150 cm (Reception) or 195 cm (Year 6). The corresponding weight thresholds used were: <5 kg (Reception) and <10 kg (Year 6); and >60 kg (Reception) and >110 kg (Year 6).

Step 3: Data analysis

Ordinal logistic regression can be performed in the statistical software Stata.
Each potential explanatory variable was checked first for significance in a univariable ordinal logistic model and all significant variables were then jointly assessed in a multivariable model.[7] All potential interactions were considered but only those in which interaction and main effect terms were both significant were retained. The code used to fit the final model was: (ologit clinweightcat11 i.clinweightcat5##i.sex i.finalethnicity4 i.IMD_quin_age5 i.la i.year). Marginal effects were then calculated which give the predicted probability (percentage chances) of a child becoming the selected weight status (underweight, normal weight, overweight, obese (or severely obese)) at Year 6, based on the six predictor variables.

The open access protocol and accompanying Stata code on which our method is based may be found here:

Protocol: http://www.nature.com/nutd/journal/v6/n3/abs/nutd20163a.html
Stata code:
http://www.nature.com/nutd/journal/v6/n3/suppinfo/nutd20163s1.html?url=/nutd/journal/v6/n3/abs/nutd20163a.html

[7] p<0.1 was used in the univariable models; all variables were significant on this basis and were therefore included in the initial joint multivariable model. All variables remained significant in the joint multivariable model using p<0.05. Significance of interactions was assessed using p<0.05

Appendix 2: Descriptive statistics which compare weight status at age 4-5 and age 10-11 by sex, deprivation and ethnicity

Table A1. Ordinal logistic regression output showing association between clinical weight status at age 10-11 (4 categories) and dependent variables

Variable	Odds Ratio	95% Confidence Interval
Clinical weight category age 4-5		
Underweight	**ref**	
Healthy weight	17.64	13.71 - 22.68
Overweight	134.51	103.02 - 175.63
Obese	653.23	489.76 - 871.26
Sex		
Male	**ref**	
Female	0.59	0.42 - 0.83
Weight category & sex interaction		
Male	**ref**	
Healthy weight & female	1.32	0.93 - 1.87
Overweight & female	1.69	1.17 - 2.44
Obese & female	1.33	0.89 - 1.98
Ethnicity		
White	**ref**	
Asian	1.16	1.10 - 1.23
Black	1.30	1.20 - 1.42
Other including missing	1.15	1.02 - 1.28
Deprivation quintile		
Most deprived 1	**ref**	
2	0.95	0.88 - 1.01

3	0.87	0.80 - 0.94
4	0.75	0.68 - 0.84
Least deprived 5	0.66	0.59 - 0.74
Missing	1.01	0.84 - 1.21
Local Authority		
LA 1	**ref**	
LA 2	1.21	1.08 - 1.35
LA 3	1.06	0.99 - 1.12
LA 4	0.84	0.71 - 1.00
Year of first measurement		
2006/07	**ref**	
2007/08	1.11	1.05 - 1.18
2008/09	1.05	0.98 - 1.11
Latent variable cut point coefficients		
Cut 1	-1.26	-1.50 - -1.02
Cut 2	4.03	3.77 - 4.29
Cut 3	5.34	5.08 - 5.60

Table A2. Ordinal logistic regression output showing association between clinical weight status at age 10-11 (5 categories) and dependent variables

Variable	Odds Ratio	95% Confidence Interval
Clinical weight category age 4-5		
Underweight	**ref**	
Healthy weight	17.52	13.62 - 22.53
Overweight	135.90	104.14 - 177.34
Obese	439.34	327.95 - 588.56
Severely obese	1183.01	873.13 - 1602.86
Sex		
Male	**ref**	
Female	0.59	0.42 - 0.83
Weight category & sex interaction		
Male	**ref**	
Healthy weight & female	1.32	0.93 - 1.87
Overweight & female	1.66	1.15 - 2.40
Obese & female	1.31	0.88 - 1.97
Severely obese & female	2.08	1.35 - 3.20
Ethnicity		
White	**ref**	
Asian	1.13	1.07 - 1.20
Black	1.30	1.20 - 1.42
Other including missing	1.14	1.02 - 1.28
Deprivation quintile		
Most deprived 1	**ref**	
2	0.94	0.88 - 1.01
3	0.86	0.79 - 0.93
4	0.73	0.66 - 0.81
Least deprived 5	0.64	0.57 - 0.72

Missing	1.01	0.84 - 1.21
Local authority		
LA 1	**ref**	
LA 2	1.17	1.05 - 1.30
LA 3	1.07	1.01 - 1.14
LA 4	0.85	0.72 - 1.00
Year of first measurement		
2006/07	**ref**	
2007/08	1.11	1.05 - 1.18
2008/09	1.05	0.99 - 1.12
Latent variable cut point coefficients		
Cut 1	-1.28	-1.52 - -1.03
Cut 2	4.01	3.75 - 4.27
Cut 3	5.32	5.06 - 5.58
Cut 4	6.87	6.61 - 7.14

Table A3. Sample cross-tabulation: weight status aged 4-5 and weight status aged 10-11 – boys (95% confidence interval for percentage in brackets)

		Clinical weight status age 10-11			
Clinical weight status age 4-5		**Underweight**	**Healthy weight**	**Overweight**	**Obese**
Underweight	n	100	295	22	6
	%	23.6 (19.8, 27.9)	69.7 (65.2, 73.9)	5.2 (3.4, 7.8)	1.4 (0.6, 3.1)
Healthy weight	n	188	10,341	2,243	1,290
	%	1.3 (1.2, 1.5)	73.5 (72.8, 74.3)	16.0 (15.4, 16.6)	9.2 (8.7, 9.7)
Overweight	n	0	483	489	705
	%	0.0	28.8 (26.7, 31.0)	29.2 (27.0, 31.4)	42.0 (39.7, 44.4)
Obese	n	0	86	164	899
	%	0.0	7.5 (6.1, 9.2)	14.3 (12.4, 16.4)	78.2 (75.8, 80.5)

Table A4. Sample cross-tabulation: weight status aged 4-5 and weight status aged 10-11 – girls (95% confidence interval for percentage in brackets)

		Clinical weight status age 10-11			
Clinical weight status age 4-5		**Underweight**	**Healthy weight**	**Overweight**	**Obese**
Underweight	n	96	188	10	5
	%	32.1 (27.1, 37.6)	62.9 (57.2, 68.2)	3.3 (1.8, 6.1)	1.7 (0.7, 4.0)
Healthy weight	n	267	10,804	2,091	868
	%	1.9 (1.7, 2.1)	77.0 (76.3, 77.7)	14.9 (14.3, 15.5)	6.2 (5.8, 6.6)
Overweight	n	0	384	481	586
	%	0.0	26.5 (24.3, 28.8)	33.2 (30.8, 35.6)	40.4 (37.9, 42.9)
Obese	n	1	62	196	698
	%	0.1 (0.0, 0.7)	6.5 (5.1, 8.2)	20.5 (18.0, 23.2)	72.9 (70.0, 75.7)

Table A5. Sample cross-tabulation: weight status aged 4-5 and weight status aged 10-11 – IMD 1 most deprived (95% confidence interval for percentage in brackets)

		Clinical weight status age 10-11			
Clinical weight status age 4-5		**Underweight**	**Healthy weight**	**Overweight**	**Obese**
Underweight	n	147	331	26	7
	%	28.8 (25.0, 32.8)	64.8 (60.5, 68.8)	5.1 (3.5, 7.4)	1.4 (0.7, 2.8)
Healthy weight	n	292	11,922	2,605	1,415
	%	1.8 (1.6, 2.0)	73.4 (72.8, 74.1)	16.1 (15.5, 16.6)	8.7 (8.3, 9.2)
Overweight	n	0	469	542	833
	%	0.0	25.4 (23.5, 27.5)	29.4 (27.4, 31.5)	45.2 (42.9, 47.5)
Obese	n	0	93	223	1,075
	%	0.0	6.7 (5.5, 8.1)	16.0 (14.2, 18.1)	77.3 (75.0, 79.4)

Table A6. Sample cross-tabulation: weight status aged 4-5 and weight status aged 10-11 – IMD 5 least deprived (95% confidence interval for percentage in brackets)

		Clinical weight status age 10-11			
Clinical weight status age 4-5		**Underweight**	**Healthy weight**	**Overweight**	**Obese**
Underweight	n	5	34	0	0
	%	12.8 (5.4, 27.6)	87.2 (72.4, 94.6)	0.0	0.0
Healthy weight	n	31	1,676	243	64
	%	1.5 (1.1, 2.2)	83.2 (81.5, 84.8)	12.1 (10.7, 13.6)	3.2 (2.5, 4.0)
Overweight	n	0	54	75	49
	%	0.0	30.3 (24.0, 37.5)	42.1 (35.1, 49.5)	27.5 (21.5, 34.6)
Obese	n	0	10	12	43
	%	0.0	15.4 (8.4, 26.4)	18.5 (10.7, 29.9)	66.2 (53.8, 76.6)

Table A7. Sample cross-tabulation: weight status aged 4-5 and weight status aged 10-11 – ethnicity white (95% confidence interval for percentage in brackets)

		Clinical weight status age 10-11			
Clinical weight status age 4-5		**Underweight**	**Healthy weight**	**Overweight**	**Obese**
Underweight	n	35	65	2	3
	%	33.3 (25.0, 42.9)	61.9 (52.2, 70.7)	1.9 (0.5, 7.3)	2.9 (0.9, 8.5)
Healthy weight	n	123	9,877	1,735	894
	%	1.0 (0.8, 1.2)	78.2 (77.5, 78.9)	13.7 (13.1, 14.3)	7.1 (6.6, 7.5)
Overweight	n	0	469	415	575
	%	0.0	32.2 (29.8, 34.6)	28.4 (26.2, 30.8)	39.4 (36.9, 41.9)
Obese	n	0	64	127	551
	%	0.0	8.6 (6.8, 10.9)	17.1 (14.6, 20.0)	74.3 (71.0, 77.3)

Table A8. Sample cross-tabulation: weight status aged 4-5 and weight status aged 10-11 – ethnicity Asian (95% confidence interval for percentage in brackets)

		Clinical weight status age 10-11			
Clinical weight status age 4-5		**Underweight**	**Healthy weight**	**Overweight**	**Obese**
Underweight	n	136	319	26	6
	%	27.9 (24.1, 32.1)	65.5 (61.2, 69.6)	5.3 (3.7, 7.7)	1.2 (0.6, 2.7)
Healthy weight	n	272	7,068	1,692	837
	%	2.8 (2.5, 3.1)	71.6 (70.7, 72.5)	17.1 (16.4, 17.9)	8.5 (7.9, 9.0)
Overweight	n	0	201	326	434
	%	0.0	20.9 (18.5, 23.6)	33.9 (31.0, 37.0)	45.2 (42.0, 48.3)
Obese	n	1	54	145	733
	%	0.1 (0.0, 0.8)	5.8 (4.5, 7.5)	15.5 (13.4, 18.0)	78.6 (75.8, 81.1)

Table A9. Sample cross-tabulation: weight status aged 4-5 and weight status aged 10-11 – ethnicity black (95% confidence interval for percentage in brackets)

		Clinical weight status age 10-11			
Clinical weight status age 4-5		**Underweight**	**Healthy weight**	**Overweight**	**Obese**
Underweight	n	13	55	3	2
	%	17.8 (10.6, 28.4)	75.3 (64.1, 83.9)	4.1 (1.3, 12.1)	2.7 (0.7, 10.4)
Healthy weight	n	23	1,920	462	260
	%	0.9 (0.6, 1.3)	72.1 (70.3, 73.7)	17.3 (15.9, 18.8)	9.8 (8.7, 10.9)
Overweight	n	0	92	112	177
	%	0.0	24.2 (20.1, 28.7)	29.4 (25.0, 34.2)	46.5 (41.5, 51.5)
Obese	n	0	17	45	191
	%	0.0	6.7 (4.2, 10.6)	17.8 (13.5, 23.0)	75.5 (69.8, 80.4)

Appendix 3: Sensitivity analysis to examine the impact of the local authority with the lowest reception to year 6 matching rate

		Predicted percent chances of being in each weight status category at age 11 (95%CI)*			
Weight status category at age 5, by sex		*Underweight*	*Healthy weight*	*Overweight*	*Obese inc. severe*
Underweight	*Male*	20.8 (17.0 to 24.7)	77.2 (73.8 to 80.7)	1.4 (1.1 to 1.7)	0.5 (0.4 to 0.7)
	Female	30.9 (25.6 to 36.2)	67.9 (62.9 to 73.0)	0.8 (0.6 to 1.0)	0.3 (0.2 to 0.4)
Healthy weight	*Male*	1.5 (1.3 to 1.6)	72.9 (72.2 to 73.6)	17.1 (16.6 to 17.6)	8.6 (8.2 to 8.9)
	Female	1.9 (1.7 to 2.1)	77.0 (76.4 to 77.7)	14.3 (13.8 to 14.8)	6.8 (6.4 to 7.1)
Overweight	*Male*	0.2 (0.2 to 0.2)	27.7 (25.9 to 29.5)	30.7 (29.9 to 31.5)	41.4 (39.3 to 43.6)
	Female	0.2 (0.2 to 0.2)	27.9 (26.0 to 29.8)	30.7 (29.9 to 31.5)	41.1 (38.9 to 43.4)
Obese (not inc. severe)	*Male*	0.0 (0.0 to 0.0)	7.4 (6.4 to 8.4)	15.4 (13.9 to 16.9)	77.2 (74.8 to 79.7)
	Female	0.1 (0.0 to 0.1)	9.3 (8.1 to 10.5)	18.1 (16.5 to 19.7)	72.6 (69.8 to 75.3)

Above, the original table including local authority with lowest matching rate. Below, the sensitivity analysis for the local authority with the lowest matching rate.

		Predicted percent chances of being in each weight status category at age 11 (95%CI)*			
Weight status category at age 5, by sex		*Underweight*	*Healthy weight*	*Overweight*	*Obese inc. severe*
Underweight	*Male*	20.3 (16.4 to 24.2)	77.8 (74.4 to 81.3)	1.4 (1.0 to 1.7)	0.5 (0.4 to 0.7)
	Female	30.2 (24.8 to 35.6)	68.6 (63.5 to 73.7)	0.8 (0.6 to 1.0)	0.3 (0.2 to 0.4)
Healthy weight	*Male*	1.5 (1.3 to 1.6)	73.4 (72.7 to 74.1)	16.7 (16.2 to 17.2)	8.5 (8.1 to 8.9)
	Female	1.9 (1.7 to 2.0)	77.4 (76.7 to 78.0)	14.0 (13.5 to 14.5)	6.8 (6.4 to 7.1)
Overweight	*Male*	0.2 (0.2 to 0.2)	27.8 (25.9 to 29.7)	30.3 (29.5 to 31.1)	41.7 (39.4 to 43.9)
	Female	0.2 (0.2 to 0.2)	28.1 (26.1 to 30.1)	30.4 (29.5 to 31.2)	41.3 (39.0 to 43.7)
Obese (not inc. severe)	*Male*	0.0 (0.0 to 0.0)	7.2 (6.2 to 8.2)	14.7 (13.2 to 16.3)	78.1 (75.5 to 80.6)
	Female	0.0 (0.0 to 0.1)	9.2 (8.0 to 10.5)	17.7 (16.0 to 19.4)	73.0 (70.1 to 75.9)

Appendix 4: Results data tables

Table A10: The predicted percent chances of a 10-11 year old boy or girl being underweight, healthy weight, overweight and obese based on their weight status at age 4-5

		Predicted percent chances of being in each weight status category at age 10-11 (95%CI)*				
Weight status category at age 4-5, by sex		*Underweight*	*Healthy weight*	*Overweight*	*Obese (not inc. severe)*	*Severely obese*
Underweight	*Male*	20.7 (16.9 to 24.6)a	77.3 (73.9 to 80.8)a	1.4 (1.1 to 1.8)	0.4 (0.3 to 0.5)	0.1 (0.1 to 0.1)
	Female	30.8 (25.4 to 36.1)a	68.1 (63.1 to 73.1)a	0.8 (0.6 to 1.1)	0.2 (0.2 to 0.3)	0.1 (0.0 to 0.1)
Healthy weight	*Male*	1.5 (1.3 to 1.6)a	72.9 (72.2 to 73.6)a	17.1 (16.6 to 17.6)a	6.6 (6.3 to 6.9)a	2.0 (1.8 to 2.1)a
	Female	1.9 (1.7 to 2.1)a	77.0 (76.4 to 77.7)a	14.3 (13.8 to 14.8)a	5.2 (5.0 to 5.5)a	1.5 (1.4 to 1.6)a
Overweight	*Male*	0.2 (0.2 to 0.2)	27.3 (25.6 to 29.1)	30.7 (29.9 to 31.5)	28.5 (27.1 to 29.8)	13.3 (12.2 to 14.5)
	Female	0.2 (0.2 to 0.2)	27.9 (26.0 to 29.8)	30.8 (30.0 to 31.6)	28.1 (26.7 to 29.5)	13.0 (11.9 to 14.2)
Obese (not inc. severe)	*Male*	0.1 (0.0 to 0.1)	10.5 (9.1 to 11.9)	19.7 (18.0 to 21.5)	36.6 (35.5 to 37.7)	33.1 (29.8 to 36.3)
	Female	0.1 (0.1 to 0.1)	13.2 (11.5 to 15.0)	22.7 (21.0 to 24.5)	36.3 (35.1 to 37.5)	27.6 (24.6 to 30.6)
Severely obese	*Male*	0.0 (0.0 to 0.0)	4.2 (3.5 to 4.9)	9.8 (8.4 to 11.1)	29.1 (27.0 to 31.3)	56.9 (52.9 to 60.9)
	Female	0.0 (0.0 to 0.0)	3.5 (2.8 to 4.2)	8.3 (6.9 to 9.7)	26.6 (23.9 to 29.3)	61.6 (57.0 to 66.3)

*numbers are rounded to one decimal place
'a' denotes significant difference between males and females in each weight category

Table A11: The predicted percent chances of a most and least deprived boys and girls being obese at age 10-11 years, based on their weight status and the residence Index of Multiple Deprivation (IMD) score at age 4-5 years

Weight status and IMD (fifths) at age 5, by sex			Predicted percent chances of being obese (including severe) at age 11 (95%CI)*
Underweight	*Male*	*Most deprived (0-20%)*	0.6 (0.4 to 0.7)
		Least deprived (80-100%)	0.4 (0.3 to 0.5)
	Female	*Most deprived (0-20%)*	0.3 (0.2 to 0.4)
		Least deprived (80-100%)	0.2 (0.2 to 0.3)
Healthy weight	*Male*	*Most deprived (0-20%)*	9.1 (8.6 to 9.5)ab
		Least deprived (80-100%)	6.2 (5.5 to 6.8)ab
	Female	*Most deprived (0-20%)*	7.2 (6.8 to 7.5)ab
		Least deprived (80-100%)	4.8 (4.3 to 5.4)ab
Overweight	*Male*	*Most deprived (0-20%)*	43.1 (40.8 to 45.4)a
		Least deprived (80-100%)	33.3 (30.3 to 36.3)a
	Female	*Most deprived (0-20%)*	42.8 (40.4 to 45.2)a
		Least deprived (80-100%)	33.1 (30.0 to 36.2)a
Obese inc. severe	*Male*	*Most deprived (0-20%)*	78.5 (76.2 to 80.9)a
		Least deprived (80-100%)	70.7 (67.1 to 74.3)a
	Female	*Most deprived (0-20%)*	74.0 (71.3 to 76.8)a
		Least deprived (80-100%)	65.3 (61.3 to 69.3)a

*numbers are rounded to one decimal place
a denotes significant differences between most and least deprived
b denotes significant differences between boys and girls

Table A12: The predicted percent chances of a most and least deprived child being severely obese at age 10-11 years based on their weight status at age 4-5years, by sex

Weight status and IMD (fifths) at age 5, by sex			Predicted percent chances of being severely obese at age 11 (95%CI)*
Underweight	*Male*	*Most deprived (0-20%)*	0.1 (0.1 to 0.2)
		Least deprived (80-100%)	0.1 (0.1 to 0.1)
	Female	*Most deprived (0-20%)*	0.1 (0.1 to 0.1)
		Least deprived (80-100%)	0.0 (0.0 to 0.1)
Healthy weight	*Male*	*Most deprived (0-20%)*	2.1 (1.9 to 2.2)ab
		Least deprived (80-100%)	1.3 (1.2 to 1.5)a
	Female	*Most deprived (0-20%)*	1.6 (1.5 to 1.7)ab
		Least deprived (80-100%)	1.0 (0.9 to 1.2)a
Overweight	*Male*	*Most deprived (0-20%)*	14.1 (12.9 to 15.3)a
		Least deprived (80-100%)	9.6 (8.3 to 10.8)a
	Female	*Most deprived (0-20%)*	13.8 (12.6 to 15.1)a
		Least deprived (80-100%)	9.3 (8.1 to 10.6)a
Obese (not inc. severe)	*Male*	*Most deprived (0-20%)*	34.7 (31.3 to 38.1)a
		Least deprived (80-100%)	25.5 (22.0 to 28.9)a
	Female	*Most deprived (0-20%)*	29.0 (25.9 to 32.2)a
		Least deprived (80-100%)	20.8 (17.8 to 23.9)a
Severely obese	*Male*	*Most deprived (0-20%)*	58.8 (54.7 to 62.8)a
		Least deprived (80-100%)	47.8 (43.0 to 52.7)a
	Female	*Most deprived (0-20%)*	63.5 (58.8 to 68.1)a
		Least deprived (80-100%)	52.8 (47.2 to 58.4)a

*numbers are rounded to one decimal place; ‘a’ denotes significant differences between most and least deprived, ‘b’ denotes significant differences between boys and girls

Table A13: The predicted percent chances of a child being obese at age 10-11 years based on their weight status at age 4-5 year by sex and ethnicity

Weight status at age 5, sex and ethnicity			Predicted percent chances of being obese (including severe) at age 11 (95%CI)*
Underweight	*Male*	*White*	0.5 (0.4 to 0.6)
		Asian	0.6 (0.4 to 0.7)
		Black	0.6 (0.5 to 0.8)
		Other	0.5 (0.4 to 0.7)
	Female	*White*	0.3 (0.2 to 0.4)
		Asian	0.3 (0.2 to 0.4)
		Black	0.4 (0.3 to 0.5)
		Other	0.3 (0.2 to 0.4)
Healthy weight	*Male*	*White*	7.8 (7.4 to 8.2)bc
		Asian	9.0 (8.5 to 9.5)a
		Black	10.0 (9.2 to 10.7)a
		Other	8.9 (8.0 to 9.8)
	Female	*White*	6.2 (5.8 to 6.5)bc
		Asian	7.1 (6.7 to 7.5)a
		Black	7.9 (7.3 to 8.5)a
		Other	7.0 (6.3 to 7.7)
Overweight	*Male*	*White*	39.1 (36.9 to 41.4)c
		Asian	42.8 (40.4 to 45.1)
		Black	45.6 (42.8 to 48.4)a
		Other	42.4 (39.2 to 45.7)

	Female	*White*	38.9 (36.5 to 41.2)c
		Asian	42.5 (40.0 to 44.9)
		Black	45.3 (42.4 to 48.2)a
		Other	42.1 (38.8 to 45.5)
Obese inc. severe	*Male*	*White*	75.6 (72.9 to 78.2)
		Asian	78.2 (75.8 to 80.7)
		Black	80.1 (77.6 to 82.6)
		Other	78.0 (75.1 to 80.9)
	Female	*White*	70.7 (67.7 to 73.7)
		Asian	73.7 (70.9 to 76.5)
		Black	75.9 (73.0 to 78.7)
		Other	73.4 (70.1 to 76.8)

*numbers are rounded to one decimal place
a denotes significant difference when compared to White children
b denotes significant difference when compared to Asian children
c denotes significant difference when compared to Black children
d denotes significant difference when compared to ‘Other’ children

Table A14: Predicted chances of improving weight status between age 4-5 and age 10-11, by sex, Index of Multiple Deprivation (IMD) and ethnicity

			Percentage predicted chances of weight status change between age 4-5 and age 10-11 (95% CI)*	
Sex, IMD at age 4-5 and ethnicity			**Overweight -> healthy weight**	**Obese inc. severe -> healthy weight**
Male	Most deprived (0-20%)	White	28.0 (26.0 to 30.0)xc	7.5 (6.4 to 8.5)x
		Asian	25.1 (23.2 to 27.0)x	6.5 (5.6 to 7.4)
		Black	23.0 (21.0 to 25.0)xa	5.8 (4.9 to 6.7)x
	Least deprived (80-100%)	White	37.0 (33.9 to 40.2)x	10.9 (9.2 to 12.6)x
		Asian	33.7 (30.5 to 36.8)x	9.5 (8.0 to 11.1)x
		Black	31.1 (27.8 to 34.4)x	8.6 (7.1 to 10.1)x
Female	Most deprived (0-20%)	White	28.2 (26.1 to 30.4)xc	9.4 (8.1 to 10.6)x
		Asian	25.3 (23.4 to 27.3)x	8.2 (7.1 to 9.3)x
		Black	23.2 (21.1 to 25.3)xa	7.3 (6.3 to 8.4)x
	Least deprived (80-100%)	White	37.3 (34.0 to 40.6)x	13.6 (11.5 to 15.6)x
		Asian	33.9 (30.6 to 37.2)x	11.9 (10.0 to 13.8)x
		Black	31.4 (28.0 to 34.8)x	10.7 (8.9 to 12.6)x

*numbers are rounded to one decimal place
a denotes significant difference when compared to white children
b denotes significant difference when compared to Asian children
c denotes significant difference when compared to black children
x denotes significant differences between most and least deprived