*Research, Policy and Planning (2019)* **33**(2), 57-68

# Widening childhood obesity inequalities in Birmingham primary schools – A longitudinal analysis and multi-level linear regression of BMI changes between 2006-2015

Susan Lowe[1] and Hashum Mahmood[2]

[1] Public Health Knowledge Evidence and Governance Lead, Birmingham City Council
[2] Public Health Manager, National Health Inequalities Team, Public Health England

---

**Abstract**
*Background: childhood obesity is a major concern in England with prevalence in Birmingham significantly higher than the national average. Cross-sectional studies indicate there is a strong link between childhood obesity and deprivation; however, there is a paucity of longitudinal research examining weight status health inequalities in children.*
*Methods: longitudinal analysis of Birmingham primary school children using NCMP data (2006-2015) for three cohorts (26,728 children). Investigating the effect of gender, ethnicity and deprivation on mean BMI z-scores using a mixed effect multi-level linear model of the effect of BMI z-score at Reception on the BMI z-score at Year 6. Examination of weight status changes.*
*Results: mean BMI z-scores almost trebled between the start and end of primary school. More than half of the children who were obese in Year 6 had been overweight or obese at school entry. Increases were markedly higher for boys, those in deprived areas and Black and Asian children.*
*Conclusions: longitudinal evidence of health inequalities widening through the primary school years with the greatest increases found in the most deprived areas. Children who have a high BMI z-score in Reception are more likely to have a higher BMI z-score at the end of primary school.*

**Keywords:** Health inequality, child obesity, NCMP

## Background

Obesity prevalence in children and adolescents has increased globally and has been associated with short and long-term health sequela (Mead *et al*., 2017). The issue has been a major concern in the UK for many years (Kimm & Obarzanek, 2002) and there is evidence that children who are overweight or obese have increased risk of asthma, type 2 diabetes, heart disease, certain types of cancer and are more likely to become obese adults (Reilly, 2007). In 2015 the House of Commons Health Committee called for 'brave and bold action' to tackle the issue. The publication of England's childhood obesity action plan chapters in 2016 and 2018 have further signalled the intention and commitment of the government to use legislative action to reduce childhood obesity.

Within England, the heights and weights of primary school children are assessed at age 4-5 (Reception) and age 10-11 (Year 6) as part of the National Child Measurement Programme (NCMP). Data for 2017/18 shows that nationally within England the prevalence of overweight (including obesity in) Reception pupils has remained steady (22%) between 2006/07 and 2017/18, however, the prevalence amongst Year 6 pupils has significantly increased between 2006/07 (31.5%) and 2017/18 (34.3%) (NHS Digital, 2018). Within the same time period in Birmingham, the prevalence of overweight (including obese) children has been higher than the national average, equating to one in four (23.5%) children being overweight (including obese) when they start school to 40.3% of children by the last year of primary school in 2017/18.

The Brisbois *et al*. review (2012) on the early markers of adult obesity reported that a large number of studies reported a significant association between childhood obesity at <5 years of age and adult overweight and obesity. Internationally there is evidence to suggest a link between disadvantaged socio-economic status and increased prevalence of obesity in developed countries (Wang & Lim, 2012). However, there is mixed evidence on the relationship of weight status and socio-economic status from studies in England (Goisis *et al.,* 2015) (Pearce, A. *et al.,* 2015). There is evidence to suggest a relationship between deprivation and obesity differs by ethnicity and by gender (Ells *et al.*, 2015).

Within Birmingham, the relationship between childhood obesity and deprivation, as well as the widening inequalities, has been reported previously, utilising the local NCMP data to conduct cross-sectional data analysis (Mahmood & Lowe, 2017). In order to take a more preventative and upstream approach to tackling childhood obesity and assuage future increases, there is a need for longitudinal research to determine those children at greater risk. As the NCMP programme has now completed a child's journey throughout primary school, it is now possible to track children that have completed their primary school education and identify potential predictive factors, which can inform local public health and school strategies to devise appropriate services and interventions to reduce the prevalence of unhealthy weight.

The aim of the present study is to examine the longitudinal changes in weight status of children in Birmingham primary schools between the ages of 4 and 11 using individualised NCMP data. The study will also explore inequalities, in particular relating to socio-economic status, gender and ethnicity and whether weight status inequalities widen or narrow in children during primary school years.

## Aims

- Track changes in BMI z-scores and weight status among children from Reception to Year 6 between 2006-2015.
- Assess relationship between BMI z-scores in Reception and Year 6 in order to examine predictors of becoming overweight and obese.

## Methods

*Ethics*

The study protocol was approved by Birmingham City Council's research governance process in December 2015. The Local Authority Regulations covering the NCMP allow for local authorities and those acting on their behalf to further process NCMP information for the purposes of research, monitoring, audit, the planning of services, or for any purpose connected with public health (Public Health England, 2019).

*Data*

The main dataset used in the study was the NCMP for three cohorts of Birmingham primary pupils. Other data sources utilised were the UK90 growth reference (Cole *et al.,* 1995) to calculate BMI z-scores and the Income Deprivation Affecting Children Index (IDACI) 2010 to provide an area level socio-economic status measure representing the proportion of children who live in low income households (Ministry of Housing, Communities & Local Government, 2011).

*Matching Reception and Year 6 Records*

NCMP data from three cohorts of children measured in Reception in 2006/07, 2007/08 and 2008/09 and their subsequent Year 6 cohorts; 2012/13, 2013/14 and 2014/15 were utilised. The linkage of records was carried out by auto-matching on a concatenation of gender, date of birth and first name variables. Any Reception records that were not matched through concatenation were matched via manual checking.

*Statistical Analysis*
Statistical analyses were carried out using STATA v13.1. These comprised of an unadjusted linear regression and a mixed effect linear regression model of the association of Reception BMI z-score on Year 6 BMI z-score. This was adjusted for the fixed effect variables of gender, ethnicity and deprivation and for school as a random effect. In addition an investigation was undertaken of the effect of gender, ethnicity and deprivation on mean BMI z-score change (two-sample t-test) and weight status change ($\chi^2$ test).

## Results

A total of 36,093 children were measured in Reception from 2006-2009. Auto matching via concatenation was able to match 24,042 (67%) records, with a further 3,715 records matched with manual checking. 1,029 records were excluded from the study due to missing or invalid measurements. A total of 26,728 (74%) records from 313 schools were matched and included in the study (**Table 1**).

Within the three cohorts boys accounted for a slightly higher percentage than girls, 52% compared to 48%. Cumulatively White and Asian ethnicities comprised of just less than three quarters of the children. Nearly a third of children resided within the most deprived IDACI quintile. Between 2006/07 and 2008/09 weight status classification (underweight, normal, overweight and obese) remained fairly constant whilst children were in Reception; however, matched Year 6 data showed increases in those with overweight and obese classifications between 2012/13 and 2014/15. Another striking feature was the increase in the unknown ethnicity category, which increased from 230 (2.7%) in cohort 1 to 1,155 (12.7%) in cohort 2 and 1,273 (13.9%) in cohort 3. This increase may have been due to changes in recording methods during this time. The unmatched records were analysed to test for significance of difference. A higher proportion of girls than boys were linked ($\chi^2$ test $p=<0.005$), and those with a healthy weight status at Reception were more likely to be lost to attrition.

*Gender*
The mean BMI z-scores for boys and girls at the start of primary school were similar (0.23 for boys, 0.22 for girls), however, by Year 6 the mean z-scores for boys (0.69) were higher than for girls (0.54). Girls were slightly more likely than boys to remain at a healthy weight (71% girls, 68% boys). Whilst prevalence of obesity was similar at Reception, by Year 6, 26% of boys were obese compared to 24% of girls. 16% of boys moved from being a healthy weight to being obese, this is higher than for girls (12%) ($p<0.001$). The proportion of children remaining obese is the same for both girls and boys.

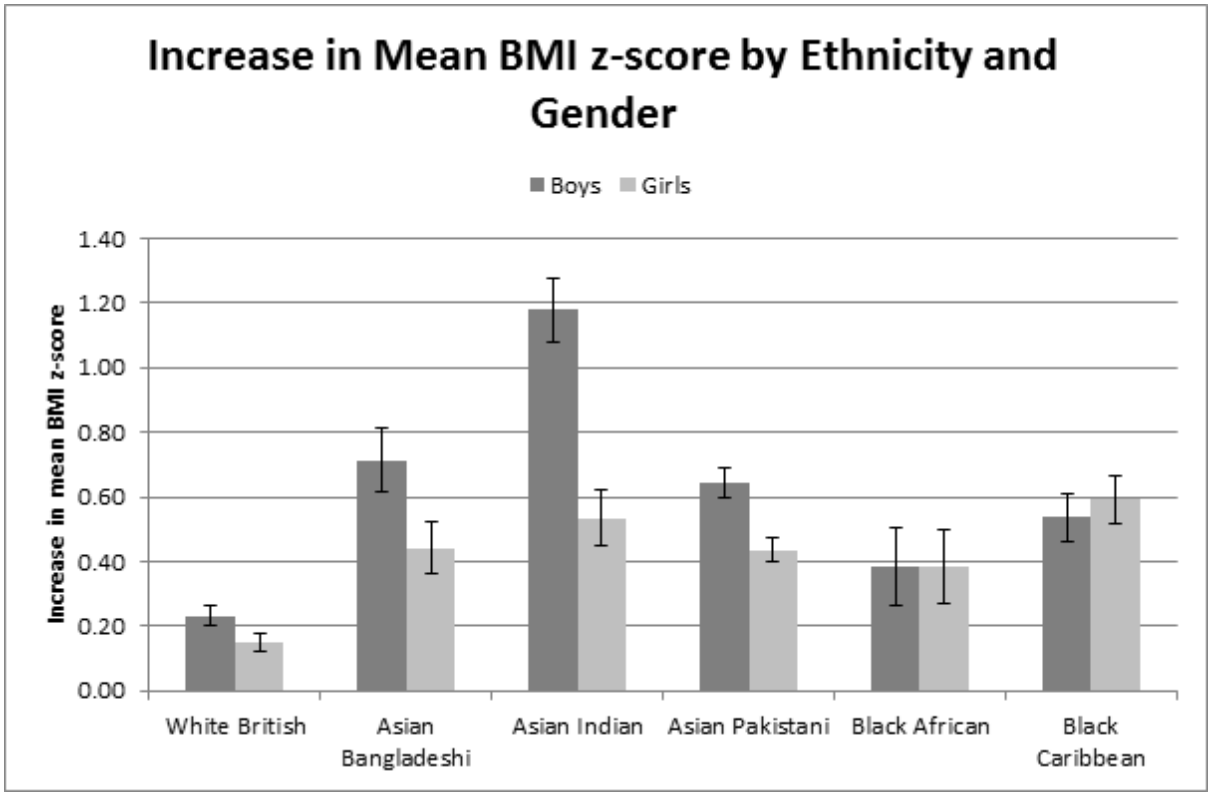
*Ethnicity*
Boys' mean BMI z-scores were more diverse by ethnicity at Reception but less so in Year 6. White British boys had the highest mean z-score at Reception (0.38) but one of the lowest in Year 6 (0.62). The highest increase through primary school was seen in Asian boys (**Figure 1**); in particular Asian Indian boys, where this group increased to a mean z-score of -0.51 at baseline to 0.67 at follow up**.**

In stark contrast the mean BMI z-scores for girls were closer at Reception than they were at Year 6. White British girls have the highest mean scores at Reception but increase only slightly from 0.37 at Reception to 0.52 at Year 6 (**Figure 1**). Black African and Black Caribbean girls have significantly higher scores at Year 6 than girls of other ethnic groups. The sharpest increases in mean scores between Reception and Year 6 are for Black Caribbean (Year 6; 0.88) and Asian Indian girls (Year 6; 0.41).

**Table 1**. Descriptive Statistics of Matched Cohorts.

| **Participants** | **2006/07 - 2012/13** | | **2007/08 - 2013/14** | | **2008/09 - 2014/15** | |
|---|---|---|---|---|---|---|
| | **n** | **(%)** | **n** | **(%)** | **n** | **(%)** |
| All | 8,445 | | 9,116 | | 9,167 | |
| Gender (female) | 4,091 | 48.4 | 4,407 | 48.3 | 4,479 | 48.9 |
| Ethnicity | | | | | | |
| White | 3,487 | 41.3 | 3,298 | 36.2 | 3,293 | 35.9 |
| Asian | 3,272 | 38.7 | 3,214 | 35.3 | 3,196 | 34.9 |
| Black | 755 | 8.9 | 823 | 9 | 820 | 9 |
| Chinese | 24 | 0.3 | 26 | 0.3 | 21 | 0.2 |
| Mixed | 516 | 6.1 | 340 | 3.7 | 375 | 4.1 |
| Any other ethnic group | 161 | 1.9 | 260 | 2.9 | 189 | 2.1 |
| Unknown | 230 | 2.7 | 1,155 | 12.7 | 1,273 | 13.9 |
| IDACI 2010 local quintile | | | | | | |
| (most deprived) 1 | 5,237 | 62 | 5,650 | 62 | 5,587 | 61 |
| 2 | 1,191 | 14.1 | 1,295 | 14.2 | 1,404 | 15.3 |
| 3 | 1,013 | 12 | 1,133 | 12.4 | 1,104 | 12 |
| 4 | 565 | 6.7 | 606 | 6.7 | 646 | 7.1 |
| 5 | 439 | 5.2 | 432 | 4.7 | 426 | 4.7 |
| Reception Weight Status | | | | | | |
| Underweight | 276 | 3.3 | 264 | 2.9 | 219 | 2.4 |
| Normal | 6,271 | 74.3 | 6,924 | 76 | 6,895 | 75.2 |
| Overweight | 996 | 11.8 | 1,050 | 11.5 | 1,066 | 11.6 |
| Obese | 902 | 10.7 | 878 | 9.6 | 987 | 10.8 |
| Year 6 Weight Status | | | | | | |
| Underweight | 207 | 2.5 | 160 | 1.8 | 177 | 1.9 |
| Normal | 4,871 | 57.7 | 5,404 | 59.3 | 5,365 | 58.5 |
| Overweight | 1,397 | 16.6 | 1,359 | 14.9 | 1,368 | 14.9 |
| Obese | 1,970 | 23.3 | 2,193 | 24.1 | 2,257 | 24.6 |
| | **Mean** | **SD** | **Mean** | **SD** | **Mean** | **SD** |
| Reception BMI z-score | 0.25 | 1.19 | 0.19 | 1.18 | 0.24 | 1.18 |
| Year 6 BMI z-score | 0.60 | 1.31 | 0.62 | 1.29 | 0.63 | 1.31 |

**Figure 1**. Increase in Mean BMI z-score by Ethnicity and Gender.



*Deprivation*
The mean BMI z-scores were similar at Reception for children in all the deprivation quintiles. Whilst the mean scores increase for all groups by Year 6, the greatest increase and the highest scores were found in the most deprived areas (**Figure 2**). The increase being almost four times higher in the most deprived areas compared to the most affluent. There is a significant gap between both boys and girls in all but the most affluent quintile.

Differences in weight status by level of deprivation already exist at Reception, however, by Year 6 the prevalence of obesity in the most deprived has risen to 26.4% (25.7%, 27.1%) compared to a prevalence of 13.0% (11.3%, 15.0%) in the most affluent areas. Furthermore, those children in the most deprived areas are more likely to remain obese (79.5%, 95% CI 77.6%, 81.2%) than those in the most affluent (65.8%, 95% CI 54.6%, 75.5%).

*Regression*
The unadjusted linear regression showed a statistically significant relationship between BMI z-score at Reception and Year 6 ($p<0.001$) with a co-efficient of 0.66. This relationship was maintained in the adjusted mixed effect linear regression model with the co-efficient being slightly larger (**Table 2**). The greatest effect on increasing BMI through primary school is BMI z-score at Reception. Although gender, ethnicity and deprivation level also have a significant effect.

## Discussion

Childhood obesity inequalities are widening in England. Latest data from 2017/18 shows an increase in the gap in obesity prevalence for children in both Reception and Year 6 between those living in the most deprived and those in the least deprived areas (NHS Digital, 2018). With the current study showing a doubling of the prevalence of obesity in children as they complete the journey through primary school between the ages of four and eleven, tackling childhood obesity remains one of the greatest public health challenges of the 21st century. Data and findings from this longitudinal investigation also indicate that there are significant differences in obesity prevalence between gender and ethnic groups. The need for urgent action on these widening inequalities was reinforced within a recent Health and Social Care Committee report that urged for stronger action on the disproportionate burden of childhood obesity on children from low income backgrounds (Health and Social Care Committee, 2018). The longitudinal tracking analysis has allowed the exploration of how the weight status of individual children changes over time and the impact of socio-demographic factors. This study found that 78% of children who are obese in Reception remain obese in Year 6. This is a higher proportion than that reported in other longitudinal studies (Pearce, M. *et al*., 2015) (Bartle *et al.*, 2013). A greater proportion of children living in deprivation could explain the higher percentage in Birmingham. The effect of gender and ethnicity which has not been explored in the other work may also contribute to the high prevalence.

Although this study did adjust for deprivation and ethnicity, these factors were still found to be independently associated with obesity risk. The findings of this research suggest that a child who is overweight at the beginning of primary school is more likely to remain overweight or to develop obesity than to achieve a healthy weight status. Within this Birmingham study 20,090 had a healthy weight status at Reception but only 69% of these had maintained this in Year 6. The doubling of the obesity prevalence is postulated to be the combination of children who have healthy or overweight weight status at Reception who move to an obese weight status in Year 6. These findings support the case for primary and secondary obesity prevention programmes for children within the healthy weight category alongside appropriate interventions for those children who are overweight or obese.

**Figure 2**. Increase in mean BMI z-score by Income Deprivation Affecting Children Index 2010 quintile and gender.

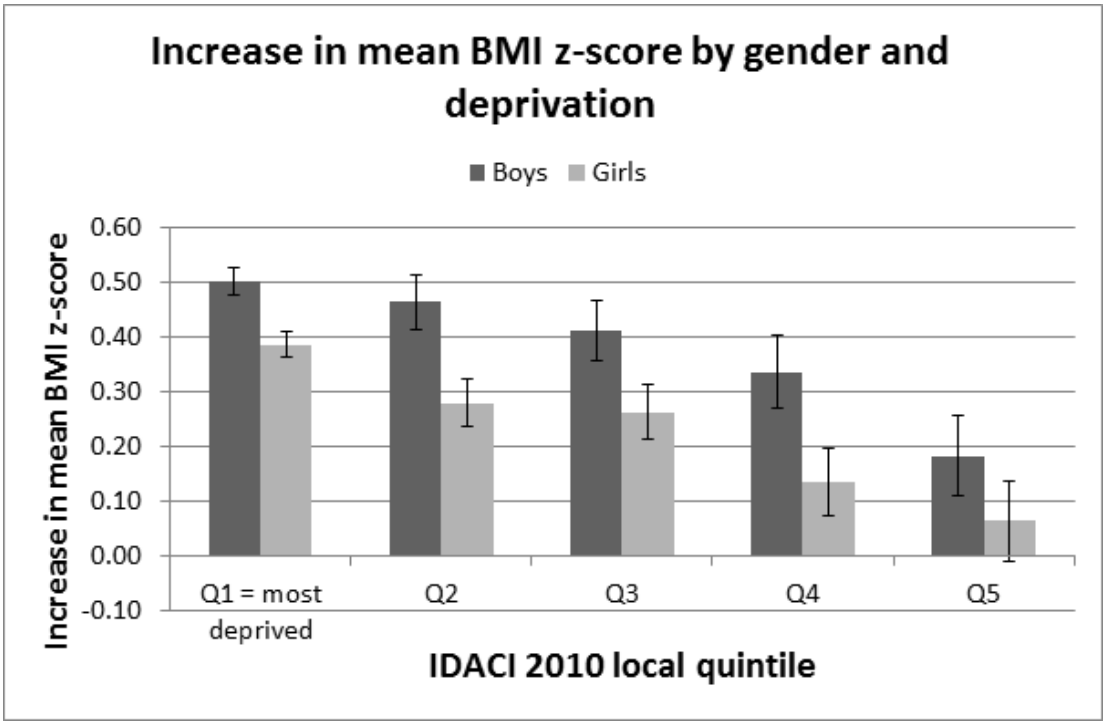



**Table 2**. Mixed effect linear regression.

| **Year 6 BMI z-score**<br>**Fixed effects** | **Co-efficient** | **95% CI** | **P value** |
|---|---|---|---|
| Reception BMI z-score | 0.69 | (0.68, 0.70) | <0.001 |
| Gender female (reference = male) | -0.14 | (-1.67, -0.12) | <0.001 |
| Ethnicity (reference = White) | | | |
| Asian | 0.24 | (0.20, 0.28) | <0.001 |
| Black | 0.25 | (0.20, 0.29) | <0.001 |
| Chinese | 0.12 | (-0.12, 0.36) | 0.320 |
| Mixed | 0.17 | (0.11, 0.23) | <0.001 |
| Any other | 0.17 | (0.09, 0.26) | <0.001 |
| Unknown | 0.14 | (0.10, 0.19) | <0.001 |
| Deprivation quintile (IDACI 2010) | | | |
| (Reference = 1 – most deprived) | | | |
| 2 | -0.34 | (-0.04, 0.31) | 0.726 |
| 3 | -0.03 | (-0.08, 0.01) | 0.122 |
| 4 | -0.09 | (-0.15, -0.04) | 0.001 |
| 5 | -0.18 | (-0.24, -0.11) | <0.001 |
| **Random effect** | | | |
| School | 0.102 | (0.01, 0.015) | |

The Government's Childhood Obesity Plan (COP1) published in 2016 aims within the next ten years to encourage industry to cut the amount of sugar in foods and drinks and for school children to consume healthy food and stay physically active. Chapter Two of the Childhood Obesity Plan (COP2) published in 2018 set a national ambition to halve childhood obesity and significantly reduce the gap in obesity prevalence between children from the most and least deprived areas by 2030. COP2 says little about diet or physical activity in the early years, with much of the focus on school age children (Knai *et al.*, 2018). The Chair of the Health and Social Care Committee's response found COP2 to be a substantial improvement on COP1, especially its ambition around the reduction of the inequality gap. The response was also complementary of the Government's pledge to develop a trailblazer programme with local authorities to understand 'what works' in different communities, especially the focus on ethnic disparities, but was discontented on the absence within COP2 of making health a licensing objective for local authorities.

Given the current significantly higher prevalence of childhood obesity of Year 6 pupils within Birmingham (25.6%) compared to the national average of 20.1%, this study provides timely evidence to parents, school staff and health professionals of the existing inequalities and the requirement to focus preventative efforts towards those at greatest risk, in order to prevent future health problems. Being one of the first tracking studies to have been undertaken within Birmingham, these findings provide an important benchmark for future analyses.

The existence of socio-demographic inequalities highlighted within this study underscores the need for assessing the predictors of child obesity in local areas. National policy drivers such as COP1 and 2 can empower local areas to influence and reduce childhood obesity rates through reducing or limiting harmful commercial influences such as advertising and marketing of unhealthy foods and drinks. A greater examination of the wider social, environmental and economic determinants of health such as fast food outlets, green space availability or fiscal policies such as the sugar tax is required (Evans, 2018) to understand the opportunities and obstacles to childhood weight management in local areas. These insights are likely to be achieved through qualitative studies and by understanding the social milieu 'whole system approach' to elucidate the best mechanisms, such as population segmentation (Mahmood & Lowe, 2017) that are able to engage effectively with those communities whose children are at greatest risk.

The findings here support national cross-sectional NCMP data that there is a strong link between childhood obesity and deprivation and that this widens by the end of primary school (Townsend *et al.*, 2011), South Gloucestershire study findings (Pearce, M. *et al*., 2015) were similar but the sample was too small to show significant effect. The widening gradient fits with the results of the longitudinal studies with wider measures of deprivation (Goisis *et al.*, 2015) (Pearce, A., 2015). However none of these studies have also looked at the effect of gender and ethnicity.

Studies that have looked at gender and ethnicity have found associations for obesity and deprivation for girls and non-White children (Griffiths *et al.*, 2013) (Ells *et al.*, 2015). In this study it was found the effect of deprivation did not markedly differ between boys and girls but that increases in BMI z-scores were generally much higher in boys than girls and that there was far greater differences by gender and ethnicity. This conflicts with findings of a longitudinal study (Bartle *et al.*, 2013) that there was no significant difference between boys and girls. Reasons why boys have higher obesity in Birmingham are potentially associated with ethnicity. The increase in mean BMI z-scores in Asian boys is higher than boys in other ethnic groups and markedly higher to Asian girls. Possibly due to cultural and societal norms and behaviours, boys may have more risk factors relating to diet and physical activity.

Early identification and a focus on the prevention of obesity in children is paramount as the impact if left disregarded can have potentially detrimental effects in later life. The findings from this study endorse wide-scale multidisciplinary primary and secondary prevention programmes with pre-school and primary school children which engage and interact with local communities to abate the rising of obesity prevalence through primary school. In order to successfully influence and reduce childhood obesity prevalence, national and local government policy must do more to develop holistic 'whole systems approaches' to tackling childhood obesity (Bagnall *et al.*, 2019) as it corrals expertise across all sectors, such as health, schools, industry and academia.

*Limitations of this Study*

This is a large longitudinal study of a representative sample of multi-ethnic population with a high rate of follow-up. It provides richer information than serial cross-sectional studies. Although the study population is representative of the ethnically diverse children in Birmingham, the data is based on children in a large city with more deprivation than there is in the England population as a whole. Therefore the trends and characteristics associated with increasing weight status may not necessarily apply to a wider population.

The data for the first years of the NCMP were of poorer quality compared to those collected in the most recent years. Particularly in the first year of collection where more data is missing than for other years. Nevertheless, the patterns observed were similar in the three cohorts of children, suggesting that the missing data was unlikely to have resulted in significant bias. No unique identifier was routinely collected until 2012/13 making it difficult to link children for a longitudinal study. Analysis of the loss to follow up found that children are not likely to drop out because they are recorded as obese at Reception, but did show that boys were less likely to be followed up than girls. As the findings of this study show that boys are more likely to increase weight it may be that these children have become obese and the parents are unwilling for them to be measured. However, it may also be because there are a higher number of boys in Birmingham schools than girls. The matched sample was representative of children within the city and obesity prevalence similar to the NCMP collection from 99% of the eligible population and therefore this study is unlikely to be adversely affected by attrition bias.

BMI is not an accurate measure of weight status (Davillas & Benzeval, 2016), however, it is a simple measure to collect and is commonly used and recommended for use in population studies and monitoring by national authorities (NICE and PHE). However, BMI does have the weakness of not being able to distinguish between excessive lean and fat mass (Must & Anderson, 2016) and this may impact on results for non-White children; overestimating obesity in Black ethnicities who are more likely to have high muscle mass and be taller for their age in comparison to White British children and underestimating prevalence for Asian children who have higher central adiposity (Nightingale *et al.*, 2013). The cut points are arbitrary and may skew results for tall children. Analysis of the heights of the Year 6 girls show that Black girls are taller than those of other ethnicities. The increase BMI z-score for girls is steepest in Black Caribbean ethnicity and this could be explained by their being taller than the other girls. Using another method than BMI would likely return a lower obesity prevalence for this group.

**Acknowledgements**

This research is funded by the National Institute for Health Research (NIHR) Collaboration for Leadership in Applied Health Research and Care (CLAHRC) West Midlands. The views expressed are those of the authors and not necessarily those of the NIHR or the Department of Health and Social Care.

**References**

Bagnall, A.M., Radley, D., Jones, R., Gately, P., Nobles, J., Van Dijk, M., Blackshaw, J., Montel, S. & Sahota, P. (2019) 'Whole systems approaches to obesity and other complex public health challenges: A systematic review', *BMC Public Health*, **19**(8), doi: 10.1186/s12889-018-6274-z.

Bartle, N.C., Hill, C., Webber, L., van Jaarsvel, C.H.M. & Wardle, J. (2013) 'Emergence and Persistence of Overweight and Obesity in 7- to 11-Year-Old Children', *Obesity Facts*, **6**(5), pp. 415-423.

Brisbois, T.D., Farmer, A.P. & McCargar, L.J. (2012) 'Early markers of adult obesity: A review', *Obes Rev*, **13**(4), pp. 347-367.

Cole, T.J., Freeman, J.V. & Preece, M.A. (1995) 'Body mass index reference curves for the UK, 1990', *Archives of Disease in Childhood*, **73**(1), p. 25.

Davillas, A. & Benzeval, M. (2016) 'Alternative measures to BMI: Exploring income-related inequalities in adiposity in Great Britain', *Social Science & Medicine*, **166**, pp. 223-232.

Department of Health and Social Care (2016) *Childhood Obesity: A Plan for Action*, London: The Stationery Office Limited.

Department of Health and Social Care (2018) *Childhood Obesity: A Plan for Action*, *Chapter 2*, London: The Stationery Office Limited.

Ells, L.J., Mead, E., Hancock, C., Copley, V.R., Mead, E., Dinsdale, H., Kinra, R.M. & Rutter, H. (2015) 'Prevalence of severe childhood obesity in England: 2006-2013', *Archives of Disease in Childhood*, **100**(7), pp. 631-636.

Evans, C. (2018) 'How successful will the sugar levy be in improving diet and reducing inequalities in health?', *Perspectives in Public Health*, **138**(2), pp. 85-86.

Goisis, A., Sacker, A. & Kelly, Y. (2015) 'Why are poorer children at higher risk of obesity and overweight? A UK cohort study', *European Journal of Public Health*, **26**(1), pp. 7-13.

Griffiths, C., Gately, P., Marchant, P.R. & Cooke, C.B. (2013) 'Area-level deprivation and adiposity in children: Is the relationship linear?', *International Journal of Obesity*, **37**(4), p. 486.

Health and Social Care Committee (2018) *Childhood Obesity: Time for Action*. *Eighth Report of Session 2017-19*, accessed 17 April 2019 online at: https://publications.parliament.uk/pa/cm201719/cmselect/cmhealth/882/882.pdf.

Health and Social Care Committee (2018) *Chair responds to Government's Childhood Obesity Plan*, accessed 17 April 2019 at: https://www.parliament.uk/business/committees/committees-a-z/commons-select/health-and-social-care-committee/news/childhood-obesity-government-plan-chairs-statement-17-19/.

House of Commons Health Committee (2015) *Childhood Obesity — Brave and Bold Action,* London: The Stationery Office Limited.

Kimm, S.Y.S. & Obarzanek, E. (2002) 'Childhood obesity: A new pandemic of the new millennium', *Pediatrics*, **110**(5), pp. 1003-1106.

Knai, C., Lobstein, T., Petticrew, M., Rutter, M. & Savona, N. (2018) 'England's childhood obesity action plan II', *British Medical Journal*, **362**, doi: 10.1136/bmj.k3098.

Mahmood, H. & Lowe, S. (2017) 'Population segmentation: An approach to reducing childhood obesity inequalities', *Perspectives in Public Health*, **137**(3), pp. 190-195.

Mead E., Brown T., Rees K., Azevedo, L.B., Whittaker, V., Jones, D., Olajide, J., Mainardi, G.M., Corpeleijn, E., O'Malley. C., Beardsmore, E., Al-Khudairy, L., Baur, L., Metzendorf, M.I., Demaio, A. & Ells, L.J. (2017) 'Diet, physical activity and behavioural interventions for the treatment of overweight or obese children from the age of 6 to 11 years', *Cochrane Database of Systematic Reviews*, **6**, doi: 10.1002/14651858.CD012651.

Ministry of Housing, Communities & Local Government (2011) *English Indices of Deprivation 2010*, accessed 30 April 2018 online at: https://www.gov.uk/government/statistics/english-indices-of-deprivation-2010.

Must, A. & Anderson, S.E. (2016) 'Body mass index in children and adolescents: Considerations for population-based applications', *International Journal of Obesity*, **30**, pp. 590-594.

NHS Digital (2018) *National Child Measurement Programme England – 2017/18 School Year*, accessed 23 April 2019 online at: https://digital.nhs.uk/data-and-information/publications/statistical/national-child-measurement-programme/2017-18-school-year.

Nightingale, C., Rudnicka, A., Owen, C., Donin, A.S., Newton, S.L., Furness, C.A., Howard, E.L., Gillings, R.D., Wells, J.C., Cook, D.G. & Whincup, P.H. (2013) '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*, **8**(10), doi: 10.1371/journal.pone.0076426.

Public Health England (2019) *National Child Measurement Programme*, *Operational Guidance 2019*, accessed 28 August 2019 online at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/817417/NCMP_Operational_Guidance_2019.pdf.

Pearce, A., Rougeaux, E. & Law, C. (2015) 'Disadvantaged children at greater relative risk of thinness (as well as obesity): A secondary data analysis of the England National Child Measurement Programme and the UK Millennium Cohort Study', *International Journal for Equity in Health*, **14**(1), doi: 10.1186/s12939-015-0187-6.

Pearce, M., Webb-Phillips, S. & Bray, I. (2016) 'Changes in objectively measured BMI in children aged 4-11 years: Data from the National Child Measurement Programme', *Journal of Public Health*, **38**(3), pp. 459-466.

Reilly, J.J. (2007) 'Childhood obesity: An overview', *Children & Society*, **21**(5), pp. 390-396.

Townsend, N., Rutter, H. & Foster, C. (2011) 'Age differences in the association of childhood obesity with area-level and school-level deprivation: Cross-classified multilevel analysis of cross-sectional data', *International Journal of Obesity*, **36**(1), pp. 45-52.

Wang, Y. & Lim, H. (2012) 'The global childhood obesity epidemic and the association between socio-economic status and childhood obesity', *Int. Rev. Psychiatry*, **24**(3), pp. 176-188.

## Notes on Contributors

**Susan Lowe** is a Public Health Knowledge Evidence and Governance Lead at Birmingham City Council. This article is based on her Master of Public Health dissertation whilst at University of Birmingham. Her research interests are health inequalities and the impact of the environment on health. She has a previous publication on childhood obesity; *Population Segmentation: An Approach to Reducing Childhood Obesity Inequalities* discussing the utilisation of segmentation to reduce health inequalities. More recently her work has looked at the health and wellbeing of armed forces veterans and the health needs of children with special education needs and disabilities.

**Hashum Mahmood** is a Public Health Manager within the National Health Inequalities Unit at Public Health England. He has worked at many levels of public health within the United Kingdom; local government, academia and primary care commissioning. With a keen interest in health inequalities data analytics and research that can inform strategy and public health policy, he has recently contributed to the 2019 Public Health England National Guidance; *Health Inequalities: Place-based Approaches to Reduce Inequalities*. A previous publication on childhood obesity in 2017; *Population Segmentation: An Approach to Reducing Childhood Obesity Inequalities* discussed the utilisation of segmentation to reduce health inequalities.

## Correspondence

E: susan.lowe@birmingham.gov.uk