Original Research Report for Archives of diseases in childhood - Title Page:

Title: Prevalence of Severe Childhood Obesity in England: 2006-2013.

Running Title: Prevalence of Severe Childhood Obesity in England

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Abstract:

Background: International evidence shows that severe paediatric obesity results in an increased risk of ill health, and may require specialised weight management strategies, yet there remains a lack of data on the extent of the problem.

Objective: To examine the prevalence of severe obesity in children aged 4-5 and 10-11 years, attending English schools between 2006/07 and 2012/13.

Design: A retrospective analysis of the National Child Measurement Programme data.

Setting: Maintained schools in England.

Participants: All children aged 4-5 and 10-11 years.

Main outcome measures: Prevalence of severe childhood obesity, defined using the 99.6th centile of the UK90 growth reference charts, analysed by sex; geography; ethnic group; and deprivation.

Results: The key findings show that in 2012/13, severe obesity (BMI ≥UK90 99.6th centile) was found in 1.9% of girls and 2.3% of boys aged 4-5 years, and 2.9% of girls and 3.9% of boys aged 10-11 years. Severe obesity prevalence also varies geographically and is more prevalent in children from more deprived areas and those from Black ethnic groups.

Conclusions: The findings from this study should help to raise awareness of the prevalence of severe obesity and ensure adequate treatment and prevention services are in place both to support children who are already severely obese, and reduce the prevalence of extreme weight in the future.

Key Words: severe obesity, child, prevalence, England

Introduction:

In children the relation between body mass index (BMI) and adiposity varies with age and sex, so BMI thresholds are usually defined in terms of a specific centile on a growth reference. There is, however, currently no universal definition of severe paediatric obesity. In England the United Kingdom 1990 (UK90) growth charts for BMI are frequently used to define paediatric weight status according to age and sex, with the highest centile line being the 99.6th [1]. The International Obesity Task Force (IOTF) has also recently published a definition for morbid obesity in children [2]. In the United States, an expert committee proposed a classification of severe childhood obesity as a BMI greater than or equal to the 99th centile of the Centers for Disease Control (CDC) growth reference [3]. Several years later, this classification was challenged and a new classification of BMI greater than or equal to the 120% of the 95% centile was proposed [4-6]. Using this new definition, analysis of the United States (US) National Health and Nutrition Examination Survey (NHANES) 1999-2012 identified an upward trend in the rates of severe obesity over time, with the latest 2011-2012 data showing a prevalence of 5.9% in children aged 2-19 years [7]. This study also demonstrated that severe obesity prevalence was highest amongst the older children, and those from Hispanic, and non-Hispanic Black, populations. These data complement an earlier study which also reported the association between severe obesity and the development of hypertension [8]. Further US studies show that severe obesity is associated both with increased paediatric cardiovascular risk factors, and risk of severe obesity in adulthood [9][10]. These studies complement similar findings from a Dutch paediatric surveillance survey [11], which found that two out of three severely obese children (defined using the Dutch age and sex specific cut points corresponding to an adult BMI of 35 or more) have cardiovascular risk factors.

The 2013 scientific statement from the American Heart Association [6], highlighted the associated immediate and long term cardiovascular, metabolic and other health consequences (obstructive

sleep apnoea, non alcoholic fatty liver disease, muscular-skeletal and psychological problems) of severe paediatric obesity, suggesting the need for specialised weight management services. As these children may require a range of interventions, accurate prevalence data are essential to inform the appropriate planning, delivery and commissioning of such services. It is also valuable to use these data to make international comparisons. This paper builds on analyses conducted for the recent Chief Medical Officers report [12], and provides the first detailed description of the prevalence of severe obesity in children in England.

Methods:

Objective

To examine the prevalence of severe obesity in children aged 4-5 and 10-11 years, attending English schools between 2006/07 and 2012/13.

Study design

A retrospective analysis of the National Child Measurement Programme (NCMP) was performed for school years 2006/07-2012/13. The NCMP data were analysed in Microsoft Access and Excel, with 95% confidence intervals (CI) calculated using the Newcombe method [13]. When analysing severe obesity prevalence within ethnic groups and at Local Authority level, the last three years data were combined for analysis, to avoid any small number disclosure and improve statistical strength.

Setting

The NCMP was established in 2006 and annually collects measured height, weight, sex, age, ethnicity and postcode data from all children in Reception (ages 4-5 years) and Year 6 (ages 10-11 years), from every maintained school across England. Data collection at privately funded and special needs schools is not mandatory. Because coverage of data collection in these schools is low, data from them have been excluded from this analysis. A full description of the methods for the NCMP has

been previously published [14]. The programme is co-ordinated by Public Health England and was established to inform local planning and delivery of children's services, gather population level surveillance data, and increase awareness of weight issues in children.

Participants

Participants are school children aged 4-5 and aged 10-11 years. The numbers measured in previous years were: n=873,584 in 2006/07 (80% participation); n=972,479 in 2007/08 (88% participation); n=1,003,866 in 2008/09 (90% participation); n=1,026,368 in 2009/10 (91% participation); n=1,036,608 in 2010/11 (93% participation), n=1,056,780 in 2011/12 (93% participation); n=1,076,824 in 2012/13 (93% participation).[1]

Main outcome measures

The primary outcome of this study was the prevalence of severe childhood obesity, defined using the 99.6th centile of the UK90 Body Mass Index growth reference charts **(this equates to an adult [age 18] BMI of approximately 31.93 for boys and 32.6 for girls). Prevalence was also analysed by sex; geography; ethnic group; and deprivation (calculated using the Index of Multiple Deprivation [IMD] 2010[2]). Secondary outcomes classified severe obesity according to two additional higher BMI centile reference points: 99.87 (which equates to an adult BMI of approximately 34.46 for boys and 35.09 for girls) and 99.98 (which equates to an adult BMI of approximately 39.38 for boys and 39.73 for girls). To facilitate international comparisons International Obesity Task Force cut points [2] were also applied to data.**

Analyses

[1] NB due to additional data cleaning these figures may differ slightly from figures previously published by the Health and Social Care Information Centre.

[2] https://www.gov.uk/government/publications/english-indices-of-deprivation-2010

Binary logistic regression was used to assess the relationship between NCMP year of measurement and IMD decile, and the probability of being severely obese. Four separate models were produced, one for each of the school year and sex combinations. The GLM function in the statistical software R[3] was used to fit the models. The models assume that the log of the odds of being severely obese is linearly related to the two explanatory variables: year of measurement; and IMD decile. IMD decile was considered as a categorical variable. The variables were assessed for significance using the chi-square test. Significance in other data presented was assessed using 95% confidence intervals, with significance assumed when intervals do not overlap.

Ethical approval for this study was not required as it involved the secondary analysis of routinely collected public health data.

Results:

Table 1 presents the first (2006/07) and last available (2012/13) prevalence figures for English school children who fell on or above the 99.6th centile of the UK90 growth charts, and met the new IOTF morbid obesity classification. As commissioners often rely on higher thresholds to define the need for highly specialised service such as bariatric surgery, two further categories for very severe obesity are also presented, based on the 99.87th and 99.98th centiles of the UK90 growth charts.

Severe obesity prevalence classified using the IOTF definition aligns most closely to the prevalence defined using the 99.87th centile of the UK90 reference. For the remainder of this paper, the 99.6th centile of the UK90 reference will be used to define severe obesity. This represents the highest

[3] R Core Team (2014). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org/.

centile line marked on the growth charts, and is thus easily distinguishable by both lay and clinical personnel using the charts with children in the UK.

Prevalence of severe obesity by sex, age group and Index of Multiple Deprivation 2010 decile over time is shown in Figure 1, with the supporting logistic regression analysis shown in Table 2. These results indicate that both year of measurement and deprivation decile are significant predictors of severe obesity. Table 2 shows that after adjustment for IMD decile the odds of being severely obese have on average increased over time for the older girls and boys, by 1.02 times for each additional year of measurement. In contrast the odds of being severely obese have decreased over time for younger girls and boys, with odds ratios of 0.99 (95% CI 0.99-0.998) and 0.98 (95% CI 0.97-0.98) respectively. The 10-11 year old girls in the most deprived IMD decile have odds of being severely obese which are 4.35 times those in the least deprived reference category (95% CI 4.13-4.58) (Table 2). The difference in severe obesity prevalence between the least deprived and most deprived IMD deciles is less marked for the other age and sex groups (older boys, younger girls and boys), with odds of severe obesity of between 3.17 and 3.64 times those in the least deprived decile. It is important to note that it was not possible to examine yearly trends by ethnic group, as ethnicity reporting was poor in the first few years of the programme and several years data need to be aggregated to avoid small number disclosure.

The latest available measurement year (2012/13), shows a prevalence of 1.9% (95% CI: 1.81 to 1.92%) for girls and 2.3% (95% CI: 2.26 to 2.37%) for boys aged 4-5, and 2.9% (95% CI: 2.82 to 2.95%) for girls and 3.9% (95% CI: 3.86 to 4.01%) for boys aged 10-11. This equates to a total of 12,316 of 4-5 year olds and 16,775 of 10-11 year olds children with severe obesity at the time of measurement in 2012/13. In addition to the differences in severe obesity between age and sex, there is also significant variation according to geography (Figure 2). Using combined data from the last three years, the prevalence of severe obesity across English local authorities varies from 0.7-4.3% for the

younger age group and 0.4-7.5% for the older children. **Furthermore, there is also significant variation in severe obesity prevalence among ethnic groups (Figure 3). Data from the last four years combined show that the Black ethnic group has higher prevalence compared to White, Mixed, Asian, Chinese and Other ethnic groups. The highest prevalence rates are seen in 10-11 year old Black Caribbean children, whilst lowest rates are seen in both the older and younger Chinese girls.**

Discussion:

This study provides the first detailed analysis of the measured prevalence of severe obesity in school children across England. Severely obese children are at risk of developing a number of serious acute and chronic health problems [6]. These children therefore pose a significant concern in terms of their health and well being, and may require the use of specialist services.

Nearly 30,000 severely obese (≥99.6th UK90 centile) children in the two primary school year groups were identified in 2012/13. This is an order of magnitude greater than the number of children falling within the very thin category (<0.4th UK90 centile) (in 2012/13, 2860 [children aged 4-5: 1311, 0.2%. children aged 10-11: 1549, 0.3%] were classified as very thin). Whilst the strength of this study is the large population size and high participation rate, it is worth noting the presented figures are likely to underestimate the prevalence of severe obesity, for two main reasons: 1) a small number of children with severe obesity may also have other conditions such as Prader Willi syndrome, and the NCMP does not measure children at special needs schools; 2) analyses of previous years' data, and extensive anecdotal evidence, suggest that heavier children are more likely to opt out of the measurement programme, especially in the older age group. It may therefore be the case that some of the increase noted in severe obesity over time is a consequence of a commensurate rise in response rate.

When compared to data from the US, [7] English school children showed similar severe obesity prevalence patterns, with higher rates in boys, older children and Black ethnic groups. However, the use of different thresholds, reference populations, and age groups in the two countries makes direct comparisons difficult [15]. Wider use of the new IOTF classification could avoid this problem. A higher prevalence in the younger age group is also observed when the very high 99.98th centile cut point is applied. The reasons for this remain unknown, although it might result from elevated opt out rates in very overweight older children, who may be more sensitive to the risks of obesity-related stigma than their younger counterparts. Whilst it would be very interesting to formally assess the impact of opt out unfortunately the data is not available to facilitate this analysis.

Although the percentages for severe obesity remain small, they still represent a very large number of children across the country, many of whom are likely to require top tier service provision. This is a particularly important service consideration when over 4,000 children in just the two school years measured by the NCMP in 2012/13, had a BMI falling on or above the exceptionally high 99.98th centile. Whilst the NCMP only provides data on two year groups, simple extrapolation of these findings to all school age children would suggest that tens of thousands of children may potentially be suffering from very severe obesity.

When examining prevalence using the 99.6th centile, the observed higher prevalence in boys and older children echoes the raised prevalence of general obesity in these groups: in 2012/13, 20.4% of boys and 17.4% of girls aged 10-11 were classified as obese (≥95th centile of the UK90 reference), compared to 9.7% of boys and 8.8% of girls aged 4-5 [14]. Severe obesity prevalence patterns also mirror the prevalence patterns for general obesity in the correlation with health inequalities. As reported for general obesity [14], severe obesity prevalence varies significantly by geography, and is

highest in the most deprived children and those from Black ethnic groups. Therefore suggesting the need, for the development and evaluation of more targeted interventions.

The findings from this study should help to raise awareness of the prevalence of severe obesity and ensure adequate treatment and prevention services are in place both to support children who are already severely obese, and reduce the prevalence of extreme weight in the future. However there remain several gaps which would benefit from future research: 1) further investigation of the role of the disproportionate drivers of severe obesity in deprived and ethnic minority groups; 2) linkage to other health outcome data to assess short and long term health impacts; 3) longitudinal analyses tracking individual children over time, to further understanding of the natural history of this condition and identify any potential predictive factors; and 4) exploration of other international data sources using the new IOTF definition of morbid obesity, to support international data comparisons.

What is already known on this topic

- Severe paediatric obesity is associated with a number of serious immediate and long term health problems.
- Prevalence of severe paediatric obesity has increased in the United States.
- Data from the United States demonstrate inequalities in the prevalence of severe paediatric obesity, with significant socio demographic variation.

What this study adds

- This is the first detailed analysis of severe paediatric obesity prevalence in English school children.
- 1.9% of girls and 2.3% of boys aged 4-5; and 2.9% of girls and 3.9% of boys aged 10-11 were classified as severely obese (falling on or above the 99.6th centile of the UK90 growth charts) in England in 2012/13.

- In England, prevalence of severe obesity varies significantly across the country and is higher in children living in the most deprived areas, and from Black ethnic groups.

Acknowledgements:

Data access for this analysis was granted to Public Health England.

Declaration of Conflicts of Interest

None of the authors have any conflicts of interest to declare.

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