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Original Research

The association between body mass index, primary healthcare use and morbidity in early childhood: findings from the Born In Bradford cohort study

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ABSTRACT

Objectives: The objective of the article was to examine the association between body mass index (BMI), health and general practice (GP) healthcare use in early childhood.
Study design: This study is a prospective cohort study.
Methods: Multivariate Poisson and logistic regression models were used to explore the association between BMI and health outcomes using data from the Born In Bradford cohort study, linked to routine data capturing objective measures of BMI at age 5 years, alongside GP appointment rates, GP prescriptions and specific morbidities in the subsequent 3-year period.
Results: Compared with healthy weight, children who were obese at the age of 5 years had significantly higher rates of GP appointments (incident rate ratio 1.14, 95% confidence interval [CI]: 1.06–1.23), GP prescriptions (incident rate ratio 1.15, 95% CI: 1.04–1.27), asthma (odds ratio 1.46, 95% CI: 1.21–1.77), sleep apnoea (odds ratio 2.50, 95% CI: 1.36–4.58), infections (incident rate ratio 1.19, 95% CI: 1.08–1.30), antibiotic prescriptions (incident rate ratio 1.25, 95% CI: 1.10–1.42) and accidents (incident rate ratio 1.20, 95% CI: 1.01–1.42) in the subsequent 3 years. Underweight children were found to have higher rates of GP appointments (incident rate ratio 1.25, 95% CI: 1.04–1.52), but there were no differences between overweight and healthy weight children.
Conclusions: Childhood obesity was found to be associated with increased primary healthcare use and a range of poorer health outcomes at the age of 8 years, underlining the importance of reducing childhood obesity in early childhood.

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Introduction

The prevalence of childhood obesity has increased substantially in the United Kingdom in recent decades, as it has in many developed and developing countries worldwide.[1–3] Results from the large-scale National Child Measurement Programme (NCMP) measuring child height and weight and derived body mass index (BMI) in England, indicate that 9.6% of children aged 4–5 years and 20.0% of children aged 10–11 years were obese in 2017.[4] Low socio-economic status is known to be associated with increased risk of childhood obesity, with evidence that these associations are becoming stronger,[5–7] although economically disadvantaged children also have higher rates of being underweight.[8] There are also differences by ethnicity;[9] the most recent results from the NCMP in England indicate that, compared with White British children, South Asian and Black children have higher rates of obesity and also higher rates of being underweight.[4] Rates of childhood obesity have also been found to vary by gender,[4] child birthweight[10] and potentially maternal age.[11] Children who are overweight or obese at an early age are at greater risk of continuing to experience obesity throughout their life course, which is associated with a range of poor health outcomes in adulthood[12–14] and greater healthcare costs. Studies in the United States and the United Kingdom have estimated that the total healthcare costs are around 25%–40% higher for obese adults, compared with healthy weight adults.[15–20] In the United Kingdom, the direct cost of overweight and obesity to the National Health Service (NHS) is estimated to be in the region of two to three billion pounds a year.[20–23]

More recently, attention has turned to the direct impact that obesity may have on both health and use of health services in childhood itself.[3] There have been few empirical studies to date, partly due to the lack of available data,[24–26] and results are inconsistent. Two cross-sectional studies, undertaken in the Netherlands, identified that obese children aged 8 years had higher rates of general practice (GP) visits, more visits related to illnesses such as asthma and infections and higher rates of antibiotic prescriptions compared with healthy weight children.[24,27] Two Australian studies, one cross-sectional and one longitudinal, have reported higher rates of asthma and lower rates of general health for obese children compared with those of healthy weight, leading to increased health service costs by the age of 6 years.[28,29] However, a cross-sectional study in Canada found no difference in prescription rates between healthy weight and obese children at age the of 6–11 years,[30] and in the United States, a recent repeated cross-sectional study showed only very small differences in healthcare use and prescriptions for obese children which did not translate to meaningful differences in costs.[31] There has been one study in the United Kingdom, using longitudinal cohort data, which has looked at childhood obesity and GP prescription rates in children aged 5–11 years, which found that obese children had greater rates of prescriptions, specifically for respiratory illnesses.[26] However, this study did not explore differences for underweight children, and there have been no studies of child BMI and primary care use in the United Kingdom to date.

Currently, the direct impact of obesity in childhood remains unclear.[26,32–34] Furthermore, all existing studies have relied on self-reported health outcomes from survey data making precise estimation of morbidity and related additional healthcare use difficult. Few studies have considered underweight children, despite there being a potentially stronger association with healthcare use and costs[35] and a climate of austerity and food poverty within the United Kingdom.[36,37] Therefore, our aim was to use objective measures from routine healthcare data to explore the association between BMI at the age of 5 years and childhood morbidity and primary healthcare use in the subsequent period of early childhood.

Methods

Participants and setting

This study uses data from the Born In Bradford (BiB) birth cohort, consisting of 12,453 women recruited at 28 weeks of pregnancy, who gave birth at the Bradford Royal Infirmary to 13,858 children between the years 2007 and 2011. The cohort reflects Bradford's multicultural mix and socio-economic profile. Almost half of children are of Pakistani heritage, and around one-third have mothers who were born outside the United Kingdom. There are high levels of poverty in the city; and in the cohort, more than 4 in 10 families are in receipt of means-tested benefits, and two-thirds of children are living in neighbourhoods within the highest national quintile of material deprivation in England. A full description of the BiB cohort study has been published elsewhere.[38]

GP use and child health outcome measures

Counts of GP appointments and GP prescriptions were constructed from linked routine data for the period of 3 years after the date of the child's height and weight measurement, from around age 5 to around age 8 years. Women recruited to the study gave their consent to access GP records via SystmOne, which currently has a complete coverage of all GP practices in Bradford. Linkage was carried out using NHS number, surname, gender and date of birth, with 99% of the cohort successfully matched. Read codes in the GP appointment data were matched to International Classification of Diseases, Tenth Revision, codes in order to strip out all non-clinical events (such as administrative actions) or codes related specifically to weight management. Routine GP data were used to identify the specific health conditions of asthma, sleep apnoea, infections, accidents and the number of antibiotic prescriptions. Costs of GP appointments and prescriptions were estimated at 2015 rates, at £44 per GP consultation[40] and £8.55 per prescription.[41] Total primary care costs were calculated by multiplying these costs by the number of related events in the period.

Childhood BMI measure and other covariates

There were 9443 children in the BiB cohort study with height and weight measures collected for the NCMP;[4] the measures reported in this study were collected at reception year when children are aged around 5 years. The NCMP reports data on BMI categorised using the UK90 growth reference and age-

adjusted z-scores.[39] This study uses the same population monitoring thresholds as the NCMP. Underweight defined as being less than or equal to the second centile, overweight being ≥85th centile but <95th and obese being ≥95th centile. Other covariates, measuring possible confounders identified in the previous discussion, were taken from a range of sources. Child gender, birthweight, gestational age at birth and maternal age were taken from linked routine hospital data collected at birth, the means-tested benefit status of the household was captured in questionnaires administered at study recruitment. Neighbourhood-level material deprivation was included as a covariate by matching the address of the child at the time of the BMI measurement, available through routine GP data, to the 2010 Index of Multiple Deprivation.[42] Child ethnicity was taken from linked educational data.

Statistical analysis

Statistical analysis was carried out using Stata 13 (StataCorp. 2013).[43] The modelling used Poisson regression (with robust standard errors to account for overdispersion) for count data, GP appointments, GP prescriptions, number of infections, accidents and antibiotic prescriptions. Logistic regression was used for modelling specific conditions where the probability of having the condition diagnosed was a binary outcome, asthma and sleep apnoea. Results from the models are displayed graphically, with estimated effect sizes as predicted rates (for GP appointments and GP prescriptions) and comparative ratios (incident rate ratios and odds ratios) for the differences in the specific health conditions investigated. Full model results are given in the Supplementary Tables 1a–1g (reported as incident rate or odds ratios).

Results

Descriptive statistics

Children were on average 58 months of age at BMI measurement; 90% were aged between 53 and 63 months. Table 1 indicates that 9.9% of the cohort were obese, a further 10.9% were overweight and 2.0% were underweight. (For a comparison of the rates for the BiB cohort against regional and national rates see Supplementary Table 2). In our study population, the prevalence of obesity was highest for those in the most materially derived neighbourhoods (11.4%) and children of Pakistani heritage (10.1%). Obesity was higher amongst males (10.1%) than females (9.6%), but there was no difference by parental means-tested benefit status. Children of Pakistani heritage were much more likely than White British children to be underweight (3.2% compared with 0.5%), as were children who were born low birthweight (5.9%) or preterm (4.7%). Maternal age at delivery was not associated with child BMI.

Rates of GP appointments and prescriptions

Fig. 1 shows the results of multivariate regression models, displaying predicted rates of GP appointments and GP prescriptions by child BMI category, adjusted for child gender, child ethnicity, birthweight, means-tested benefit status and neighbourhood material deprivation. (Full univariate and multivariate model results are given in Supplementary Tables 1a and 1b, reported as incident rate ratios). Obese children had significantly higher rates of GP appointments, 4.20 per person-year (95% confidence interval [CI]: 3.92–4.49) and GP prescriptions, 4.50 per person-year (95% CI: 4.09–4.92), compared with healthy weight children, 3.69 (95% CI: 3.59–3.78) and 3.93 (95% CI: 3.78–4.07) per person-year, respectively. Underweight children had higher rates of GP appointments, 4.62 (95% CI: 3.74–5.50) but did not have significantly higher rates of GP prescriptions than healthy weight children. There was no significant difference in the rates of GP appointments and prescriptions between healthy weight and overweight children.

Cost analysis

A crude cost of GP appointments and prescriptions was estimated by applying standard GP appointment and prescription charges to recorded events. Obese children had additional estimated costs of £28 (95% CI: 18–37) a year compared with children of healthy weight. Costs associated with underweight children were higher, an additional £49 (95% CI: 12–87) a year more compared with children of healthy weight (Supplementary Table 3).

Specific health conditions

Fig. 2 illustrates results from multivariate models examining the association between child BMI and specific health conditions, controlling for child gender, child ethnicity, birthweight, means-tested benefit status and neighbourhood material deprivation where appropriate. Differences between obese and healthy weight children and between underweight and healthy children are expressed as incident rate ratios or odds ratios. For all the specific health conditions we examined, obese children had a higher risk of poorer health outcomes by the age of 8 years. Compared with healthy weight children, obese children had a greater chance of being diagnosed with asthma (odds ratio 1.46, 95% CI: 1.21–1.77) and sleep apnoea (odds ratio 2.50, 95% CI: 1.36–4.58). Compared with healthy weight children, children who were obese also had higher rates of infections (incident rate ratio 1.19, 95% CI: 1.08–1.30), antibiotic prescriptions (incident rate ratio 1.25, 95% CI: 1.10–1.42) and accidents (incident rate ratio 1.20, 95% CI: 1.01–1.42). There were some differences between underweight and healthy weight children, but these were not statistically significant. There were no substantive differences between overweight and healthy weight children, so for clarity of presentation, Fig. 2 omits this comparison group, and full model results are given in Supplementary Tables 1c–1g.

Discussion

We found that, when compared with those who were healthy weight, children who were obese at the age of 5 years had significantly higher rates of GP appointments and GP prescriptions in the subsequent 3 years of early childhood; they were more likely to be diagnosed with asthma and sleep apnoea to have higher rates of infections, antibiotic prescriptions and

Table 1 – Sample characteristics and BMI categories.

Characteristic	*n*	BMI categories (UK90 NCMP cutoff values)				
		Underweight (%)	Healthy weight (%)	Overweight (%)	Obese (%)	*P*-value[a]
All children	9443	2.0	77.2	10.9	9.9	
Child gender						
Female	4584	1.6	77.7	11.1	9.6	0.012
Male	4859	2.5	76.7	10.7	10.1	
Missing	0					
Child ethnicity						
White British	3382	0.5	76.3	13.2	10.0	<0.001
Pakistani heritage	4401	3.2	77.4	9.3	10.1	
Other ethnicity	1640	2.3	78.2	10.7	8.8	
Missing	20					
Child low birthweight (under 2500 g)						
Low birthweight	798	5.9	80.6	6.8	6.8	<0.001
Not low birthweight	8467	1.7	76.7	11.3	10.3	
Missing	178					
Child gestational age						
Preterm (born < 37 wk)	576	4.7	76.4	9.4	9.6	0.001
Not preterm	8689	1.9	77.1	11.1	10.0	
Missing	178					
Maternal age at delivery (y)						
<25	3065	1.7	76.5	11.8	10.1	0.142
25–29	3093	1.9	77.7	10.4	10.0	
>30	3285	2.5	77.2	10.6	9.6	
Missing	0					
Means-tested benefit status						
In receipt	3219	2.1	77.0	11.0	9.9	0.999
Not in receipt	4507	2.1	77.1	10.9	9.9	
Missing	1717					
Neighbourhood material deprivation (IMD 2010)						
In 10% most deprived	4161	2.1	75.2	11.2	11.4	<0.001
Not in 10% most deprived	4949	1.9	78.7	10.7	8.7	
Missing	333					

BMI = body mass index; NCMP = National Child Measurement Programme.
[a] The *P*-values reported are based on Chi-squared tests.

accidents. This is broadly consistent with the limited number of other European and Australian studies that have taken place to date,[24,26–29] but unlike results reported in the United States and Canada,[30,31] suggesting that differences in healthcare systems at the national level may be important.

Making direct comparisons of effect sizes is difficult due to variation in methodology. All previous studies have used parental self-report to capture healthcare use and outcomes; also, there are differences in the nature of the questions asked. Of the two previous studies examining GP appointment rates, one measured GP use specifically related to weight issues only,[24] and the other asked parents whether their child had been to see the GP in the last 2 months (when aged 8 years) and reported obese children were 98% more likely to have done so compared with healthy weight children.[27] Our study found smaller differences; rates of GP attendance were 14% higher in obese children compared with healthy weight children over the 3-year study period. While our estimate is lower, it may be more accurate, being less prone to error than self-reported measures from surveys. Our results are broadly consistent with a previous UK study of child BMI and GP prescriptions, which used self-reported outcomes and found obese children had 8% more prescriptions compared with healthy weight children.[26] We found a higher rate of 15% more prescriptions compared with healthy weight children although the differences are within the margins of error for each study it could, again, be argued that our results, from objective routine data, are more accurate than parental self-report. In addition, our linked routine data allowed for the objective investigation of differences for a range of conditions that have been linked to childhood obesity. Previous studies have shown higher rates of asthma, sleep apnoea, infections, antibiotic use and accidents.[27–29] We also found a higher prevalence or incidence of all these conditions in obese children compared with healthy weight children. These differences are substantive, for example, obese children were around 50% more likely to have been diagnosed with asthma by age 8 years and had around 20% more infections and antibiotic prescriptions between the ages of 5 and 8 years.

We also found GP appointment rates were 25% higher for underweight children when compared with those who were healthy weight. This is a finding which, to our knowledge, has not previously been reported (as previous studies have tended to focus on obesity alone and not considered children who are underweight). However, underweight children did not have higher rates of GP prescriptions or significantly poorer health outcomes when compared with healthy weight children. Due to the smaller number of underweight children in our study, estimates are less precise for this group, with relatively large confidence intervals; so, in our study, there is less statistical

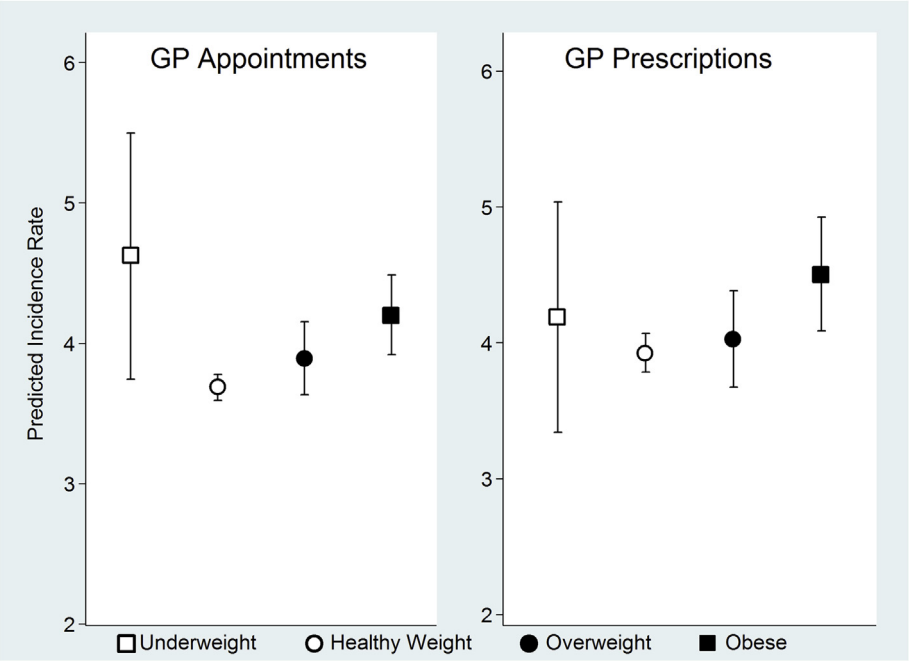

Fig. 1 – Estimates rates of GP appointments and prescriptions for 3-year period after BMI measure (with 95% confidence intervals). Controlling for child gender, ethnicity, birth weight, household means-tested benefit status and neighbourhood material deprivation (IMD); see Supplementary Material 3 for univariate and multivariate models with results expressed as incidence rate ratios. GP, general practice; BMI, body mass index.

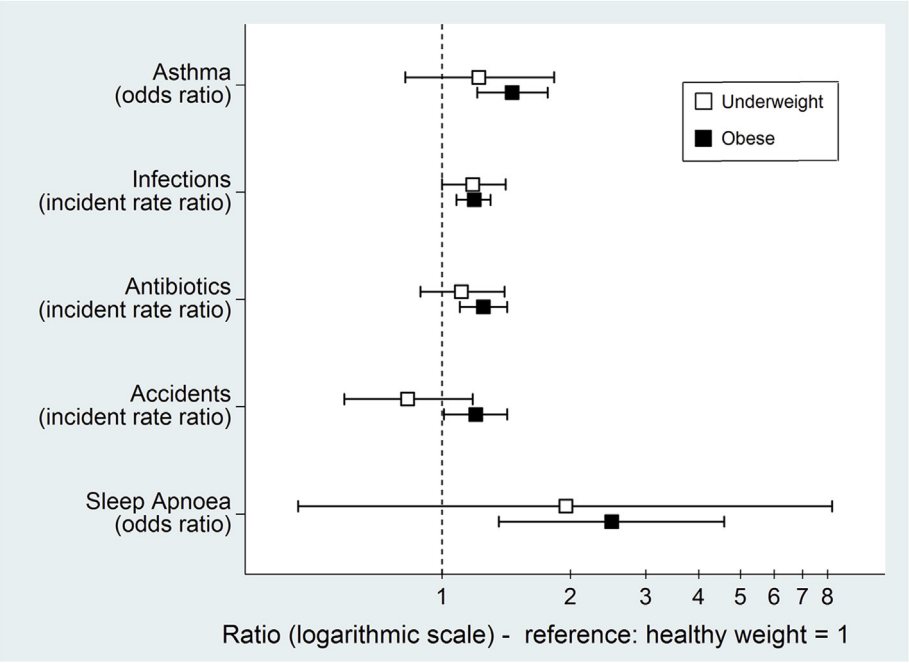

Fig. 2 – Odds ratios and incident rate ratios for morbidity conditions—obese and underweight compared with healthy weight (with 95% confidence intervals). Controlling for child gender, ethnicity, birth weight, household means-tested benefit status and neighbourhood material deprivation (IMD) where appropriate; see Supplementary Material 1c–1g for univariate, full multivariate and parsimonious multivariate models with results expressed as incidence rate ratios and odds ratios.

power to detect effects for the underweight children when compared with obese children.

In our study, we found no differences were found between overweight and healthy weight children. Most previous studies report no, or very small, differences between overweight and healthy weight children at this young age.[26–31] One study did find that overweight children had higher rates of prescriptions when compared with healthy weight children,

but only for older children, aged 12 years of age onwards.[30] So, it may be that the health impact of being overweight is less than that of being obese and is apparent only in older children.

We estimated that, compared with children of healthy weight, primary care costs were 14% higher for obese children (£28 a year more), and 24% higher for underweight children (£49 a year more). There are no similar childhood studies to compare this to, but previous US studies in adults have suggested that healthcare costs of obesity are between 25% and 40% greater than those of healthy weight individuals.[16–19] In the United Kingdom, combined primary and secondary care costs have been estimated to be £146 greater for obese adults when compared with adults of healthy weight.[23] Our findings are considerably lower than these adult estimates, but this might be expected as we only considered primary care costs (not secondary care), and the impact of obesity on childhood morbidity is likely to be less than the cumulative impact of obesity on morbidity through the life course. Supplementary Table 3 estimates the scaled-up primary care costs for the broader Bradford and England population of children in the 5–8 years age group. These suggest that, although costs associated with underweight children are higher than those associated with obese children at the individual level, the direct primary care costs associated with childhood obesity in England, for children aged 5–8 years of age, are around £5.5 million a year, with additional costs of around £1 million a year for underweight children (as the prevalence of obesity in the population is around 10 times greater than the prevalence of being underweight at age 5 years).

A major strength of this study is the use of routine health data to obtain objective measurements of BMI, primary care use and health outcomes and the ability to link this to rich contextual data from the BiB cohort. The use of routine data offers potential for greater accuracy than self-reported survey data, which are prone to measurement error; routine data also offer the potential to create outcomes that are more comparable across studies. There are a number of limitations to our study. We have only looked at primary care use and have only given a very rough estimate of healthcare costs; also, we did not address other outcomes that have been suggested to be associated with childhood obesity, such as bullying or self-esteem. Our study uses observational data, so we can make no inference about the nature or direction of any causal relationships.

In summary, while there is the need for further research, particularly into causal mechanisms, we found childhood obesity to be associated with increased primary healthcare use and a range of poorer health outcomes, in early childhood, apparent by the age of 8 years. This suggests childhood obesity does not just impact on future life course and adult outcomes, as differences are apparent even before the second BMI measurement of the NCMP, which occurs at around age 10–11 years. These findings lend weight to the importance of early intervention to tackle childhood obesity.

Author statements

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Ethical approval

Ethical approval for all aspects of the research was granted by Bradford Research Ethics Committee (Ref 07/H1302/112).

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Competing interests

None declared.

Authors' contributions

BK, JW and JWr conceived the study idea, designed the study and developed the methods. BK and JW developed the analysis plan, BK and DM were involved in data linkage and management, and BK undertook the main analysis. BK wrote the initial drafts of the article. All authors were involved in formulating the final text, and all authors read and approved the final article.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.puhe.2018.10.019.