

Title: The effect of childhood deprivation on weight status and mental health in childhood and adolescence: Longitudinal findings from the Millennium Cohort Study.

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Running title: Deprivation and health between age 7 and 14.

Abstract

Background: The study aims were to: 1) examine associations between deprivation at age 7 and health outcomes at age 7 and 14, (2) determine whether a deprivation gradient to health outcomes exists at age 7 and 14, and (3) assess the extent to which health outcomes at age 7 are associated with health outcomes at age 14.

Methods: Data were from wave four and six of the Millennium Cohort Study. Health outcome measures were weight status, and Strengths and Difficulties Questionnaire measured mental health problems. Deprivation was determined using the 2004 English Indices of Multiple Deprivation. Adjusted logistic and multinomial logistic regressions were conducted.

Results: 6109 children (1890 girls) had complete data. Overweight, obesity, and mental health problems were greatest among children in the highest deprivation decile at age 7 and 14 ($p < 0.001$). Health outcomes at age 7 were significantly associated with health outcomes at age 14 ($p < 0.001$).

Conclusions: A marked social gradient to weight status and mental health was evident at age 7 and 14, and no evidence of equalisation was found. Weight status and mental health in childhood is strongly associated with weight status and mental health in adolescence.

Introduction

Poor health including obesity and mental health have their origins in childhood [1]. In the UK, the prevalence of child obesity and mental health has increased markedly in recent decades [2,3]. While several factors contribute to child obesity and mental health, deprivation is among the strongest of influences [4]. Various UK studies have reported inequalities in child obesity but many of these have been conducted at the local-level involving homogenous samples [5,6], which precludes generalisation of findings to other areas of the UK. Moreover, the limited sample heterogeneity in previous studies prohibited investigation of child obesity and mental health across the social gradient. As such, the studies may have underestimated the magnitude of inequalities in child obesity and mental health in the UK.

Despite evidence of pervasive health inequalities in childhood, adolescence is considered a period of relative health equality [7]. The equalisation hypothesis postulates that during adolescence, health is influenced more strongly by peer social relations rather than the social status of the family [which drive child and adult health inequalities] and this leads to an attenuation of health inequalities [8]. In England, a period of equalisation in late adolescence and early adulthood has been reported for obesity and mental health but these findings were based on cross-sectional data [9]. Little is known about changes in health inequalities among cohort children between childhood and adolescence. Rougeaux et al. [10] found that weight status and mental health inequalities [as measured by maternal education] persisted, and in some cases widened between age 3 and 11 for a cohort of UK children. However, the study provided limited understanding of equalisation during adolescence or the effect of childhood deprivation on health in adolescence.

Rarely have studies in this area assessed whether poor health in childhood is positively associated with poor health in adolescence. Some studies have revealed that weight status [11,12] and mental health [13] during early childhood is positively associated with weight status and mental health during mid-late childhood. However, little is known about the strength of association between childhood health and adolescent health in the UK. It is important to examine different indicators of child health during different phases of development as it may reveal aspects of child health or periods in childhood, that would benefit from greater public health focus. Current UK evidence on child health and inequalities relates heavily on weight status and less so on mental health which also conveys negative health and economic

consequences throughout the life course [1]. Therefore, to address these research gaps, the aims of this study were threefold: to (1) examine associations between deprivation at age 7 and health outcomes (i.e., weight status and mental health) at age 7 and 14, (2) determine whether a deprivation gradient to health outcomes exists at age 7 and 14, and (3) assess the extent to which health outcomes at age 7 are associated with health outcomes at age 14.

Methods

Data and sample

Data for this study was derived from wave four and six of the UK Millennium Cohort Study (MCS). The MCS is a nationally representative UK sample of children born between September 2000 and January 2002. The first survey was conducted throughout 2001-2002 and involved 18 819 children from 18 533 families. Subsequent surveys were administered at age 3, 5, 7, 11 and 14. To enable consistent and accurate comparisons across time points, the present study only included English children who had complete deprivation data at age 7 and weight status and mental health data at age 7 and 14. Applying these criteria resulted in a final sample of 6109 children (3098 boys). Ethical approval for the original study was granted by the Northern and Yorkshire Research Ethics Committee (07/MRE03/32).

All measures were collected in the child's home at age 7 and 14. Stature was measured to the nearest millimetre using a portable stadiometer (Leicester Height Measure, Seca, Birmingham, UK), and body mass measured to the nearest 0.1 kg using Tanita HD-305 scales (Tanita UK Ltd., Middlesex, UK). Body mass index (BMI) was calculated from stature and body mass (kg/m^2). Weight status classifications were determined using the International Obesity Taskforce age- and gender-specific BMI cut-points [14]. Mental health was assessed using the Strengths and Difficulties Questionnaire (SDQ; (<http://www.sdqinfo.com/>)). The SDQ comprises 25 items covering five domains of behaviour including hyperactivity, emotional symptoms, conduct problems, peer problems and prosocial behaviour. An overall difficulties score was derived from the sum of all scales, excluding the prosocial behaviour domain. Overall scores ranged from 0-40. Mental health problems were defined as a score of ≥ 14 . Deprivation decile scores at age 7 were calculated from home postcodes using the 2004 English Indices of Multiple Deprivation (IMD; [15]). Firstly, a median-split categorical variable was created to represent children living in areas of low deprivation (LD; deciles 6-10) and high

deprivation (HD; deciles 1-5). Secondly, decile scores were collapsed into 5 categories ranging from the most to least deprived.

Potential confounding factors were selected a priori based on previous evidence [16,17,18]. Participant gender and ethnicity were parent-reported. Ethnic group categories were based on census categories [19] and included White, Mixed, Indian, Pakistani and Bangladeshi, Black or Black British, and Other Ethnic group. A dichotomous variable was created to represent White and non-White participants.

Statistical analysis

Analyses were conducted using SPSS v. 24 (SPSS Inc; Chicago, IL) and statistical significance was set at $p < 0.05$. Descriptive statistics were calculated for all measured variables. To analyse study aim 1, logistic regression analyses assessed associations between deprivation at age 7 and health outcomes at age 7 and 14. Analyses were adjusted for gender, ethnicity and age 7 health outcomes (age 14 analyses only). To assess study aim 2, multinomial logistic regression analyses examined whether a social gradient to weight status and mental health existed at age 7 and 14. The highest level of deprivation was the reference category. Analyses were adjusted for gender, ethnicity and age 7 health outcomes (age 14 analyses only). To address study aim 3, logistic regression analyses examined associations between weight status and mental health at age 7 and 14. Analyses were adjusted for gender, ethnicity and deprivation decile.

Results

Sample characteristics

Of the 6109 participants (3098 boys), 53.4% were HD, 24.1% and 19.5% were in the most and least deprived categories. The ethnic origin of the participants was 78.1% White. At age 7, 17.9% of participants were overweight, 4.9% were obese and 13.2% had mental health problems. Health outcomes were worse at age 14. Between the age of 7 and 14, the prevalence of overweight, obesity and mental health problems increased by 8.0%, 2.2% and 3.1% respectively. Of the participants classified as overweight ($n=1096$), obese ($n=302$) and having mental health problems ($n=807$) at age 7, adverse health outcomes persisted in 77.0%, 58.0% and 51.0% of the children, respectively.

Study aim 1

Table 1 displays unadjusted and adjusted associations between deprivation at age 7 and health outcomes at age 7 and 14. At age 7, HD children were significantly more likely to be overweight (OR 1.24; 95% CI 1.08 - 1.43; $p < 0.01$), obese (OR 1.58; 95% CI 1.22 - 2.05; $p < 0.001$) and have mental health problems compared to LD children (OR = 2.18; 95% CI 1.85 - 2.58; $p < 0.001$). At age 14, overweight (OR 1.45; 95% CI 1.26 - 1.68; $p < 0.001$), obesity (OR 1.73; 95% CI 1.36 - 2.19; $p < 0.001$) and mental health problems (OR 1.75; 95% CI 1.50 - 2.05; $p < 0.001$) were significantly higher among HD children compared with LD children.

Study aim 2

Multinomial regression analyses revealed a strong deprivation gradient to weight status and mental health at age 7 and 14 (Table 2). Marked inequalities for all health outcomes were evident at age 7 and 14, but the inequality gradient between the least and most deprived children differed by age and health outcome. At age 7, the most deprived children were more likely to be overweight compared with the second to least (OR 1.34; 95% CI 1.08 - 1.67; $p < 0.001$), and least deprived children (OR 1.53; 95% CI 1.23 - 1.90; $p < 0.001$), more likely to be obese compared with the second to least (OR 1.64; 95% CI 1.13 - 2.39; $p < 0.01$), and least deprived children (OR 2.65; 95% CI 1.72 - 4.08; $p < 0.001$), and more likely to have mental health problems compared with the fourth to least (OR 1.51; 95% CI 1.23 - 1.85; $p < 0.001$), third to least (OR 2.39; 95% CI 1.89 - 3.02; $p < 0.001$), second to least (OR 2.41; 95% CI 1.89 - 3.07; $p < 0.001$), and least deprived children (OR 3.95; 95% CI 3.01 - 5.17; $p < 0.001$). At age 14, the most deprived children were more likely to be overweight compared with the fourth to least (OR 1.23; 95% CI 1.01 - 1.51; $p < 0.05$), third to least (OR 1.40; 95% CI 1.13 - 1.73; $p < 0.01$), second to least (OR 1.53; 95% CI 1.23 - 1.92; $p < 0.001$), and least deprived children (OR 1.85; 95% CI 1.48 - 2.32; $p < 0.001$), more likely to be obese compared with the fourth to least (OR 1.44; 95% CI 1.06 - 1.96; $p < 0.05$), third to least (OR 1.55; 95% CI 1.12 - 2.13; $p < 0.01$), second to least (OR 1.81; 95% CI 1.27 - 2.59; $p < 0.01$), and least deprived children (OR 2.73; 95% CI 1.85 - 4.05; $p < 0.001$), and more likely to have mental health problems compared with the third to least (OR 1.62; 95% CI 1.29 - 2.04; $p < 0.001$), second to least (OR 1.71; 95% CI 1.35 - 2.17; $p < 0.001$), and least deprived children (OR 2.68; 95% CI 2.06 - 3.47; $p < 0.001$).

[TABLE 1 NEAR HERE]

[TABLE 2 NEAR HERE]

Study aim 3

Logistic regression analyses revealed that health outcomes at age 7 strongly predicted health outcomes at age 14 (Table 3). Participants classified as overweight, obese and having mental health problems at age 7, were more likely to be classified as overweight (OR 19.44; 95% CI 16.52 - 22.87; $p < 0.001$), obese (OR 28.20; 95% CI 21.65 - 36.75; $p < 0.001$) and have mental health problems at age 14 (OR 7.86; 95% CI 6.65 - 9.28; $p < 0.001$), respectively.

[TABLE 3 NEAR HERE]

Discussion*Main findings of this study*

This study revealed that deprivation at age 7 is positively associated with overweight, obesity and mental health problems at age 7 and 14. Supplementary analyses revealed marked health inequalities between the least and most deprived children at age 7 and 14 which underscores the importance of studying child health across the deprivation gradient. While marked inequalities for all health outcomes were evident at age 7 and 14, the health inequality gradient between the least and most deprived children differed by age and health outcome. This finding evidences the importance of investigating child health inequalities at different ages and assessing different markers of health.

The study showed that weight status and mental health during childhood is strongly associated with weight status and mental health during adolescence. Children classified as being overweight, obese and having mental health problems at age 7 were more likely to remain so at age 14, compared to their healthier peers. The study revealed that of the children classified as overweight at age 7, 77% remained overweight at age 14, compared to only 51% of children classified as having mental health problems at age 7.

What is already known on this topic?

Some cross-sectional research conducted at the local-level in England has reported higher obesity rates among deprived children compared to affluent children [5,6]. A social gradient to child obesity has been evidenced among 7-year-old English children [20]. Recently, Bann and colleagues evidenced widening socioeconomic inequalities in child and adolescent BMI in the UK [21]. Some UK studies have reported that obesity persists during childhood [10,11] but few studies have examined the persistence of child obesity and mental health into adolescence using UK longitudinal data.

What this study adds

This is the first study to examine associations between deprivation and different health outcomes among English children at age 7 and 14. At age 7 and 14, HD children were significantly more likely to be overweight, obese and have mental health problems compared to LD children. Further analyses revealed marked inequalities in weight status and mental health at age 7 and 14 which extends beyond earlier cross-sectional research [20]. This particular finding demonstrates the importance of investigating child and adolescent health across the deprivation gradient. Failure to do so could potentially mask the effect of deprivation on child and adolescent health.

Although health inequalities persisted between age 7 and 14, the pattern and magnitude of inequality over time varied by health outcome. Limited UK studies have examined whether health inequalities widen between childhood and adolescence. Rougeaux and colleagues [10] conducted a similar study to the present study but focussed on maternal education rather than deprivation and studied children aged 3-11 years, which precluded investigation of the equalisation hypothesis during adolescence. Based on age 7 deprivation, we found no evidence of a health inequality attenuation in mid-adolescence. Recent evidence though suggests that equalisation is more likely to occur during late-adolescence rather than mid-adolescence [9]. Forthcoming waves of the MCS would allow for further investigation of the equalisation hypothesis as cohort members enter late-adolescence and early adulthood. Moreover, the new data will provide a contemporary picture of adolescent health inequalities in England. The results of this study may underestimate the current magnitude of child and adolescent health

inequalities in England as the data was collected in 2008 (child; age 7) and 2015 (adolescent; age 14) which precedes many of the recently implement Government led austerity measures. Such measures have likely widened child and adolescent health inequalities in England.

Another novel aspect of the study was the examination of associations between different health outcomes at age 7 and 14. This study showed that overweight/obesity and mental health persist from childhood to adolescence which underscores the importance of childhood as a focus for public health. There are likely complex reasons why some health outcomes are affected by deprivation more than others, and track more strongly between childhood and adolescence. Further research is needed to understand these mechanisms linking deprivation and child health at different ages of development. The study findings suggest that a new approach to improving child health and tackling health inequalities is needed in the UK to prevent health disparities continuing into adolescence. For too long has the focus been on individual responsibility and the use of behavioural interventions alone to improve child health. A more effective and progressive approach is to target the social determinants of health, the underlying living conditions that impact child health [22,23].

Limitations of this study

The study has several strengths. It represents the first study to examine the persistence of health outcomes between childhood and adolescence in a cohort of English children. The design was longitudinal, the sample was large, and the study covered the whole of England providing extensive heterogeneity in the socio-demographic characteristics of the participants. In addition, the study assessed different indicators of child and adolescent health (i.e., weight status and mental health). There are also some study limitations to acknowledge. Firstly, the measure of weight status, BMI, reflects both fat and fat-free components of body mass [24] and is known to underestimate excess body fat mass [25]. However, at a population level, BMI is considered a relatively robust method and continues to be used by epidemiologists globally [3]. Secondly, the parent-reported SDQ scores may have been subject to measurement error and social desirability bias and may reflect gendered stereotypes of child behaviour. Although the analyses were adjusted for several known confounding factors there are other factors that may have influenced the health outcomes studied but were outside the scope of the present study.

Conclusion

This study provides evidence of a strong deprivation gradient to child and adolescent overweight/obesity and mental health in England. Children living in the most-deprived areas of England at age 7 were at greatest risk of overweight/obesity and mental health problems at age 7 and 14. These findings underscore the importance of assessing child and adolescent health across a range of deprivation indices. Failing to do so may underestimate the pervasive effect of deprivation on child and adolescent health. Overweight/obesity and mental health at age 7 was strongly associated with overweight/obesity and mental health at age 14, respectively. This study demonstrates the need for Government policy level interventions to reduce deprivation inequalities in child and adolescent health to prevent health inequalities continuing into adulthood.

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Conflict of interest statement: The author declares no conflict of interest.

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Table 1. Logistic regression associations between deprivation and health outcomes at age 7 and 14 ($n=6109$).

Table 2. Multinomial logistic regression associations between deprivation deciles and health outcomes at age 7 and 14 ($n=6109$).

Table 3. Logistic regression associations between health outcomes at age 7 and health outcomes at age 14 ($n=6109$).

Table 1. Logistic regression associations between deprivation and health outcomes at age 7 and 14 ($n=6109$).

	Unadjusted odds ratio (95% CI)	Adjusted odds ratio (95% CI)
Age 7 †		
Overweight ($n=1096$)	1.33 (1.16 - 1.52) ***	1.24 (1.08 - 1.43) **
Obese ($n=302$)	1.87 (1.46 - 2.39) ***	1.58 (1.22 - 2.05) ***
Mental health problems ($n=807$)	2.24 (1.91 - 2.62) ***	2.18 (1.85 - 2.58) ***
Age 14 ††		
Overweight ($n=1580$)	1.49 (1.32 - 1.67) ***	1.45 (1.26 - 1.68) ***
Obese ($n=434$)	1.93 (1.57 - 2.38) ***	1.73 (1.36 - 2.19) ***
Mental health problems ($n=995$)	2.03 (1.76 - 2.34) ***	1.75 (1.50 - 2.05) ***

† Adjusted for gender and ethnicity; †† Adjusted for gender, ethnicity and health outcome at age 7; HD group were reference category; Overweight and obese according to IOTF classification for ages 7 and 14 years; Mental health problems if SDQ ≥ 14 for ages 7 and 14 years; CI=confidence interval; ** $p<0.01$; *** $p<0.001$.

Table 2. Multinomial logistic regression associations between deprivation deciles and health outcomes at age 7 and 14 ($n=6109$).

	Most deprived ($n=1471$)	Q4 ($n=1213$)	Q3 ($n=1142$)	Q2 ($n=1093$)	Least deprived ($n=1190$)
	Odds ratio (95% CI)	Odds ratio (95% CI)	Odds ratio (95% CI)	Odds ratio (95% CI)	Odds ratio (95% CI)
Age 7					
Overweight ($n=1096$)	(ref)	1.16 (0.96-1.40)	1.09 (0.90-1.32)	1.47 (1.19-1.81) ***	1.69 (1.37-2.08) ***
Overweight †		1.09 (0.90-1.33)	1.01 (0.82-1.23)	1.34 (1.08-1.67) ***	1.53 (1.23-1.90) ***
Obese ($n=302$)	(ref)	1.56 (1.13-2.14) **	1.69 (1.21-2.36) **	2.05 (1.43-2.94) ***	3.36 (2.22-5.09) ***
Obese †		1.36 (0.98-1.88)	1.40 (0.99-1.97)	1.64 (1.13-2.39) **	2.65 (1.72-4.08) ***
Mental health problems ($n=807$)	(ref)	1.50 (1.23-1.83) ***	2.38 (1.90-2.99) ***	2.41 (1.91-3.04) ***	3.88 (2.99-5.04) ***
Mental health problems †		1.51 (1.23-1.85) ***	2.39 (1.89-3.02) ***	2.41 (1.89-3.07) ***	3.95 (3.01-5.17) ***
Age 14					
Overweight ($n=1580$)	(ref)	1.23 (1.04-1.45) *	1.30 (1.09-1.54) **	1.60 (1.33-1.91) ***	1.95 (1.63-2.34) ***
Overweight ††		1.23 (1.01-1.51) *	1.40 (1.13-1.73) **	1.53 (1.23-1.92) ***	1.85 (1.48-2.32) ***
Obese ($n=434$)	(ref)	1.48 (1.13-1.94) **	1.51 (1.15-2.00) **	2.11 (1.55-2.87) ***	3.28 (2.32-4.66) ***
Obese ††		1.44 (1.06-1.96) *	1.55 (1.12-2.13) **	1.81 (1.27-2.59) **	2.73 (1.85-4.05) ***
Mental health problems ($n=995$)	(ref)	1.24 (1.03-1.50) *	1.91 (1.55-2.34) ***	1.98 (1.61-2.45) ***	3.36 (2.65-4.26) ***
Mental health problems ††		1.15 (0.93-1.41)	1.62 (1.29-2.04) ***	1.71 (1.35-2.17) ***	2.68 (2.06-3.47) ***

† Adjusted for gender and ethnicity; †† Adjusted for gender, ethnicity and health outcome at age 7; Most deprived group were reference category; Overweight and obese according to IOTF classification for ages 7 and 14 years; Mental health problems if SDQ ≥ 14 for ages 7 and 14 years; CI=confidence interval; * $p<0.05$; ** $p<0.01$; *** $p<0.001$.

Table 3. Logistic regression associations between health outcomes at age 7 and health outcomes at age 14 ($n=6109$).

	Unadjusted odds ratio (95% CI)	Adjusted † odds ratio (95% CI)
Health outcome age 14		
Overweight ($n=1580$)	19.70 (16.76-23.15) ***	19.44 (16.52-22.87) ***
Obese ($n=434$)	30.05 (23.16-38.99) ***	28.20 (21.65-36.75) ***
Mental health problems ($n=995$)	8.64 (7.34-10.17) ***	7.86 (6.65-9.28) ***

†Adjusted for gender, ethnicity and deprivation decile; Reference group was overweight, obese and mental health problems at age 7. Overweight and obese according to IOTF classification for ages 7 and 14 years; Mental health problems if SDQ ≥ 14 for ages 7 and 14 years; CI=confidence interval; *** $p<0.001$.