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Complete List of Authors:	Rougeaux, Emeline; University College London Institute of Child Health, Population, Policy & Practice Hope, Steven; University College London Institute of Child Health, Population, Policy & Practice Law, Catherine; University College London Institute of Child Health, Population, Policy & Practice Pearce, Anna; University College London Institute of Child Health, Population, Policy & Practice
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The development of population-level health inequalities in the New Labour generation: longitudinal findings from the UK Millennium Cohort Study

Emeline Rougeaux* e.rougeaux@ucl.ac.uk, Steven Hope s.hope@ucl.ac.uk, Catherine Law catherine.law@ucl.ac.uk, Anna Pearce anna.pearce@ucl.ac.uk

Population Policy and Practice, UCL Institute of Child Health, 30 Guilford Street, London, WC1N 1EH UK.

*Corresponding author

KEYWORDS

Inequalities, child health, policy, cohort, lifecourse epidemiology

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ABSTRACT

Objectives To examine how population-level socio-economic health inequalities developed longitudinally throughout childhood, for children born at the turn of the 21st century and who grew up with major initiatives to tackle health inequalities (under the New Labour Government).

Setting The United Kingdom.

Participants Singleton children in the Millennium Cohort Study at ages 3 (n=15381), 5 (n=15041), 7 (n=13681) and 11 (n=13112) years.

Primary outcomes Relative inequalities (prevalence ratios [PR]) and absolute inequalities (prevalence differences [PD]) were estimated by socio-economic circumstances (SEC; using highest maternal academic qualification achieved, ranging from *None* to *Degree* [baseline]). Three health outcomes were examined: overweight (including obesity), limiting-long-standing illness (LLSI), and socio-emotional difficulties (SED).

Results Relative and absolute inequalities in overweight emerged by age 5 and increased until 11; these were socially graded with higher levels of overweight in children with mothers who had no academic qualifications compared to Degree-educated mothers (at 11: PR=1.6 [95%CI: 1.4-1.8], PD=12.9%[9.1-16.8]). For LLSI, inequalities emerged by age 7 for children whose mothers had no academic qualifications and remained at 11 (PR=1.7[1.3-2.3], PD=4.8% [2-7.5]). Inequalities in SED (observed across the social gradient) declined between 3 and 11, but remained large at 11 (e.g. PR=2.4[1.9-2.9], PD=13.4%[10.2-16.7] in children with non-academically educated mothers compared to Degree-educated mothers).

Conclusions Children from less advantaged backgrounds tend to have poorer health than their more advantaged peers. Although this has been well documented in cross-sectional and trend data in the UK, it is less clear how such inequalities develop during childhood. We found that relative and absolute health inequalities persisted, and in some cases widened during childhood, for a cohort of children who grew up in a context of unprecedented policy efforts to reduce inequalities. Further research examining and comparing the pathways through which SECs influence health may further our understanding of how inequalities could be prevented.

STRENGTHS & LIMITATIONS

- This is the most recent study to examine how population-level inequalities in health developed throughout childhood in a cohort who were born in 2000-2002 and grew up in the context of unprecedented initiatives to reduce health inequalities (under the New Labour Government)
- We used data from a large nationally representative sample of UK children, which includes a broad range of health, demographic and socioeconomic data throughout childhood
- We carried out a longitudinal analysis of both relative and absolute inequalities for three important physical and mental health outcomes (overweight, limiting long standing illness, and socio-emotional difficulties), assessed across the socioeconomic gradient, measured using both education attainment and income
- Evaluation of New Labour's policies was, however, not possible as we cannot assess what would have happened in their absence
- Response weights were used to account for attrition and sensitivity analyses indicated that item missingness was unlikely to have biased the results

INTRODUCTION

Children from less advantaged backgrounds have, on average, worse health than their more advantaged peers. These socio-economic inequalities in health are unfair and avoidable, yet research indicates that inequalities for children and young people may have widened since the 1980s for many aspects of health and health behaviours, including overweight [1], physical activity, psychological and physical symptoms [2-5]. However, these studies mainly document inequalities in cohorts of children at single points in time. Much less is known about how population-level health inequalities change in the same group of children as they age. This is important as the context in which children grow up varies over time and may influence the development of health inequalities.

In this study we examine the longitudinal development of health inequalities in the most recent UK cohort of children, the Millennium Cohort Study. These children were born at the turn of the millennium and shortly after the start of the New Labour government. Following a pledge to eradicate child poverty in a generation [6] and the introduction of a strategy to sustainably tackle inequalities in health [7], New Labour put in place a number of policies to tackle the social determinants of health with a particular focus on the early years [6-8].

The aim of this study was to examine how population-level socio-economic inequalities in health developed throughout childhood for children growing up in the 21st century. Three health measures were assessed: overweight, limiting long-standing illness (LLSI) and socio-emotional difficulty (SED), prevalent physical and mental health outcomes which have the potential to significantly impact on current and future health and wellbeing [9-11].

METHODS

Sample

We used data from the UK Millennium Cohort Study (MCS), a nationally representative survey of children born in the UK, in September 2000 - January 2002. A stratified clustered sampling design was used to over-represent children living in Wales, Scotland and Northern Ireland, disadvantaged areas and those with high proportions of ethnic minority groups (in England) [12]. The parents of cohort children were first contacted for interview at 9 months, when information was collected on 72% of those contacted, providing information for 18818 children (of which 18296 were singletons and are the focus of this paper). Children were followed-up at 3, 5, 7 and 11 years of age and 68% [*n*=13112] of singletons took part in the age 11 interview [12-16]. Interviews were carried out in the

home with the main respondent, usually the mother, and if applicable, the partner (where possible) [12].

Ethical approval was received from a Research Ethics Committee at each study survey [12]. The present secondary data analyses did not require additional ethics approval.

Health outcomes

Dichotomous measures were constructed at ages 3, 5, 7 and 11 years for the following three outcomes:

Overweight (including obesity): children's height and weights were measured by interviewers (using Tanita BF-522W scales for weight and a Leceister statiometer for height [17]). Body Mass Index (BMI; kg/m²) was categorised into being overweight (including obesity) or of healthy weight using the International Obesity Task Force (IOTF) age and sex adjusted cut-offs for children [18].

Limiting long-standing illness (LLSI): mothers were asked if their child had any long-standing illness (physical or mental health conditions or illnesses lasting or expected to last twelve months or more) that limited the child in their everyday activities. Children were classified as having LLSI or not.

Socio-emotional difficulty (SED): the Strengths and Difficulties Questionnaire (SDQ) [19] was completed by the mother. The 'total difficulties score' is the sum of four subscales of the SDQ which capture key areas of child socio-emotional wellbeing: emotional symptoms, conduct problems, hyperactivity, and peer problems. Children were classified with validated cut-offs [19], as having SED (borderline/abnormal score, 14-40) or having no SED (normal score, 0-13). Where one or two (out of a total of five) items were missing in a subscale of the total difficulties score, values were imputed based on the mean of other item responses [20].

Measure of socio-economic circumstances

Socio-economic circumstances (SECs) were represented by highest maternal academic qualification when the cohort member was aged 3, 5, 7 and 11 years and categorised as: Degree, Diploma, A levels, General Certificate of Secondary Education (GCSE) grades A*-C, GCSE grades D-G, or None. Those with 'Other' academic education are shown in Table 1 but were excluded thereafter. Maternal education was used as the main measure of SECs in the analyses because it was stable throughout the period under study, is frequently used to assess inequalities in children [21], and had limited missing data (<1%). As a sensitivity analysis, analyses were repeated using an alternative measure of SECs (quintiles of equivalised household income) and patterns of results were replicated (data not shown).

Confounding

We adjusted for cohort member's sex and factors which might influence maternal education and were found to be associated with the health outcomes elsewhere [22, 23] (cohort member's ethnicity and maternal age at first live birth, categories shown in Table 1). In the majority of cases, these variables were significantly associated with the three health outcomes; data are shown Table 1 for the earliest [age 3] and latest [age 11] sweeps.

Table I. Socio-demographic characteristics and health outcomes of singletons in the Millennium Cohort Study at ages 3 (n=15381) and 11 (n=13112); number (n), weighted percentages (%)

		Age 3					Age 11				
		Total		Overweight (n=13315) %	Limiting long-standing illness (n=15232) %	Socio-emotional difficulty (n=14217) %	Total		Overweight (n=11790) %	Limiting long-standing illness (n=13002) %	Socio-emotional difficulty (n=12584) %
		n	%				n	%			
Cohort member's sex	Male	7862	51.0	23.1	3.3	23.7	6632	51.7	26.6	9.9	20.7
	Female	7519	49.1	24.9	2.9	18.5	6480	48.3	31.3	6.5	13.6
	Chi-square test p-value	-	-	*0.04*	*0.2*	*<0.001*	-	-	*<0.001*	*<0.001*	*<0.001*
Cohort member's ethnic group	White	12768	86.5	24.1	3.0	20.3	10837	84.4	27.7	8.4	17.3
	Indian	398	1.9	12.4	3.8	25.0	338	2.1	30.1	5.2	17.1
	Pakistani/Bangladeshi	1024	4.3	22.1	3.7	39.5	943	5.1	37.7	6.1	14.8
	Black/Black British	505	2.8	29.7	2.7	20.9	423	3.5	40.7	6.0	13.6
	Mixed	444	3.2	24.1	5.4	23.6	378	3.5	34.9	12.6	20.6
	Other (incl. Chinese)	223	1.3	24.3	3.2	28.9	186	1.5	26.1	4.3	17.2
	Chi-square test p-value	-	-	*0.002*	*0.08*	*<0.001*	-	-	*<0.001*	*0.01*	*0.4*
Maternal age at first live birth (years)	12-17	979	6.5	25.1	4.9	38.6	782	8.2	26.2	8.9	28.3
	18-20	2661	18.2	24.3	4.1	31.7	2251	21.4	32.6	10.3	24.5
	21-25	3769	25.1	25.0	3.0	22.1	3214	25.4	30.3	8.5	18.0
	26-30	4118	29.0	23.9	2.4	14.7	3622	27.9	27.2	7.3	11.7
	31 or more	2711	20.2	22.5	2.7	12.0	2370	17.2	25.0	6.3	9.8
	Chi-square test p-value	-	-	*0.5*	*<0.001*	*<0.001*	-	-	*<0.001*	*0.002*	*<0.001*
Maternal highest academic attainment	Degree	2655	17.8	22.6	2.8	8.8	2936	19.0	21.2	6.6	8.2
	Diploma	1450	9.7	23.1	2.3	13.7	1589	11.6	26.1	6.0	11.1
	A levels	1465	9.5	20.8	1.9	13.1	1137	8.0	28.0	7.3	13.8
	GCSE A-C	4986	34.0	24.1	3.5	20.9	3828	30.9	30.5	8.9	17.8
	GCSE D-G	1597	11.0	26.6	3.2	31.2	1200	10.8	32.5	8.6	23.6
	Other (incl. overseas)	619	3.6	26.9	4.0	32.5	832	6.9	32.9	8.8	23.8
	None	2499	14.5	26.1	3.8	40.0	1521	12.9	34.5	11.3	28.6
	Chi-square test p-value	-	-	*0.03*	*0.04*	*<0.001*	-	-	*<0.001*	*<0.001*	*<0.001*

Analysis

Relative and absolute inequalities in each health outcome were estimated using panel population-averaged Poisson regression, which adjusted for correlation between observations from the same children. Relative inequalities are given by prevalence ratios (PR) and absolute inequalities by prevalence differences (PDs); these give a comparison of prevalence in a given maternal education category compared to baseline (Degree), either as a ratio (PR) or a difference (PD).

PDs and PRs were estimated at each age (3, 5, 7 and 11). The 95% Confidence Intervals (95% CIs) for the PDs and PRs represent statistical certainty for the age-specific inequalities (using Degree as baseline). Probability values (*p*-values) were estimated with an interaction term between maternal education and age, to indicate whether PRs and PDs at ages 5, 7 and 11 were statistically significantly different from those at age 3 (baseline). These *p*-values are reported in the results tables, with [i] ($p \leq 0.05$) and [ii] ($p \leq 0.001$).

Analyses were carried out before and after adjusting for confounders and gender; adjusted results are the focus of the paper with unadjusted results provided in Annex I. The analytic sample comprised singleton children who had the data on relevant health outcome at age 3 and at least one other time point and complete data for all covariates (see Tables 2-4 for sample numbers and missing data). Weights were used to account for survey design and attrition to the most recent completed interview. As a sensitivity analysis, we repeated the models without weights, and the patterns of inequality over time were unchanged. Analyses were carried out in Stata/SE 13.1 (StataCorp LP, Texas, USA). Data were downloaded from the UK Data Service, University of Essex and University of Manchester, in March 2014.

RESULTS

Overweight (including obesity)

At age 3, 24.0% percent (95% CI: 23.1-24.9) of children were overweight, falling slightly to 21.9% (21.1-22.7) and 21.4% (20.6-22.2) at ages 5 and 7 respectively, before increasing to 28.9% (27.9-29.9) at age 11. At all ages, the proportion of children who were overweight was lower when maternal academic attainment was higher (Table 1 shows data for age 3 and 11).

Relative and absolute inequality in overweight emerged by age 5, and was observed across the socio-economic gradient (using 'Degree' as baseline) (Table 2). PRs and PDs appeared to increase with age and by age 11, children whose mothers had no academic qualifications were 60% (PR: 1.6; 95%CI: 1.4-1.8) more likely to be overweight, and the absolute difference in prevalence was 12.9% (9.1-16.8). A statistically significant interaction (between age and maternal education) confirmed a

widening of absolute and relative inequalities over time (Table 2). Patterns were similar for unadjusted analyses (Annex I).

Table 2. Socio-economic inequalities in overweight in the Millennium Cohort Study by maternal academic education at ages 3, 5, 7 and 11 (n=14872; 46094 observations)

Relative inequality: Adjusted^ prevalence ratios (PR) for overweight (95% Confidence Intervals [CI])				
	Age 3	Age 5	Age 7	Age 11
Degree	-	-	-	-
Diploma	1 (0.9;1.1)	1.2 (1.0;1.4) [i]	1.2 (1.0;1.4)	1.2 (1.1;1.4) [i]
A Level	0.9 (0.8;1.0)	1.0 (0.9;1.2)	1.2 (1.0;1.4) [i]	1.2 (1.1;1.4) [ii]
GCSE A*-C	1.0 (0.9;1.2)	1.2 (1.1;1.4) [i]	1.4 (1.2;1.5) [ii]	1.5 (1.3;1.6) [ii]
GCSE D-G	1.1 (1.0;1.3)	1.3 (1.1;1.5)	1.4 (1.2;1.6) [i]	1.5 (1.3;1.7) [i]
None	1.1 (0.9;1.2)	1.3 (1.1;1.5) [i]	1.5 (1.3;1.8) [ii]	1.6 (1.4;1.8) [ii]
Absolute inequality: Adjusted^ prevalence differences (PD) for overweight (95% Confidence Intervals [CI])				
Degree	-	-	-	-
Diploma	-0.2 (-3.4;3.0)	3.2 (0.3;6.1) [i]	2.6 (-0.1;5.3)	5 (1.9;8.0) [i]
A Level	-2.8 (-6.0;0.3)	0.5 (-2.5;3.5) [i]	2.7 (-0.2;5.8) [i]	5.2 (1.7;8.7) [ii]
GCSE A*-C	0.9 (-1.6;3.4)	4.2 (2.0;6.4) [i]	5.9 (3.7;8.1) [ii]	9.6 (7.1;12.1) [ii]
GCSE D-G	3.2 (-0.3;6.8)	5.1 (1.8;8.3)	6 (2.8;9.2)	10.3 (6.5;14) [i]
None	1.8 (-1.6;5.2)	5.8 (2.7;8.9) [i]	8.3 (5.2;11.5) [ii]	12.9 (9.1;16.8) [ii]

^Adjusted for maternal age at first live birth, child sex and ethnicity.
[ii] ≤0.001, [i] ≤0.05; significance test p-value for age PR differences (interaction) and PD differences (pairwise comparisons) (age 3 baseline).
Notes: Missing data (n) at age 3, 5, 7, 11 for: overweight: 1373, 251, 340, 410; maternal academic education: 110, 100, 88, 69; missing data (n) for maternal age at first live birth: 1359; cohort member ethnicity: 31.

Limiting long-standing illness

The prevalence of LLSI increased with age from 3.1% (95%CI: 2.8-3.5) at age 3, to 5.9% (5.5-6.4), 6.8% (6.3-7.4) and then 8.3% (7.7-8.9) at ages 5, 7 and 11 respectively. At all ages, the proportion of children who had LLSI was lower with higher maternal academic attainment (Table 1 shows data for age 3 and 11).

Relative and absolute inequalities emerged in the least qualified groups by age 7 and remained at 11 years (Table 3). For example, at age 11 children whose mothers had no educational qualifications were 70% (PR: 1.7; 95%CI: 1.3-2.3) more likely to have LLSI (compared to those whose mothers had a Degree), and the absolute difference in prevalence was 4.8% (95%CI: 2.0-7.5). The interaction term confirms that inequalities at age 7 and 11 were significantly greater than those observed at age 3 (Table 3). The unadjusted analyses shows similar patterns (Annex I).

Table 3. Socio-economic inequalities in limiting long-standing illness (LLSI) in the Millennium Cohort Study by maternal

academic education at ages 3, 5, 7 and 11 (n=15250; 50401 observations)				
Relative inequality: Adjusted^ prevalence ratios (PR) for LLSI (95% Confidence Intervals [CI])				
	Age 3	Age 5	Age 7	Age 11
Degree	-	-	-	-
Diploma	0.8 (0.5;1.2)	0.7 (0.5;1.0)	1.1 (0.8;1.4)	0.9 (0.7;1.2)
A Level	0.6 (0.4;1.0)	0.9 (0.7;1.3)	1.1 (0.8;1.5) [i]	1.1 (0.8;1.5) [i]
GCSE A*-C	1.1 (0.8;1.5)	1.1 (0.9;1.4)	1.2 (1.0;1.6)	1.3 (1.0;1.6)
GCSE D-G	0.8 (0.5;1.3)	1.1 (0.9;1.6)	1.4 (1.0;1.9)	1.1 (0.8;1.5)
None	1.1 (0.8;1.6)	1.2 (0.9;1.6)	1.7 (1.3;2.3) [i]	1.7 (1.3;2.3) [i]
Absolute inequality: Adjusted^ prevalence differences (PD) for LLSI (95% Confidence Intervals [CI])				
Degree	-	-	-	-
Diploma	-0.8 (-2.0;0.4)	-1.7 (-3.2; 0.1)	0.3 (-1.4;2.0)	-0.4 (-2.2;1.4)
A Level	-1.4 (-2.5; -0.2)	-0.5 (-2.2; 1.3)	0.6 (-1.2;2.5) [i]	0.8 (-1.4;3.0)
GCSE A*-C	0.4 (-0.7;1.5)	0.6 (-0.8;2.0)	1.3 (-0.1;2.7)	1.8 (0.2;3.4)
GCSE D-G	-0.5 (-1.9;0.9)	0.3 (-1.7;2.3)	2 (-0.3;4.2) [i]	0.9 (-1.3;3.1)
None	0.5 (-0.9-1.8)	1.3 (-0.5;3.1)	3.9 (1.8;6.0) [ii]	4.8 (2.0;7.5) [i]

^Adjusted for maternal age at first live birth, child sex and ethnicity.
[ii] ≤0.001, [i] ≤0.05; significance test p-value for age PR differences (interaction) and PD differences (pairwise comparisons) (age 3 baseline).
Notes: Missing data (n) at age 3, 5, 7, 11 for: LLSI: 149, 82, 82, 110; maternal education: 110, 100, 88, 69; missing data (n) for maternal age at first live birth: 1359; cohort member ethnicity: 31.

Socio-emotional difficulty

At age 3, 21.2% (20-22.4) of children were classified as having socio-emotional difficulty (SED); this declined to 11.4% (10.6-12.1) at age 5 but increased to 14.7% (13.8-15.6) and 17.2% (16.2-18.3) at ages 7 and 11 respectively. At all ages, the proportion of children who had SED was lower as maternal academic attainment was higher (Table 1 shows data for age 3 and 11).

Large relative and absolute inequalities in SED were observed across the socio-economic gradient from the age of 3. Relative inequalities appeared to increase at age 5, and then decrease thereafter (Table 4). The interaction term between age and maternal education indicated that compared to age 3, relative inequalities (between the highest and lowest socio-economic groups) had significantly increased by age 5, but by age 11 had become significantly smaller. In contrast, absolute inequalities declined steadily (and significantly) after age 3. This apparent discrepancy between absolute and relative inequalities was largely driven by the reduction in the prevalence of SED (overall and in every socio-economic group) after age 3. Despite this, inequalities at age 11 remained; children whose mothers had no academic qualifications were more than twice as likely to have SED (PR: 2.4 [1.9-2.9]), with an absolute adjusted difference of 13.4% (10.2-16.7). In the unadjusted analyses inequalities at each age were greater, but patterns of change over age remained the same (Annex I).

Table 4. Socio-economic inequalities in socio-emotional difficulty (SED) in the Millennium Cohort Study by maternal academic education at ages 3, 5, 7 and 11 (n=15103; 48832 observations)				
Relative inequality: adjusted^ prevalence ratios (PR) for SED (95% confidence intervals [CI])				
	Age 3	Age 5	Age 7	Age 11
Degree		-	-	-
Diploma	1.5 (1.2;1.8)	1.5 (1.1;1.9)	1.6 (1.3;2.0)	1.3 (1.0;1.6)
A Level	1.3 (1.1;1.6)	1.8 (1.4;2.4) [i]	1.5 (1.1;1.9)	1.4 (1.1;1.8)
GCSE A*-C	1.9 (1.6;2.3)	1.9 (1.5;2.4)	1.9 (1.6;2.3)	1.7 (1.5;2.1)
GCSE D-G	2.7 (2.3;3.2)	2.9 (2.2;3.7)	2.5 (2.0;3.1)	2.1 (1.7;2.5) [i]
None	3.1 (2.6;3.7)	4 (3.2;5.1) [i]	3.1 (2.5;3.8)	2.4 (1.9;2.9) [i]
Absolute inequality: adjusted^ prevalence differences (PD) (95% confidence intervals [CI])				
Degree		-	-	-
Diploma	5.5 (2.6;8.4)	2.4 (0.5;4.3) [i]	4.5 (2.3;6.7)	2.7 (0.3;5.0)
A Level	3.4 (0.7;6.2)	4.4 (2.3;6.6)	3.3 (0.9;5.7)	4.2 (1.2;7.1)
GCSE A*-C	10.3 (8.1;12.4)	4.8 (3.4;6.3) [ii]	6.6 (4.8;8.4) [i]	7.4 (5.4;9.4) [i]
GCSE D-G	18.8 (15.7;22.0)	9.8 (7.4;12.2) [ii]	10.8 (8.0;13.6) [ii]	10.9 (7.7;14.0) [ii]
None	23.1 (19.9;26.3)	16.1 (13.5;18.7) [ii]	15.8 (12.9;18.7) [ii]	13.4 (10.2;16.7) [ii]

^Adjusted for maternal age at first live birth, child sex and ethnicity.
[ii] ≤0.001, [i] ≤0.05; significance test p-value for age PR differences (interaction) and PD differences (pairwise comparisons) (age 3 baseline).
Notes: Missing data (n) at age 3, 5, 7, 11 for: SED: 1164, 647,492,528; maternal education: 110, 100, 88, 69; missing data (n) for maternal age at first live birth: 1359; cohort member ethnicity: 31.

DISCUSSION

Summary of findings

Health inequalities persisted and in some cases widened in a representative contemporary cohort of UK children who grew up during a period of major policy initiatives designed to address health inequalities. However, patterns of inequality over time varied by health outcome. Throughout childhood, absolute and relative inequalities in overweight increased steadily across the social gradient compared to the most advantaged group (in terms of education and income). In LLSI, inequality also widened between ages 3 and 11 years for children with mothers with no academic qualifications. In contrast, inequalities in SED decreased in both relative and absolute terms by age 11, but nevertheless remained substantial.

Strengths and limitations

This is the first study to document how population-level health inequalities have changed throughout childhood, in a cohort of children who were born at the beginning of the 21st century. Population average models were used to account for the longitudinal study design, and an interaction term between maternal education (our socio-economic measure) and age was estimated in order to examine whether differences by age were significant. The study drew on a large nationally representative sample of children which over-represented disadvantaged groups. The range of social and health information available in the MCS allowed us to examine three important

outcomes (indicating both physical and mental health) and two measures of SEC (maternal education and household income). We have provided estimates of relative and absolute inequality, as recommended for inequalities research [24, 25], an approach also used when monitoring progress towards national inequalities targets [7]. Overweight was based on measured heights and weights and classified using validated cut-offs [18]. Questions regarding LLSI are widely used in other health and social surveys [26] and SED was assessed using the SDQ, which is a validated tool for measuring socio-emotional difficulty in children [27, 28].

However, both LLSI and SED were rated by the parent and thus reflected the parent's perceptions, which may be influenced by socio-demographic characteristics, personal opinions or their own experiences [29].Though the children of the MCS have grown up in the context of New Labour's policies, this study is not an evaluation of these policies as we cannot assess what would have happened in the absence of these policies. Loss to follow-up is a problem common to all cohort studies, and the percentage of attrition in the MCS increased at every data collection time point so that, by age 11, 31% of the original cohort did not take part. While response weights were used to account for attrition, they do not overcome any bias due to item missingness. Item missingness differed by age, thus possibly biasing our estimates of change in health inequality over time. To assess this we repeated our analyses in a complete case sample (i.e children who had health outcomes at all four sweeps) and found little change in the results.

Comparison with existing literature

Few studies have examined how health inequalities develop during childhood. To our knowledge, the only other recent cohort (other than the MCS) that allows tracking of national-level inequality in UK children growing up in the 2000s is the Growing Up in Scotland (GUS) Study. Analyses using data from the first GUS birth cohort (born 2004/05) show some similar findings for Scotland to those observed in the MCS (across the UK). For example, inequalities in obesity emerged at age 6 and widened by age 8 [30] and there were inequalities in socio-emotional difficulty at age 4 [31] which appeared to persist to age 7 [32]. An analysis of the Avon Longitudinal Study of Parents and their Children (ALSPAC) found that inequalities in BMI emerged at age 4 and increased to late childhood [33]. More research on the same cohort found that lower maternal academic education was associated with lower height, greater adiposity, higher blood pressure and higher SED; over time (to age 11) inequalities increased in height and decreased for blood pressure, while those in fat mass and SED remained the same [34]. However, ALSPAC is not representative of the UK population, and these children were born in the early 1990s (and therefore the context in which they were growing up was likely to have been different to the cohort that we studied). Some research has indicated that

early adolescence may be a period of equalisation for some health outcomes (although inequalities may re-emerge in adulthood)[35]. Our analysis showed little indication of equalisation by age 11. The only reduction in inequality was found for SED, albeit social differences remained substantial at 11 years. Recent research has indicated that equalisation may be shifting to later adolescence [5]. This should be further assessed as the MCS participants enter mid and late adolescence.

Implications for policy and practice

For the MCS children, indicators of inequalities in physical and mental health emerged early in life and persisted throughout childhood. This was despite growing up during unprecedented policy efforts to tackle health inequalities, which included interventions to improve incomes and employment in disadvantaged families as well as factors linked to child health such as neighbourhoods, housing, childcare and maternal health-related behaviours [7]. The reasons why New Labour's concerted policy efforts to reduce inequalities in child health were only partly successful continue to be the subject of debate [6, 36]. Explanations have included lack of understanding of the mechanisms through which SECs and child health are linked, insufficient focus on those most in need and on inequalities in income, and inadequate scale and timescale for implemented interventions [36]. Further research examining and comparing the pathways through which SECs influence health may further our understanding of how inequalities might be prevented. More evaluations of existing interventions are also needed to understand how these might affect health inequalities over the lifecourse. For the MCS children and their contemporaries, adolescence may offer a second opportunity to reduce health inequalities [37].

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COMPETING INTERESTS

All authors have completed the ICMJE uniform disclosure form at http://www.icmje.org/coi_disclosure.pdf and declare no competing interests.

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AUTHOR CONTRIBUTIONS

All authors contributed to the study conception and to the design of the analysis. ER carried out the analyses and drafted the paper. All authors revised the paper. All authors had full access to the data and take responsibility for the integrity of the data and accuracy of the data analysis. All authors read and approved the final manuscript.

DATA SHARING STATEMENT

No additional data are available.

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Annex I. Socio-economic inequalities in the Millennium Cohort Study by maternal education at ages 3, 5, 7 and 11; prevalence ratios (PR) & prevalence difference (PD) (95% confidence intervals [CI])-Unadjusted results

	Overweight (n=14872; 46094 observations)				Limiting Long-Standing Illness (n=15401; 50401 observations)				Socio-emotional Difficulty (n=15103; 48832 observations)			
	Age 3	Age 5	Age 7	Age 11	Age 3	Age 5	Age 7	Age 11	Age 3	Age 5	Age 7	Age 11
Relative inequality: PR (95%CI)												
Degree	-	-	-		-	-	-		-	-	-	
Diploma	1.0 (0.9;1.2)	1.2 (1.0;1.4) [i]	1.2 (1.0;1.4)	1.2 (1.1;1.4) [i]	0.8 (0.5;1.2)	0.7 (0.5;1.0)	1.1 (0.8;1.5)	1.0 (0.8;1.3)	1.7 (1.4;2.0)	1.6 (1.2;2.1)	1.8 (1.4;2.2)	1.4 (1.2;1.8)
A Level	0.9 (0.8;1.0)	1.0 (0.9;1.2)	1.2 (1.0;1.4) [i]	1.2 (1.1;1.4) [ii]	0.6 (0.4;1.0)	1.0 (0.7;1.3)	1.2 (0.9;1.6) [i]	1.2 (0.9;1.6) [i]	1.5 (1.2;1.8)	2.1 (1.6;2.7) [i]	1.6 (1.3;2.1)	1.6 (1.3;2.0)
GCSE A*-C	1.0 (0.9;1.2)	1.2 (1.1;1.4) [i]	1.4 (1.2;1.5) [ii]	1.4 (1.3;1.6) [ii]	1.2 (0.9;1.7)	1.2 (1.0;1.5)	1.4 (1.1;1.7)	1.4 (1.1;1.7)	2.4 (2.0-2.8)	2.3 (1.9;2.9)	2.3 (1.9;2.8)	2.1 (1.8;2.5)
GCSE D-G	1.1 (1.0;1.3)	1.3 (1.1;1.5)	1.4 (1.2;1.6) [i]	1.5 (1.3;1.7) [i]	1.0 (0.6;1.5)	1.2 (0.9;1.6)	1.5 (1.1;2.1)	1.3 (1.0;1.7)	3.6 (3.0;4.2)	3.7 (2.9;4.8)	3.2 (2.6;4.0)	2.7 (2.2;3.3) [i]
None	1.1 (1.0;1.2)	1.3 (1.1;1.5) [i]	1.5 (1.3;1.7) [ii]	1.6 (1.4;1.8) [ii]	1.3 (0.9;1.9)	1.4 (1.1;1.9)	2.0 (1.6;2.6) [i]	2 (1.5;2.6)	4.5 (3.8;5.2)	5.7 (4.6;7.2) [i]	4.4 (3.6;5.4)	3.3 (2.7;4.0) [i]
Absolute inequality: PD (95%CI)												
Degree	-	-	-		-	-	-		-	-	-	
Diploma	-0.04 (-3.2;3.2)	3.3 (0.4;6.3) [i]	2.7 (-0.1;5.4)	5.1 (2.0;8.2) [i]	-0.7 (-1.8;0.5)	-1.4 (-2.9;0.1)	0.5 (-1.1;2.1)	-0.1 (-1.8;1.6)	6.0 (3.4;8.6)	2.7 (1.0;4.4) [i]	4.9 (2.9;6.9)	3.6 (1.4;5.8)
A Level	-2.9 (-6.1; 0.2)	0.4 (-2.6;3.4) [i]	2.7 (-0.3;5.7) [i]	5.0 (1.5;8.5) [ii]	-1.2 (-2.3;-0.1)	-0.2 (-1.8;1.5)	0.9 (-0.9;2.6) [i]	1.1 (-1.1;3.2) [i]	4.5 (2.0;6.9)	4.8 (2.8;6.8)	3.9 (1.7;6.2)	5.0 (2.3;7.7)
GCSE A*-C	0.8 (-1.7;3.2)	4 (1.9;6.2) [i]	5.8 (3.6;8.7) [ii]	9.4 (6.9;11.8) [ii]	0.7 (-0.3;1.7)	1.1 (-0.2;2.4)	1.8 (0.5;3.1)	2.4 (0.8;3.9) [i]	12.6 (10.6;14.5)	5.9 (4.5;7.3) [ii]	8.1 (6.5;9.8) [ii]	9.3 (7.4;11.2) [i]
GCSE D-G	3.0 (-0.5;6.4)	4.8 (1.6;8.0)	5.7 (2.5;8.9)	9.8 (6.2;13.5) [i]	-0.1 (-1.5;1.3)	1.0 (-1.0;3.0)	2.7 (-0.5;5.0) [i]	1.7 (-0.5;3.9)	23.6 (20.4;26.9)	12.2 (9.7;14.7) [ii]	13.8 (10.9;16.8) [ii]	14.5 (11.2;17.7) [ii]
None	1.8 (-1.4;5.0)	5.7 (2.8;8.7) [i]	8.3 (5.2;11.3) [ii]	12.9 (9.2;16.5) [ii]	1 (-0.3;2.3)	2.4 (0.7;4.1)	5.1 (3.0;7.1) [ii]	6.1 (3.4;8.9) [ii]	31.6 (28.3;34.8)	21.1 (18.2;24) [ii]	21.6 (18.4;24.0) [ii]	19.5 (15.9;23.1) [ii]

[ii] ≤0.001, [i] ≤0.05; significance test *p*-value for age PR differences (interaction) and PD differences (pairwise comparisons) (age 3 baseline).

Notes: Missing data (n) at age 3, 5, 7, 11 for: weight: 1373, 251, 340, 410; LLSI: 149, 82, 82,110; SED: 1164, 647, 492, 528; maternal education: 110, 100, 88, 69.

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	p.1&2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	p.2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	p.4
Objectives	3	State specific objectives, including any prespecified hypotheses	p.4
Methods			
Study design	4	Present key elements of study design early in the paper	p.7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	p.4
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	p.4
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	p. 5
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	p. 5
Bias	9	Describe any efforts to address potential sources of bias	Weighting & sensitivity analyses discussed in 'Methods' p. 4-6; bias further discussed in 'Strengths & Limitations' p.10-11
Study size	10	Explain how the study size was arrived at	See 'Sample' p.4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	p. 4 – 5 & Table 1
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	p.5 & 7
		(*b*) Describe any methods used to examine subgroups and interactions	p.7
		(*c*) Explain how missing data were addressed	p.5 for missing SDQ data and p.7 in 'Analysis' & further

			discussed in 'Strengths and Limitations'p.10-11
		(*d*) If applicable, explain how loss to follow-up was addressed	'Strengths and Limitations'p.11
		(*e*) Describe any sensitivity analyses	p.7 &11
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Reported earlier in Methods & in results tables
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	p. 3-4 'Sample' numbers, Table 1 sample characteristics at ages 3 and 11 & regression model numbers and missing data given in and under Table 2 to 4 & Annex I
		(b) Indicate number of participants with missing data for each variable of interest	See response to 14 (a)
		(c) Summarise follow-up time (eg, average and total amount)	Time (age) points at which sample was interviewed and any missing data given as described in 14 (a)
Outcome data	15*	Report numbers of outcome events or summary measures over time	p. 7-10 for all three health outcomes at each age (in text) & Tables
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Unadjusted regression results are in Annex I; confounders described p.5 and adjusted estimates given in results (p.7-10)
		(*b*) Report category boundaries when continuous variables were categorized	Variable categories given p.4-5 & Table 1
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Both relative and absolute findings reported and discussed throughout the paper
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Interaction with age reported in results p. 7-9 and sensitivity analyses p.7 & p.11

Discussion			
Key results	18	Summarise key results with reference to study objectives	p.10
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	p.10&11
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	p.12
Generalisability	21	Discuss the generalisability (external validity) of the study results	p.10-12; factors which could have affected generalisability discussed in Strengths and Limitations p.10-11
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	p.13

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.

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Have health inequalities changed during childhood in the New Labour generation? Findings from the UK Millennium Cohort Study

Emeline Rougeaux* e.rougeaux@ucl.ac.uk, Steven Hope s.hope@ucl.ac.uk, Catherine Law catherine.law@ucl.ac.uk, Anna Pearce anna.pearce@ucl.ac.uk

Population Policy and Practice, UCL Great Ormond Street Institute of Child Health, 30 Guilford Street, London, WC1N 1EH UK.

*Corresponding author

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Inequalities, child health, policy, cohort, lifecourse epidemiology

WORD COUNT

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ABSTRACT

Objectives To examine how population-level socio-economic health inequalities developed during childhood, for children born at the turn of the 21st century and who grew up with major initiatives to tackle health inequalities (under the New Labour Government).

Setting The United Kingdom.

Participants Singleton children in the Millennium Cohort Study at ages 3 (n=15381), 5 (n=15041), 7 (n=13681) and 11 (n=13112) years.

Primary outcomes Relative inequalities (prevalence ratios [PR]) and absolute health inequalities (prevalence differences [PD]) were estimated in longitudinal models by socio-economic circumstances (SEC; using highest maternal *academic* attainment, ranging from '*No academic qualifications*' to '*Degree*' [baseline]). Three health outcomes were examined: overweight (including obesity), limiting-long-standing illness (LLSI), and socio-emotional difficulties (SED).

Results Relative and absolute inequalities in overweight, across the social gradient, emerged by age 5 and increased with age. By age 11, children with mothers who had no academic qualifications were considerably more likely to be overweight as compared to those with Degree-educated mothers (PR=1.6[95%CI: 1.4-1.8], PD=12.9%[9.1-16.8]). For LLSI, inequalities emerged by age 7 and remained at 11, but only for children whose mothers had no academic qualifications (PR=1.7[1.3-2.3], PD=4.8% [2-7.5]). Inequalities in SED (observed across the social gradient and at all ages) declined between 3 and 11, although remained large at 11 (e.g. PR=2.4[1.9-2.9], PD=13.4% [10.2-16.7] comparing children whose mothers had no academic qualifications with those of Degree-educated mothers).

Conclusions Although health inequalities have been well documented in cross-sectional and trend data in the UK, it is less clear how they develop during childhood. We found that relative and absolute health inequalities persisted, and in some cases widened, for a cohort of children born at the turn of the century. Further research examining and comparing the pathways through which SECs influence health may further our understanding of how inequalities could be prevented in future generations of children.

STRENGTHS & LIMITATIONS

- This is the first study to examine how population-level inequalities in health developed during childhood in a UK cohort who were born in 2000-2002 and grew up in the context of unprecedented initiatives to reduce health inequalities (under the New Labour Government)
- Evaluation of New Labour's policies was, however, not possible as we cannot assess what would have happened in their absence
- We used data from a large nationally representative sample of UK children, which includes a range of health, demographic and socioeconomic data recorded throughout childhood
- We carried out longitudinal analyses of both relative and absolute inequalities for three important physical and mental health outcomes (overweight, limiting long standing illness, and socio-emotional difficulties), assessed across the socioeconomic gradient, measured using both maternal education and income
- Response weights were used to account for attrition, and sensitivity analyses indicated that item missingness was unlikely to have biased the results

INTRODUCTION

Children from less advantaged backgrounds have, on average, worse health than their more advantaged peers. This fuels inequalities in subsequent life chances (such as educational achievement and employment opportunities) and health and wellbeing in adulthood [1-3]. Socio-economic inequalities in health are unfair and avoidable, yet research indicates that inequalities for children and young people may have widened since the 1980s for many aspects of health and health behaviours, including overweight [4], physical activity, psychological and physical wellbeing [5-8]. However, the majority of research has documented inequalities in children at single points in time. Although there is evidence of a possible period of equalization during adolescence [8], this has largely been based on cross-sectional data and much less is known about how population-level health inequalities change in the same group of children as they age throughout childhood. Cohort data would improve our understanding of how health inequalities develop over this important period of the lifecourse and whether patterns vary for different aspects of health.

At the start of the New Labour government (1997-2010), a pledge to eradicate child poverty in a generation [9] and the introduction of a strategy to sustainably tackle inequalities in health [10], led to a number of policies to tackle the social determinants of health, with a particular focus on the early years (such as Sure Start Children's Centres and increases in statutory paid parental leave [9-11]). Although it would be impossible to assess what would have happened to health inequalities in the absence of these policies, it is important to track how inequalities changed for the children who grew-up during this period of concerted policy efforts. This could help to inform future policies and practice, by highlighting the aspects of health or periods in childhood that might benefit from greater focus.

The aim of this study was to examine how population-level socio-economic inequalities in health developed throughout childhood for those born at the beginning of the 21st century. Three health measures were assessed across the socio-economic gradient: overweight, limiting long-standing illness (LLSI) and socio-emotional difficulty (SED). These are prevalent physical and mental health outcomes which may significantly impact current and future health and wellbeing [1-3].

METHODS

Sample

We used data from the UK Millennium Cohort Study (MCS), a nationally representative survey of children born in the UK, in September 2000 - January 2002. A stratified clustered sampling design was used to oversample children living in Wales, Scotland and Northern Ireland, disadvantaged areas

and those with high proportions of ethnic minority groups (in England) [12]. The parents of cohort children were first contacted for interview at 9 months, when information was collected on 72% of those contacted, providing information for 18818 children (of which 18296 were singletons and are the focus of this paper). Children were followed-up at 3, 5, 7 and 11 years of age and 68% [*n*=13112] of singletons took part in the age 11 interview [12-16]. Interviews were carried out in the home with the main respondent, predominantly the natural mother, and if applicable, the partner (where possible) [12].

Ethical approval was received from a Research Ethics Committee at each study survey [12]. The present secondary data analyses did not require additional ethics approval.

Health outcomes

Dichotomous measures were constructed at ages 3, 5, 7 and 11 years for the following three outcomes:

Overweight (including obesity): children's height and weight were measured by interviewers (using Tanita BF-522W scales for weight and a Leceister statiometer for height [17]). Body Mass Index (BMI; kg/m²) was categorised into being overweight (including obesity) or of healthy weight using the International Obesity Task Force (IOTF) age and sex adjusted cut-offs for children [18].

Limiting long-standing illness (LLSI): main respondents were asked if their child had any long-standing illness (physical or mental health conditions or illnesses lasting or expected to last twelve months or more) that limited the child in their everyday activities. Children were classified as having LLSI or not.

Socio-emotional difficulty (SED): the Strengths and Difficulties Questionnaire (SDQ) [19] was completed by the main respondent. The 'total difficulties score' is the sum of four subscales of the SDQ which capture key areas of child socio-emotional wellbeing: emotional symptoms, conduct problems, hyperactivity, and peer problems. Children were classified with validated cut-offs [19], as having SED (borderline/abnormal score, 14-40) or having no SED (normal score, 0-13). Where one or two (out of a total of five) items were missing in a subscale of the total difficulties score, values were imputed based on the mean of other item responses [20].

Measure of socio-economic circumstances

Socio-economic circumstances (SECs) were represented by natural mother's highest *academic* attainment (hereafter referred to as 'maternal education') when the cohort member was aged 3, 5, 7 and 11 years and categorised as: Degree, Diploma (in higher education-shortened to 'Diploma'

hereafter), A levels, General Certificate of Secondary Education (GCSE) grades A*-C, GCSE grades D-G, or No academic qualifications (shortened to 'No qualifications' hereafter). Those with 'Other' maternal education are shown in Table 1 but were excluded thereafter. Maternal education was used as the main measure of SECs in the analyses because it was stable throughout the period under study, is frequently used to assess inequalities in children [21], and had limited missing data (<1%). Furthermore, this measure can be applied to mothers who have never had paid employment. As a sensitivity analysis, analyses were repeated using an alternative measure of SECs (quintiles of equivalised household income) and patterns of results were replicated (data not shown).

Covariates

We adjusted for cohort member's sex and ethnicity, and maternal age at first live birth (as this was found to be associated with the health outcomes elsewhere and might also influence maternal education [22, 23]) (categories shown in Table 1). In general, these variables were significantly associated with the three health outcomes (as shown in Table 1 for the earliest [age 3] and latest [age 11] sweeps only).

Table I. Cross-sectional socio-demographic characteristics and health outcomes of singletons in the Millennium Cohort Study at ages 3 (n=15381) and 11 (n=13112); number (n), weighted percentages (%)

		Age 3					Age 11				
		Total		Overweight (n=13315) %	Limiting long-standing illness (n=15232) %	Socio-emotional difficulty (n=14217) %	Total		Overweight (n=11790) %	Limiting long-standing illness (n=13002) %	Socio-emotional difficulty (n=12584) %
		n	%				n	%			
Cohort member's sex	Male	7862	51.0	23.1	3.3	23.7	6632	51.7	26.6	9.9	20.7
	Female	7519	49.1	24.9	2.9	18.5	6480	48.3	31.3	6.5	13.6
	Chi-square test p-value	-	-	*0.04*	*0.2*	*<0.001*	-	-	*<0.001*	*<0.001*	*<0.001*
Cohort member's ethnic group	White	12768	86.5	24.1	3.0	20.3	10837	84.4	27.7	8.4	17.3
	Indian	398	1.9	12.4	3.8	25.0	338	2.1	30.1	5.2	17.1
	Pakistani/Bangladeshi	1024	4.3	22.1	3.7	39.5	943	5.1	37.7	6.1	14.8
	Black/Black British	505	2.8	29.7	2.7	20.9	423	3.5	40.7	6.0	13.6
	Mixed	444	3.2	24.1	5.4	23.6	378	3.5	34.9	12.6	20.6
	Other (incl. Chinese)	223	1.3	24.3	3.2	28.9	186	1.5	26.1	4.3	17.2
	Chi-square test p-value	-	-	*0.002*	*0.08*	*<0.001*	-	-	*<0.001*	*0.01*	*0.4*
Maternal age at first live birth (years)	12-17	979	6.5	25.1	4.9	38.6	782	8.2	26.2	8.9	28.3
	18-20	2661	18.2	24.3	4.1	31.7	2251	21.4	32.6	10.3	24.5
	21-25	3769	25.1	25.0	3.0	22.1	3214	25.4	30.3	8.5	18.0
	26-30	4118	29.0	23.9	2.4	14.7	3622	27.9	27.2	7.3	11.7
	31 or more	2711	20.2	22.5	2.7	12.0	2370	17.2	25.0	6.3	9.8
	Chi-square test p-value	-	-	*0.5*	*<0.001*	*<0.001*	-	-	*<0.001*	*0.002*	*<0.001*
Maternal highest academic attainment	Degree	2655	17.8	22.6	2.8	8.8	2936	19.0	21.2	6.6	8.2
	Diploma	1450	9.7	23.1	2.3	13.7	1589	11.6	26.1	6.0	11.1
	A levels	1465	9.5	20.8	1.9	13.1	1137	8.0	28.0	7.3	13.8
	GCSE A*-C	4986	34.0	24.1	3.5	20.9	3828	30.9	30.5	8.9	17.8
	GCSE D-G	1597	11.0	26.6	3.2	31.2	1200	10.8	32.5	8.6	23.6
	Other (incl. overseas)	619	3.6	26.9	4.0	32.5	832	6.9	32.9	8.8	23.8
	No qualifications	2499	14.5	26.1	3.8	40.0	1521	12.9	34.5	11.3	28.6
	Chi-square test p-value	-	-	*0.03*	*0.04*	*<0.001*	-	-	*<0.001*	*<0.001*	*<0.001*

Analysis

Population-averaged inequalities in each health outcome were estimated during childhood using Generalized Estimating Equations (GEE) for panel data, taking into account the correlation of repeated measurements from the same children. Poisson regression models were used to estimate relative inequalities (given by prevalence ratios [PRs]) and absolute inequalities (given by prevalence differences [PDs]); these compare the prevalence in each maternal education category to baseline (Degree), either as a ratio (PR) or a difference (PD).

An interaction term between maternal education and age was included in the model in order to estimate PDs and PRs at age 3, 5, 7 and 11 years. The 95% Confidence Intervals (95% CIs) for the PDs and PRs represent statistical certainty for the age-specific inequalities (using Degree as baseline at a given age). Probability values (*p*-values) derived from the interaction term between maternal education and age indicate whether PRs and PDs at ages 5, 7 and 11 were statistically significantly different from those at age 3 (baseline). These *p*-values are indicated in the results tables with [i] ($p \leq 0.05$) and [ii] ($p \leq 0.001$).

Analyses were carried out before and after adjusting for covariates; adjusted results are the focus of the paper, with unadjusted results provided in online supplementary Annex I. The analytic sample comprised singleton children who had data on the covariates (recorded at age 9 months) and relevant health outcomes for at least one of the relevant time points (see Tables 2-4 for sample numbers and missing data). Weights were used to account for survey design and attrition to the most recent completed interview. As a sensitivity analysis, we repeated the models without weights and the patterns of inequality over time were unchanged. We also carried out multiple imputation on each of the health outcomes as a sensitivity analysis to assess bias from item missingness and the patterns of inequality over time remained unchanged. As a final sensitivity analysis, the models were repeated in a sample limited to cases where the main respondent was always the natural mother (to ensure that any changes in health inequalities were not the result of changes in main respondent) and results were unchanged. Analyses were carried out in Stata/SE 13.1 (StataCorp LP, Texas, USA). Data were downloaded from the UK Data Service, University of Essex and University of Manchester, in March 2014.

RESULTS

Overweight (including obesity)

At age 3, 24.0% percent (95% CI: 23.1-24.9) of children were overweight, falling slightly to 21.9% (21.1-22.7) and 21.4% (20.6-22.2) at ages 5 and 7 respectively, before increasing to 28.9% (27.9-

29.9) at age 11. A visible social gradient in overweight had emerged by age 7, which then steepened at age 11 (Figure 1; Table 1 shows numbers and percentages at ages 3 and 11).

[Figure 1]

Table 2 indicates that small relative and absolute inequalities in overweight (after adjusting for covariates) emerged by age 5 and were observed across the socio-economic gradient (using 'Degree' as baseline) (Table 2). PRs and PDs increased with age, and by 11 years children whose mothers had no qualifications were 60% (PR: 1.6; 95%CI: 1.4-1.8) more likely to be overweight than children of Degree-educated mothers, and the absolute difference in prevalence was 12.9% (9.1-16.8). A statistically significant interaction (between age and maternal education) confirmed a widening of absolute and relative inequalities, across the gradient, over time (Table 2). Patterns were similar for unadjusted analyses (online supplementary Annex I).

Table 2. Socio-economic inequalities in overweight in the Millennium Cohort Study by maternal academic attainment at ages 3, 5, 7 and 11 (n=14872; 46094 observations)

Relative inequality: Adjusted^ prevalence ratios (PR) for overweight (95% Confidence Intervals [CI])				
	Age 3	Age 5	Age 7	Age 11
Degree	-	-	-	-
Diploma	1.0 (0.9;1.1)	1.2 (1.0;1.4) [i]	1.2 (1.0;1.4)	1.2 (1.1;1.4) [i]
A Level	0.9 (0.8;1.0)	1.0 (0.9;1.2)	1.2 (1.0;1.4) [i]	1.2 (1.1;1.4) [ii]
GCSE A*-C	1.0 (0.9;1.2)	1.2 (1.1;1.4) [i]	1.4 (1.2;1.5) [ii]	1.5 (1.3;1.6) [ii]
GCSE D-G	1.1 (1.0;1.3)	1.3 (1.1;1.5)	1.4 (1.2;1.6) [i]	1.5 (1.3;1.7) [i]
No qualifications	1.1 (0.9;1.2)	1.3 (1.1;1.5) [i]	1.5 (1.3;1.8) [ii]	1.6 (1.4;1.8) [ii]
Absolute inequality: Adjusted^ prevalence differences (PD) for overweight (95% Confidence Intervals [CI])				
Degree	-	-	-	-
Diploma	-0.2 (-3.4;3.0)	3.2 (0.3;6.1) [i]	2.6 (-0.1;5.3)	5 (1.9;8.0) [i]
A Level	-2.8 (-6.0;0.3)	0.5 (-2.5;3.5) [i]	2.7 (-0.2;5.8) [i]	5.2 (1.7;8.7) [ii]
GCSE A*-C	0.9 (-1.6;3.4)	4.2 (2.0;6.4) [i]	5.9 (3.7;8.1) [ii]	9.6 (7.1;12.1) [ii]
GCSE D-G	3.2 (-0.3;6.8)	5.1 (1.8;8.3)	6 (2.8;9.2)	10.3 (6.5;14) [i]
No qualifications	1.8 (-1.6;5.2)	5.8 (2.7;8.9) [i]	8.3 (5.2;11.5) [ii]	12.9 (9.1;16.8) [ii]

^Adjusted for maternal age at first live birth, child sex and ethnicity.
[ii] ≤0.001, [i] ≤0.05; significance test p-value for age PR differences (interaction) and PD differences (pairwise comparisons) (age 3 baseline).
Notes: Missing data (n) at age 3, 5, 7, 11 for: overweight: 1373, 251, 340, 410; maternal academic attainment: 110, 100, 88, 69; missing data (n) for maternal age at first live birth: 1359; cohort member ethnicity: 31.

Limiting long-standing illness

The prevalence of LLSI increased with age from 3.1% (95%CI: 2.8-3.5) at age 3, to 5.9% (5.5-6.4), 6.8% (6.3-7.4) and then 8.3% (7.7-8.9) at ages 5, 7 and 11 respectively. A gradient in the prevalence

of LLSI by maternal education appeared from age 5 and steepened slightly up to age 11(Figure 2; Table 1 shows numbers and percentages at ages 3 and 11).

[Figure 2]

Relative and absolute inequalities (after adjusting for covariates) were only observed from age 7 and were limited to children with mothers who had no qualifications (Table 3). By age 11, children whose mothers had no qualifications were 70% (PR: 1.7; 95%CI: 1.3-2.3) more likely to have LLSI (compared to those whose mothers had a Degree), and the absolute difference in prevalence was 4.8% (95%CI: 2.0-7.5). The interaction term confirms that inequalities between children whose mothers had no qualifications compared to those with a Degree-educated mothers were significantly greater at age 7 and 11 than at age 3 (Table 3). The unadjusted analyses shows similar patterns (online supplementary Annex I).

Table 3. Socio-economic inequalities in limiting long-standing illness (LLSI) in the Millennium Cohort Study by maternal academic attainment at ages 3, 5, 7 and 11 (n=15250; 50401 observations)

Relative inequality: Adjusted^ prevalence ratios (PR) for LLSI (95% Confidence Intervals [CI])				
	Age 3	Age 5	Age 7	Age 11
Degree	-	-	-	-
Diploma	0.8 (0.5;1.2)	0.7 (0.5;1.0)	1.1 (0.8;1.4)	0.9 (0.7;1.2)
A Level	0.6 (0.4;1.0)	0.9 (0.7;1.3)	1.1 (0.8;1.5) [i]	1.1 (0.8;1.5) [i]
GCSE A*-C	1.1 (0.8;1.5)	1.1 (0.9;1.4)	1.2 (1.0;1.6)	1.3 (1.0;1.6)
GCSE D-G	0.8 (0.5;1.3)	1.1 (0.9;1.6)	1.4 (1.0;1.9)	1.1 (0.8;1.5)
No qualifications	1.1 (0.8;1.6)	1.2 (0.9;1.6)	1.7 (1.3;2.3) [i]	1.7 (1.3;2.3) [i]
Absolute inequality: Adjusted^ prevalence differences (PD) for LLSI (95% Confidence Intervals [CI])				
Degree	-	-	-	-
Diploma	-0.8 (-2.0;0.4)	-1.7 (-3.2; 0.1)	0.3 (-1.4;2.0)	-0.4 (-2.2;1.4)
A Level	-1.4 (-2.5; -0.2)	-0.5 (-2.2; 1.3)	0.6 (-1.2;2.5) [i]	0.8 (-1.4;3.0)
GCSE A*-C	0.4 (-0.7;1.5)	0.6 (-0.8;2.0)	1.3 (-0.1;2.7)	1.8 (0.2;3.4)
GCSE D-G	-0.5 (-1.9;0.9)	0.3 (-1.7;2.3)	2 (-0.3;4.2) [i]	0.9 (-1.3;3.1)
No qualifications	0.5 (-0.9-1.8)	1.3 (-0.5;3.1)	3.9 (1.8;6.0) [ii]	4.8 (2.0;7.5) [i]

^Adjusted for maternal age at first live birth, child sex and ethnicity.

[ii] ≤0.001, [i] ≤0.05; significance test p-value for age PR differences (interaction) and PD differences (pairwise comparisons) (age 3 baseline).

Notes: Missing data (n) at age 3, 5, 7, 11 for: LLSI: 149, 82, 82, 110; maternal academic attainment: 110, 100, 88, 69; missing data (n) for maternal age at first live birth: 1359; cohort member ethnicity: 31.

Socio-emotional difficulty

At age 3, 21.2% (20-22.4) of children were classified as having socio-emotional difficulty (SED); this declined to 11.4% (10.6-12.1) at age 5 but increased to 14.7% (13.8-15.6) and 17.2% (16.2-18.3) at ages 7 and 11 respectively. There was a strong gradient in the prevalence of SED by maternal

education at age 3. The gradient was less steep but remained at ages 5, 7 and 11 (Figure 3; Table 1 shows numbers and percentages at ages 3 and 11).

[Figure 3]

Large relative and absolute inequalities in SED (after adjusting for covariates) were observed across the socio-economic gradient from the age of 3. Relative inequalities appeared to increase at age 5, and then decrease thereafter (Table 4). The interaction term between age and maternal education indicated that compared to age 3, relative inequalities (between the highest and lowest socio-economic groups) had significantly increased by age 5, but by age 11 had become significantly smaller. In contrast, absolute inequalities declined steadily (and significantly) after age 3. This apparent discrepancy between absolute and relative inequalities was largely driven by the reduction in the prevalence of SED (overall and in every socio-economic group) after age 3. Despite this inequalities at age 11 remained; children whose mothers had no qualifications were more than twice as likely to have SED (PR: 2.4 [1.9-2.9]), with an absolute adjusted difference of 13.4% (10.2-16.7). In the unadjusted analyses inequalities at each age were greater, but patterns of change over age remained the same (online supplementary Annex I).

Table 4. Socio-economic inequalities in socio-emotional difficulty (SED) in the Millennium Cohort Study by maternal academic attainment at ages 3, 5, 7 and 11 (n=15103; 48832 observations)

Relative inequality: adjusted^ prevalence ratios (PR) for SED (95% confidence intervals [CI])				
	Age 3	Age 5	Age 7	Age 11
Degree		-	-	-
Diploma	1.5 (1.2;1.8)	1.5 (1.1;1.9)	1.6 (1.3;2.0)	1.3 (1.0;1.6)
A Level	1.3 (1.1;1.6)	1.8 (1.4;2.4) [i]	1.5 (1.1;1.9)	1.4 (1.1;1.8)
GCSE A*-C	1.9 (1.6;2.3)	1.9 (1.5;2.4)	1.9 (1.6;2.3)	1.7 (1.5;2.1)
GCSE D-G	2.7 (2.3;3.2)	2.9 (2.2;3.7)	2.5 (2.0;3.1)	2.1 (1.7;2.5) [i]
No qualifications	3.1 (2.6;3.7)	4 (3.2;5.1) [i]	3.1 (2.5;3.8)	2.4 (1.9;2.9) [i]
Absolute inequality: adjusted^ prevalence differences (PD) (95% confidence intervals [CI])				
Degree		-	-	-
Diploma	5.5 (2.6;8.4)	2.4 (0.5;4.3) [i]	4.5 (2.3;6.7)	2.7 (0.3;5.0)
A Level	3.4 (0.7;6.2)	4.4 (2.3;6.6)	3.3 (0.9;5.7)	4.2 (1.2;7.1)
GCSE A*-C	10.3 (8.1;12.4)	4.8 (3.4;6.3) [ii]	6.6 (4.8;8.4) [i]	7.4 (5.4;9.4) [i]
GCSE D-G	18.8 (15.7;22.0)	9.8 (7.4;12.2) [ii]	10.8 (8.0;13.6) [ii]	10.9 (7.7;14.0) [ii]
No qualifications	23.1 (19.9;26.3)	16.1 (13.5;18.7) [ii]	15.8 (12.9;18.7) [ii]	13.4 (10.2;16.7) [ii]

^Adjusted for maternal age at first live birth, child sex and ethnicity.
[ii] ≤0.001, [i] ≤0.05; significance test p-value for age PR differences (interaction) and PD differences (pairwise comparisons) (age 3 baseline).
Notes: Missing data (n) at age 3, 5, 7, 11 for: SED: 1164, 647,492,528; maternal academic attainment: 110, 100, 88, 69; missing data (n) for maternal age at first live birth: 1359; cohort member ethnicity: 31.

DISCUSSION

Summary of findings

Health inequalities persisted and in some cases widened in a representative contemporary cohort of UK children who grew up during a period of major policy initiatives designed to address health inequalities. However, patterns of inequality over time varied by health outcome. The socio-economic gradient in overweight increased steadily during childhood, in both relative and absolute terms. In LLSI, inequality also widened between ages 3 and 11 years. However, the inequalities in LLSI were not seen across the entire socio-economic gradient and were confined to the most disadvantaged group (children with mothers with no academic qualifications). In contrast, inequalities in SED, which were seen across the entire gradient, decreased in both relative and absolute terms by age 11, but nevertheless remained substantial.

Strengths and limitations

This is the first study to document how population-level health inequalities have changed during childhood in a nationally representative cohort of UK children born at the beginning of the 21st century. Population average models were used to account for the longitudinal study design and correlation of repeated measurements, and an interaction term between maternal education (our socio-economic measure) and age was included in order to examine whether differences in health inequalities by age were statistically significant. The range of social and health information available in the MCS allowed us to examine three important outcomes (indicating both physical and mental health) and two measures of SECs (maternal education and household income). We have provided estimates of relative and absolute inequality, as recommended for inequalities research [24, 25] and an approach also used when monitoring progress towards national inequalities targets [10]. Overweight was based on measured heights and weights and classified using validated cut-offs [18]. Questions regarding LLSI are widely used in other health and social surveys [26] and SED was assessed using the SDQ, which is a validated tool for measuring socio-emotional difficulty in children [27, 28]. The content of the SDQ is consistent throughout childhood with the exception of three items which have been altered for preschool children (ages 2-4) to make them more age appropriate (for example 'often lies or cheats' has been replaced by 'often argumentative with adults'). Both the preschool and regular versions of the SDQ have been validated [27, 28] and it is unlikely the item changes would have affected our results.

However, both LLSI and SED were rated by the main respondent (usually the mother) and thus reflected the parent's perceptions, which may be influenced by socio-demographic characteristics,

personal opinions, their own experiences or the context in which they observe the child [29, 30]. Loss to follow-up is a problem common to all cohort studies, and the percentage of attrition in the MCS increased at every data collection time point so that, by age 11, 31% of the original cohort did not take part. While response weights were used to account for attrition, they do not overcome any bias due to item missingness. Item missingness differed by age, thus possibly biasing our estimates of change in health inequality over time. To assess this we repeated our analyses both in a complete case sample (i.e children who had health outcomes at all four sweeps) and after running multiple imputation on the health outcomes and found little change in the pattern of results for either. Finally, it was not possible to evaluate the impacts of policies with which the children of the MCS grew up as we could not assess what would have happened in their absence.

Comparison with existing literature

Few studies have examined how health inequalities develop during childhood. To our knowledge, the only other recent cohort (other than the MCS) that allows tracking of national-level inequality in UK children growing up in the 2000s is the Growing Up in Scotland (GUS) Study. Analyses using data from the first GUS birth cohort (born 2004/05) show some similar findings for Scotland to those observed in the MCS (across the UK). For example, inequalities in obesity emerged at age 6 and widened by age 8 [31] and there were inequalities in socio-emotional difficulty at age 4 [32] which appeared to persist to age 7 [33]. An analysis of the Avon Longitudinal Study of Parents and their Children (ALSPAC) found that inequalities in BMI emerged at age 4 and increased to late childhood [34]. More research on the same cohort found that lower maternal qualification was associated with lower height, greater adiposity, higher blood pressure and higher SED; over time (to age 11) inequalities increased in height and decreased for blood pressure, while those in fat mass and SED remained the same [35]. However, ALSPAC is not representative of the UK population, and these children were born in the early 1990s (and therefore the context in which they were growing up was likely to have been different to the cohort that we studied). Research has suggested that early adolescence may be a period of equalisation for some health outcomes (although inequalities may re-emerge in adulthood) [36]. Our analysis showed little indication of equalisation by age 11. The only reduction in inequality was found for SED, albeit social differences remained substantial at 11 years. Recent research highlighted previously has indicated that equalisation may be shifting to later adolescence [8]. This should be further assessed as the MCS participants enter mid and late adolescence.

Implications for policy and practice

For the MCS children, indicators of inequalities in physical and mental health emerged early in life and persisted throughout childhood. This was despite growing up during unprecedented policy efforts to tackle health inequalities, which included interventions to improve incomes and employment in disadvantaged families as well as factors linked to child health such as neighbourhoods, housing, childcare and maternal health-related behaviours [10]. The reasons why New Labour's concerted policy efforts to reduce inequalities in child health were only partly successful continue to be the subject of debate [9, 37]. Explanations have included lack of understanding of the mechanisms through which SECs and child health are linked, insufficient focus on those most in need and on inequalities in income, and inadequate scale and timescale for implemented interventions [37]. Earlier MCS analyses have highlighted potential mechanisms that may underlying cross-sectional inequalities in children's health, which range from parents' and children's health behaviours to parenting and the home environment [38-42]. Further research examining and comparing the pathways through which health inequalities develop throughout childhood may further our understanding of how they might be alleviated. Evaluations of existing interventions to reduce child health inequalities are also needed to understand their effect on health inequalities over the lifecourse. For the MCS children and their contemporaries, adolescence may offer a second opportunity to reduce health inequalities [43].

[Online supplementary file: Annex I]

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COMPETING INTERESTS

All authors have completed the ICMJE uniform disclosure form at http://www.icmje.org/coi_disclosure.pdf and declare no competing interests.

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AUTHOR CONTRIBUTIONS

All authors contributed to the study conception and to the design of the analysis. ER carried out the analyses and drafted the paper. All authors revised the paper. All authors had full access to the data and take responsibility for the integrity of the data and accuracy of the data analysis. All authors read and approved the final manuscript.

DATA SHARING STATEMENT

No additional data are available.

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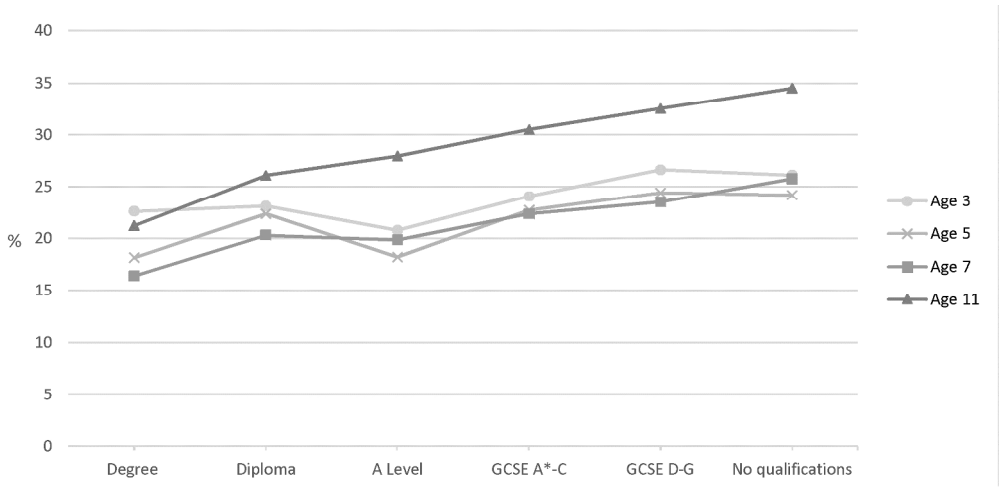
FIGURE LEGENDS

Figure 1. Prevalence of overweight in singletons in the Millennium Cohort Study at ages 3 (n=15381), 5 (n=15041), 7 (n=13681) and 11 (n=13112) by concurrent maternal academic attainment, weighted %

Figure 2. Prevalence of LLSI in singletons in the Millennium Cohort Study at ages 3 (n=15381), 5 (n=15041), 7 (n=13681) and 11 (n=13112) by concurrent maternal academic attainment, weighted %

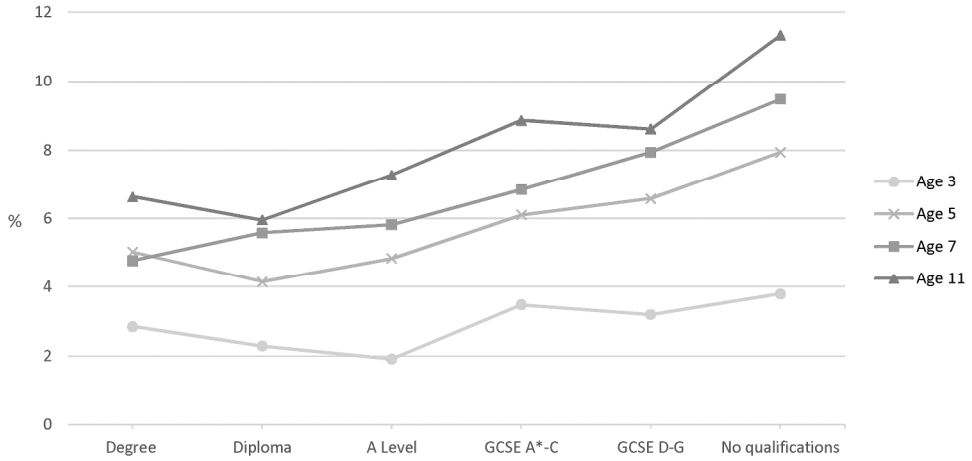
Figure 3. Prevalence of SED in the Millennium Cohort Study in singletons at ages 3 (n=15381), 5 (n=15041), 7 (n=13681) and 11 (n=13112) by concurrent maternal academic attainment, weighted %



Prevalence of overweight in singletons in the Millennium Cohort Study at ages 3 (n=15381), 5 (n=15041), 7 (n=13681) and 11 (n=13112) by concurrent maternal academic attainment, weighted %

Figure 1

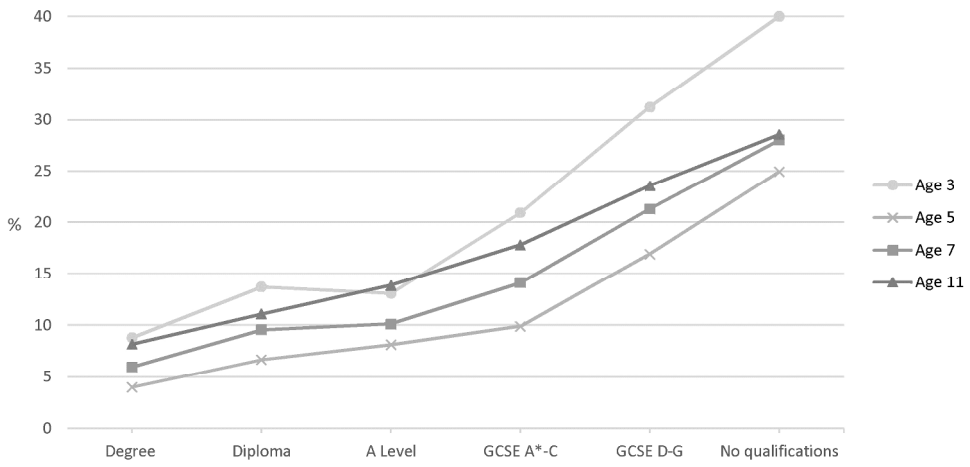
260x125mm (300 x 300 DPI)



Prevalence of LLSI in singletons in the Millennium Cohort Study at ages 3 (n=15381), 5 (n=15041), 7 (n=13681) and 11 (n=13112) by concurrent maternal academic attainment, weighted %

Figure 2

264x126mm (300 x 300 DPI)



Prevalence of SED in the Millennium Cohort Study in singletons at ages 3 (n=15381), 5 (n=15041), 7 (n=13681) and 11 (n=13112) by concurrent maternal academic attainment, weighted %
Figure 3
264x126mm (300 x 300 DPI)

Annex I. Socio-economic inequalities in the Millennium Cohort Study by maternal academic attainment at ages 3, 5, 7 and 11; prevalence ratios (PR) & prevalence difference (PD) (95% confidence intervals [CI])- Unadjusted results

	Overweight (n=14872; 46094 observations)				Limiting Long-Standing Illness (n=15401; 50401 observations)				Socio-emotional Difficulty (n=15103; 48832 observations)			
	Age 3	Age 5	Age 7	Age 11	Age 3	Age 5	Age 7	Age 11	Age 3	Age 5	Age 7	Age 11
Relative inequality: PR (95%CI)												
Degree	-	-	-		-	-	-		-	-	-	
Diploma	1.0 (0.9;1.2)	1.2 (1.0;1.4) [i]	1.2 (1.0;1.4)	1.2 (1.1;1.4) [i]	0.8 (0.5;1.2)	0.7 (0.5;1.0)	1.1 (0.8;1.5)	1.0 (0.8;1.3)	1.7 (1.4;2.0)	1.6 (1.2;2.1)	1.8 (1.4;2.2)	1.4 (1.2;1.8)
A Level	0.9 (0.8;1.0)	1.0 (0.9;1.2)	1.2 (1.0;1.4) [i]	1.2 (1.1;1.4) [ii]	0.6 (0.4;1.0)	1.0 (0.7;1.3)	1.2 (0.9;1.6) [i]	1.2 (0.9;1.6) [i]	1.5 (1.2;1.8)	2.1 (1.6;2.7) [i]	1.6 (1.3;2.1)	1.6 (1.3;2.0)
GCSE A*-C	1.0 (0.9;1.2)	1.2 (1.1;1.4) [i]	1.4 (1.2;1.5) [ii]	1.4 (1.3;1.6) [ii]	1.2 (0.9;1.7)	1.2 (1.0;1.5)	1.4 (1.1;1.7)	1.4 (1.1;1.7)	2.4 (2.0-2.8)	2.3 (1.9;2.9)	2.3 (1.9;2.8)	2.1 (1.8;2.5)
GCSE D-G	1.1 (1.0;1.3)	1.3 (1.1;1.5)	1.4 (1.2;1.6) [i]	1.5 (1.3;1.7) [i]	1.0 (0.6;1.5)	1.2 (0.9;1.6)	1.5 (1.1;2.1)	1.3 (1.0;1.7)	3.6 (3.0;4.2)	3.7 (2.9;4.8)	3.2 (2.6;4.0)	2.7 (2.2;3.3) [i]
No qualifications	1.1 (1.0;1.2)	1.3 (1.1;1.5) [i]	1.5 (1.3;1.7) [ii]	1.6 (1.4;1.8) [ii]	1.3 (0.9;1.9)	1.4 (1.1;1.9)	2.0 (1.6;2.6) [i]	2 (1.5;2.6)	4.5 (3.8;5.2)	5.7 (4.6;7.2) [i]	4.4 (3.6;5.4)	3.3 (2.7;4.0) [i]
Absolute inequality: PD (95%CI)												
Degree	-	-	-		-	-	-		-	-	-	
Diploma	-0.04 (-3.2;3.2)	3.3 (0.4;6.3) [i]	2.7 (-0.1;5.4)	5.1 (2.0;8.2) [i]	-0.7 (-1.8;0.5)	-1.4 (-2.9;0.1)	0.5 (-1.1;2.1)	-0.1 (-1.8;1.6)	6.0 (3.4;8.6)	2.7 (1.0;4.4) [i]	4.9 (2.9;6.9)	3.6 (1.4;5.8)
A Level	-2.9 (-6.1; 0.2)	0.4 (-2.6;3.4) [i]	2.7 (-0.3;5.7) [i]	5.0 (1.5;8.5) [ii]	-1.2 (-2.3;-0.1)	-0.2 (-1.8;1.5)	0.9 (-0.9;2.6) [i]	1.1 (-1.1;3.2) [i]	4.5 (2.0;6.9)	4.8 (2.8;6.8)	3.9 (1.7;6.2)	5.0 (2.3;7.7)
GCSE A*-C	0.8 (-1.7;3.2)	4 (1.9;6.2) [i]	5.8 (3.6;8.7) [ii]	9.4 (6.9;11.8) [ii]	0.7 (-0.3;1.7)	1.1 (-0.2;2.4)	1.8 (0.5;3.1)	2.4 (0.8;3.9) [i]	12.6 (10.6;14.5)	5.9 (4.5;7.3) [ii]	8.1 (6.5;9.8) [ii]	9.3 (7.4;11.2) [i]
GCSE D-G	3.0 (-0.5;6.4)	4.8 (1.6;8.0)	5.7 (2.5;8.9)	9.8 (6.2;13.5) [i]	-0.1 (-1.5;1.3)	1.0 (-1.0;3.0)	2.7 (-0.5;5.0) [i]	1.7 (-0.5;3.9)	23.6 (20.4;26.9)	12.2 (9.7;14.7) [ii]	13.8 (10.9;16.8) [ii]	14.5 (11.2;17.7) [ii]
No qualifications	1.8 (-1.4;5.0)	5.7 (2.8;8.7) [i]	8.3 (5.2;11.3) [ii]	12.9 (9.2;16.5) [ii]	1 (-0.3;2.3)	2.4 (0.7;4.1)	5.1 (3.0;7.1) [ii]	6.1 (3.4;8.9) [ii]	31.6 (28.3;34.8)	21.1 (18.2;24) [ii]	21.6 (18.4;24.0) [ii]	19.5 (15.9;23.1) [ii]

[ii] ≤0.001, [i] ≤0.05; significance test *p*-value for age PR differences (interaction) and PD differences (pairwise comparisons) (age 3 baseline).

Notes: Missing data (n) at age 3, 5, 7, 11 for: weight: 1373, 251, 340, 410; LLSI: 149, 82, 82,110; SED: 1164, 647, 492, 528; maternal academic attainment: 110, 100, 88, 69.

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	p.1&2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	p.2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	p.4
Objectives	3	State specific objectives, including any prespecified hypotheses	p.4
Methods			
Study design	4	Present key elements of study design early in the paper	p.7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	p.4
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	p.4
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	p. 5
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	p. 5
Bias	9	Describe any efforts to address potential sources of bias	Weighting & sensitivity analyses discussed in 'Methods' p. 4-6; bias further discussed in 'Strengths & Limitations' p.10-11
Study size	10	Explain how the study size was arrived at	See 'Sample' p.4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	p. 4 – 5 & Table 1
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	p.5 & 7
		(*b*) Describe any methods used to examine subgroups and interactions	p.7
		(*c*) Explain how missing data were addressed	p.5 for missing SDQ data and p.7 in 'Analysis' & further

			discussed in 'Strengths and Limitations'p.10-11
		(*d*) If applicable, explain how loss to follow-up was addressed	'Strengths and Limitations'p.11
		(*e*) Describe any sensitivity analyses	p.7 &11
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Reported earlier in Methods & in results tables
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	p. 3-4 'Sample' numbers, Table 1 sample characteristics at ages 3 and 11 & regression model numbers and missing data given in and under Table 2 to 4 & Annex I
		(b) Indicate number of participants with missing data for each variable of interest	See response to 14 (a)
		(c) Summarise follow-up time (eg, average and total amount)	Time (age) points at which sample was interviewed and any missing data given as described in 14 (a)
Outcome data	15*	Report numbers of outcome events or summary measures over time	p. 7-10 for all three health outcomes at each age (in text) & Tables
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Unadjusted regression results are in Annex I; confounders described p.5 and adjusted estimates given in results (p.7-10)
		(*b*) Report category boundaries when continuous variables were categorized	Variable categories given p.4-5 & Table 1
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Both relative and absolute findings reported and discussed throughout the paper
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Interaction with age reported in results p. 7-9 and sensitivity analyses p.7 & p.11

Discussion			
Key results	18	Summarise key results with reference to study objectives	p.10
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	p.10&11
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	p.12
Generalisability	21	Discuss the generalisability (external validity) of the study results	p.10-12; factors which could have affected generalisability discussed in Strengths and Limitations p.10-11
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	p.13

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.