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Higher maternal education is associated with favourable growth of young children in different countries

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Abstract

Background—Childhood growth affects long-term health and could contribute to health inequalities that persist throughout life.

Methods—We compared growth data of 4–6 year old children born 1997–2002 in UK (n=15,168), Sweden (n=6,749) and rural China (n=10,327). Standard deviation scores (SDS) were

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Author contributions RL wrote the first draft of the paper and obtained the UK Millennium Cohort Study (MCS) dataset. JDZ extracted and cleaned the China data, RL and KO performed the analyses. JL is the founder and project leader of All Babies in South East Sweden Study (ABIS) and JZ is the founder and project leader of National Children's Growth Standard Survey (NCGSS), constructed and systemised the China data. TS co-ordinated compiling the data from Sweden and China and writing the paper. All authors contributed to the critical revision of the manuscript and approved the final version.

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calculated against the WHO Standard. Obesity and overweight were defined by International Obesity Taskforce cut-offs, and stunting, underweight and thinness by height, weight or BMI < -2 SDS. Associations with maternal education were standardised by calculating the Slope Index of Inequality (SII).

Results—Mean SDS height, weight and BMI in UK (−0.01; 0.42; 0.62, respectively) and Sweden (0.45; 0.59; 0.45) were higher than in China (−0.98, −0.82, −0.29). Higher maternal education was consistently associated with taller offspring height SDS (SII: UK 0.25; Sweden 0.17; China 1.06). Underweight and stunting were less common in UK (prevalence: 0.6% and 2.2%, respectively) and Sweden (0.3% and 0.6%) than in China (9.5% and 16.4%), where these outcomes were inversely associated with maternal education (SII: −25.8% and −12.7%). Obesity prevalence in UK, Sweden and China was 4.8%, 3.7% and 0.4%, respectively. Maternal education was inversely associated with offspring obesity in UK (SII: −3.3%) and Sweden (−2.8%), but not in China (+0.3%).

Conclusions—Higher maternal education was associated with more favourable growth in young children: lower obesity and overweight in UK and Sweden, and lower stunting and underweight in rural China. Public health strategies to optimize growth in early childhood need to acknowledge socioeconomic factors, but possibly with a different emphasis in different settings.

Keywords

growth; nutrition; inequalities; obesity; public health

INTRODUCTION

Growth during childhood is assessed by comparing a child's body size (height, weight and Body Mass Index, BMI) to that of optimally nourished children of the same age and sex. When the growth of a child is outside a predetermined threshold, it is suggestive of under- or over-nutrition. The World Health Organisation (WHO) has published international growth charts based on the growth of optimally nourished, breastfed children in six countries and recommend these as the standard of optimal childhood growth.[1] According to WHO, "stunting" is defined as height < -2 standard deviation scores (SDS), "underweight" as weight < -2 SDS and "thinness" as BMI < -2 SDS for age and sex. Stunting and thinness indicate chronic and acute under-nutrition, respectively, while underweight indicates the combination of these factors.[2] Child under-nutrition is associated with increased mortality and affects both physical and cognitive performance.[3] The International Obesity Task Force has specified age and sex specific thresholds for defining overweight and obesity that are related to long term adverse health outcomes such as type 2 diabetes, cardiovascular disease, certain cancers, fatty liver disease and osteoarthritis, among others.[4] The rising prevalence of childhood obesity therefore presents a major public health challenge for the 21st century, increasing the burden of chronic non-communicable diseases in both developed and developing countries.[5,6]

The WHO Commission on Social Determinants of Health has called for national and global health equity surveillance systems for monitoring of policy and action to reduce health inequity and to create a more just and fair society.[7] The above epidemiological evidence suggests that preventing under- and over-nutrition and optimizing the growth of children during early life could reduce inequalities in health that result from socioeconomic disparity. We hypothesized that the effects of such socioeconomic disparities on childhood growth would differ in different settings, depending on both the prevalence of under- and over-nutrition in those settings, and also on the strength of socioeconomic gradients, which may vary widely even within developed settings.[8] For example, within Europe, Sweden has among the lowest socioeconomic gradients in self-perceived health, a good predictor of

future health, according to education levels in women, while England has among the highest gradients.[9] The most commonly used markers of socioeconomic position are education, occupation and income, which are highly inter related. Due to the problem of co-linearity in statistical models, most studies have used a single marker of socioeconomic status. A recent review found that a single indicator of socioeconomic status was used in 31/45 studies, parental education was most commonly studied (20/45 studies) and was inversely associated with childhood adiposity in 15 of these 20 studies.[10] As maternal education is likely to affect income and nutrition knowledge, we compared the associations between maternal education, as a marker of socioeconomic position with particular relevance to early childhood nutrition, and growth in contemporary 4-6 year old children in Sweden, UK and rural China, as settings chosen to represent extremes of socioeconomic effects.

METHODS

Study design and populations

UK: Millennium cohort study (MCS)—MCS is a nationally representative birth cohort study of 18,819 babies born 2000-01 in the UK. MCS is unique in having intentionally oversampled from families living in areas of child poverty and areas with high ethnic minority populations and provides extensive data on social, economic and psychological factors.[11] Maternal education was ascertained by questionnaire. Interviews and measurements took place in the home when children were 9 months, 3 years (n=15,382) and 5 years (n=15,042) old. For this analysis, we used anthropometry data from the 3rd MCS sweep, when children were 5 years old.

Sweden: All babies in Southeast Sweden study (ABIS)—ABIS is a representative birth cohort study of 17,055 babies born 1997-1999 in Southeast Sweden. Questionnaire data were provided at birth and at ages 1, 2.5 and 5 years. For this analysis, we used data on maternal education and child anthropometry collected at 5 years. Child anthropometry was not measured objectively and was reported by parents. This data has been shown to have good agreement with those recorded objectively at the Child Health Service (intraclass correlation coefficient for height: $r = 0.93$, $p < 0.001$, for weight $r = 0.98$, $p < 0.001$).[12]

Rural China: National Children Growth Standard Survey (NCGSS)—NCGSS is a cross-sectional survey of 84,009 rural Chinese children below 5 years, from 10 provinces, conducted in 2006. Children who lived with an agricultural-registered parent in rural areas for a duration of at least two thirds of their life, were identified as rural children and eligible for this survey. First, ten provinces (Jilin, Shanxi, Gansu, Xinjiang, Jiangsu, Sichuan, Jiangxi, Hunan, Guangxi and Guizhou) were selected from a total of 31 provinces in mainland China. Thereafter, four counties from each province were sampled except for Jilin province which had five counties recruited to achieve the sample size requirement for each province. This was followed by 3-6 towns/villages, selected from each county. To allow comparison of similar aged British, Swedish and Chinese children, for this analysis we used data from the 10,327 NCGSS children who were between 4-5 years old (born 2001-2002). Socio-demographic data were collected by parental questionnaire and child anthropometry was collected by centrally trained staff using the same calibrated instruments.

Research ethics committee approval was obtained for all studies from the relevant ethics committees in each country and all parents gave informed consent.

Maternal education

In each study, we grouped level of maternal education into 5 categories from lowest to highest. In MCS (UK), categories were based on age when mother left full-time education

(below 15yrs, 16yrs, 17/18yrs, 19/20 yrs and above 20 yrs). In ABIS (Sweden), categories were based on level of completed education (primary school, vocational training, academic/specialist training, undergraduate and university). In NCGSS (rural China) categories were based on level of completed education (illiterate/semi-illiterate, elementary, middle, high school and college) (Supplementary Figure 1). In each study, the proportion of children in the different categories of maternal education (lowest to highest) was calculated and the outcome (child growth status) was attributed to the midpoint of the cumulative proportion in that category. This allowed all education groups to be assigned their relative rank in the population and these values were used for the regression analyses. For example in MCS 10% were in the lowest category, hence the midpoint of 0.05 was used (cumulative 10% and range 0-10%, hence midpoint of range $0+10/2$). 38% were in the second category so the midpoint for the cumulative distribution was 0.29 (cumulative 48% and range 10-48%, hence midpoint of range $10+38/2$). 29% were in the third and the midpoint was 0.62 (cumulative 77% and range 48-77%, hence midpoint of range $48+29/2$). 7% were in the fourth and the midpoint was 0.80 (cumulative 84% and range 77-84%, hence midpoint of range $77+7/2$). 16% were in the fifth category and the midpoint was 0.92 (cumulative 100% and range 84-100%, hence midpoint of range $84+16/2$). A similar process was followed for all the databases.

Child anthropometry

Height, weight and BMI were converted to Standard Deviation Scores (SDS) adjusted for age and sex based on the WHO Growth Standard.[13] The SDS refers to the number of standard deviations the measurement lies above (+) or below (−) the median. Hence 2.3% of the population will be expected to lie above +2 SDS, and 2.3% lie below −2 SDS for any measurement. We excluded implausible values for BMI, weight or height (beyond ± 6 SDS).

According to WHO criteria, stunting, underweight and thinness were classified by height, weight and BMI < -2 SDS, respectively. Obesity and overweight were defined using the International Obesity Task Force (IOTF) age and sex specific BMI cut offs which were reported for the UK 1990 reference.[14]

Statistical analysis

Since education was recorded and classified differently in the three countries and the percentage of participants in the different categories varied from 1% to 59%, we analysed the Slope Index of Inequality (SII) and Relative Index of Inequality (RII) as standardised measures of the association between 'relative' socioeconomic disparity and child growth outcomes within each setting, and to allow a fair comparison these associations between settings. SII is the regression coefficient from linear regression models and represents the absolute difference in growth of children of mothers in the hypothetical top and bottom centiles for maternal education. RII is the SII divided by the mean (for continuous variables) or prevalence (for categorical variables) of the outcome measure. These regression-based indices take into account the whole socioeconomic distribution and remove variability in the size of socioeconomic groups as a source of variation in the magnitude of inequalities in health.[15]

We also performed multivariable logistic regression analyses to quantify the association between maternal education (lowest of the five categories as reference) and adverse childhood growth (obesity, overweight, underweight, stunting and thinness).

Since maternal education may be confounded by maternal age, we adjusted all regression models for mothers' age at birth of the child and in UK additionally adjusted for ethnicity.

All analyses were performed using STATA statistical software.

RESULTS

Sample characteristics

Anthropometry data were available on 15,168 UK (MCS), 6,749 Swedish (ABIS) and 10,327 rural Chinese (NCGSS) children at mean ages 5.2, 5.4 and 4.5 years, respectively (Table 1). In UK and Sweden, mean weight SDS and BMI SDS were above the WHO median (UK: 0.42 and 0.62, Sweden: 0.59 and 0.45 respectively). In Sweden, mean height SDS (0.45) was also above WHO median. In rural China, mean height, weight and BMI SDS were below the WHO median (−0.98, −0.82, −0.29). Of these children, data on maternal education were available on 98% (n=14,799) in MCS, 98% (n=6,602) in ABIS and 99.7% (n=10,301) in NCGSS and children included in this analysis were representative of the entire cohort. Due to sex differences in prevalence of underweight and stunting among the rural Chinese sample, data are presented for boys and girls separately (Supplementary Tables 1&2).

Inequality in children's height

In all three settings, maternal education was positively associated with offspring height SDS, but the effects were largest in rural China (SII in UK: 0.25; Sweden 0.17; rural China 1.06; Table 2). The prevalence of stunting was lowest in Sweden (0.6%) and highest in China (16.4%), where it was strongly inversely associated with maternal education (SII: −25.8%; RII: −158%) (Table 3). In rural China, the predicted prevalence of stunting among children in the lowest rank of maternal education was 28.3% compared to only 2.5% in the top rank (Figure 1). In UK, the prevalence of stunting was low (2.2%), but showed a strong inverse association with maternal education (SII: −2.7%; RII: −123%; lowest rank predicted prevalence 3.6% and highest rank predicted prevalence 0.9%).

Inequality in children's weight

In rural China, maternal education was positively associated with offspring weight SDS (SII: 0.71, Table 2). The prevalence of underweight was low in UK (0.6%) and Sweden (0.3%), but high in rural China (9.5%), where it was strongly inversely associated with maternal education (SII: −12.7%; RII: −134%) (Table 3). In rural China, the predicted prevalence of underweight among children in the lowest rank of maternal education was 15.3% compared to 2.6% in the top rank (Figure 2).

Inequality in children's BMI

In UK and Sweden, maternal education was inversely associated with offspring BMI SDS (SII: −0.18 in both UK and Sweden), while in rural China there was no association with BMI SDS (SII: 0.02) (Table 2). The prevalence of obesity was 4.8%, 3.7% and 0.4% in UK, Sweden and rural China, respectively, and was inversely associated with maternal education in UK and Sweden (SII: −3.3% and −2.8%; RII: −69% and −75%, respectively), whereas in rural China positive trends were seen (SII: 0.3%; RII 68%), particularly among boys (SII: 0.7%; RII 131%; Supplementary Table 2). In UK and Sweden predicted obesity prevalence among children in the lowest maternal education centiles was 6.1% and 5.1% respectively and for children of mothers in the highest education centiles it was only 2.8% and 2.4% respectively (Figure 3).

Similarly, overweight prevalence was 20.5%, 16.5% and 2.9% in UK, Sweden and rural China, respectively, and was inversely associated with maternal education in UK and Sweden (SII −5.2% and −7.4%, respectively), but not in rural China (SII: 0.1%) (Figure 4). Prevalence of thinness (BMI SDS < −2) was low in all three settings (0.4%, 0.6% and 2.6% in UK, Sweden and China respectively) and not associated with maternal education.

DISCUSSION

Main findings

Across three contrasting socioeconomic settings, we observed that higher maternal education was associated with the child's weight, height and BMI being closer to the WHO standard for optimal growth. Childhood stunting and underweight were common in rural China and were strongly inversely associated with maternal education. Childhood obesity and overweight were common in Sweden and UK and were inversely associated with maternal education in both countries. There was no association between stunting and maternal education in Sweden, but an inverse association in UK, consistent with other reports that these European countries exhibit different levels of health inequity.[8] These differences in associations in the three settings are demonstrated by the non-overlapping 95% confidence intervals for SII (Figure 5). In rural China, the vast difference in stunting between the top and bottom ranks of maternal education indicates a very strong socioeconomic gradient on child growth in that setting. In fact the predicted prevalence of stunting in the top rank of maternal education in rural China (2.5%) was lower than the predicted prevalence of stunting in the bottom rank of maternal education in the UK (3.6%) and similar to the overall prevalence of stunting in the UK (2.2%).

Comparison with other studies

Since the publication of the WHO Growth Standard in 2006, numerous studies have compared on the growth of children under-5 years old to these standards. In general, studies in developing countries have reported a high prevalence of stunting[16] and thinness/wasting,[17] while studies in developed countries have reported a high prevalence of tall stature[18,19] and obesity/overweight[20] compared to the WHO Growth Standard. This has led to debate on whether the WHO Growth Standard is suitable for all countries; however, as they place the growth of healthy breastfed babies as the 'norm' they are recommended as the optimal growth pattern for health, and they also allow international comparisons to be made.[1]

We observed high prevalences of stunting and underweight in rural Chinese children. Even higher estimates were reported in a previous study by Wang et al. among children < 5 years old in 2006 from fifty counties of thirteen mid-western provinces of China where the prevalence of stunting, underweight and wasting were 30.2 %, 10.2 % and 2.9 %, respectively[21] and this could be due to secular changes resulting in improved nutrition. Other studies in China have also reported area-level variations in the prevalence of stunting.[22] In contrast to rural China, the heights and weights of urban Chinese children have recently been reported to have reached or even surpassed the WHO Growth Standard[23,24] with some evidence that prevalence of overweight is higher among children in higher-income families.[25] In a study that tracked the temporal changes in prevalence of obesity among 7-18 year old children in different regions of China from 1995-2005, large disparities were found between regions. Although certain regions experienced a rapid increase in prevalence of childhood obesity, no increase was found in the developing rural areas.[26] Hence in countries like China undergoing a rapid economic and nutrition transition, policies to promote optimal childhood growth may have to differ between affluent urban and poorer rural areas.

The social patterning of childhood obesity has been recently systematically reviewed.[27] In developed countries, a number of studies report that childhood obesity is more prevalent in families of lower socioeconomic status,[6,28,29] while in developing countries some studies have suggested the opposite associations.[30] In the UK ALSPAC birth cohort study (born 1990-91), socioeconomic differences in BMI began to emerge from the age of 4 years,[31]

however in a more recent cohort of twins born in 2007, differences in weight gain was already apparent by age 3 months.[32] In a study of 3-4 year old children from Scotland (UK), both under-nutrition and obesity were associated with area-based level of deprivation. [33] Similarly in Sweden, overweight and obesity in 4 year olds has been related to living in a lower socioeconomic area.[34,35] In a study of Hong Kong children age 6-11 years born in 1997, there was no overall association between maternal education and BMI; rather parental education was inversely associated children's BMI in children of Hong Kong-born mothers, in contrast to a positive association in children of mainland China-born mothers. [36]

To our knowledge, our current study is the first to compare the association between maternal education and early growth outcomes in contemporary children from a range of different settings. While the types and prevalences of adverse growth outcomes differed widely across these settings, in all three populations higher maternal education was associated with more optimal child growth. In UK and Sweden where obesity and overweight prevalence are higher than underweight and stunting, more educated mothers are likely to give their children less energy dense foods high in fat and sugar. In rural China where stunting and underweight are more common, more educated mothers are likely to feed their babies more nutritious food that protects them from these adverse growth outcomes.

Strengths and limitations

All three studies were based on large population-based samples. We standardised the maternal education exposure across the diverse settings by using the Slope Index of Inequality and Relative Index of Inequality. Child anthropometry was objectively measured, by trained staff, following standardised protocols in UK and China and was reported by parents in the Swedish sample at or following clinic visits. In the Swedish sample, there was no relation between reporting error and mothers' education. In the UK sample we were able to adjust for ethnicity, and we expect ethnicity to be largely homogenous in the other studies.

Our study has several limitations. We analysed observational associations between childhood growth and maternal education (adjusted for maternal age), hence cannot comment on causality or the mechanisms involved. Several related factors, which are also socially patterned (such as: parental body size, parental smoking, breastfeeding and other lifestyles) and if these mediated the effects of maternal education then adjusting for these factors would have attenuated the associations. We are therefore unable to infer any causal role of maternal education.

Similarly, we did not examine other SES exposures, such as income and occupation and the influence of paternal education which could all influence childhood growth. One view is that SES differences are the results of factors that are largely financial,[37] however cultural factors could also play an important role[36]. In Europe and other developed countries, energy dense foods are relatively cheaper compared to the more nutritious food like fruits and vegetables.[38,39] In China, the situation seems different as a study by Shan et al. found that in Beijing, the consumption of soft drinks was low due to the high prices.[23]

Conclusions and implications

The foundations for lifelong socioeconomic inequalities in health are laid in early life; hence optimising the growth of children early on could help to reduce inequalities throughout the life course. Although the UN Millennium Development Goals set a target for universal education by 2015, this has not been achieved by many countries[40] and this is likely to lead to persistent health inequalities. We found that higher maternal education was

associated with lower obesity and overweight in UK and Sweden, and lower stunting and underweight in rural China. Depending on the setting, public health policies to monitor and promote healthy childhood growth and weight gain may need to have a differing emphasis on under- and over-nutrition, with timely review in settings of rapid transition. Developing countries, especially those going through a rapid economic transition need more studies investigating lifestyle factors such as diet and physical activity/inactivity to understand the factors associated with these lifestyle changes and their impact on long-term health.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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Abbreviations

ABIS	All Babies in South East Sweden study
BMI	Body Mass Index
IOTF	International Obesity task Force
MCS UK	Millennium Cohort Study, United Kingdom
NCGSS	National Children's Growth Standard Survey, China
SDS	Standard Deviation Score
SII	Slope Index of Inequality
RII	Relative Index of Inequality
WHO	World Health Organisation

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What is already known on this subject?

Studies in developing countries have reported a high prevalence of stunting and thinness/wasting, while studies in developed countries have reported a high prevalence of tall stature and obesity/overweight compared to the WHO Growth Standard.

What this study adds?

Higher maternal education was associated with more favourable growth patterns in young children: lower obesity and overweight in UK and Sweden, and lower stunting and underweight in rural China. Public health strategies to optimize growth in early childhood need to acknowledge socioeconomic factors, but possibly with a different emphasis in different settings.

Figure 1. Inequalities in childhood stunting

Lines represent the slope index of inequality, based on standardised maternal education; symbols represent prevalence of stunting by WHO classification.

Figure 2. Inequalities in childhood underweight

Lines represent the slope index of inequality, based on standardised maternal education; symbols represent prevalence of underweight by WHO classification.

Figure 3. Inequalities in childhood obesity

Lines represent the slope index of inequality, based on standardised maternal education, symbols represent prevalence of obesity by IOTF classification.

Figure 4. Inequalities in childhood overweight

Lines represent the slope index of inequality, based on standardised maternal education, symbols represent prevalence of overweight by IOTF classification.

Figure 5.

Forest plots demonstrate heterogeneity in the Slope Index of Inequality (SII) for various child growth outcomes between different settings

Table 1
Summary of measures in each study

MCS, UK n=15,168	mean	SE	min	max
Child's age (years)	5.2	0.00	4.4	6.1
Mother's age (years)	29.9	0.1	15	52
Father's age (years)	32.5	6.2	15	69
Birth weight (kg)	3.5	0.01	1	6
Height SDS	-0.01	0.01	-4.41	4.16
Weight SDS	0.42	0.01	-4.25	5.38
BMI SDS	0.62	0.01	-4.99	5.93
ABIS, Sweden n=6,749	mean	SD	min	max
Child's age (years)	5.4	0.3	4.5	6.5
Mother's age (years)	29.9	4.5	16	46
Father's age (years)	32.3	5.3	16	66
Birth weight (kg)	3.6	0.5	0.8	5.6
Height SDS	0.45	1.00	-3.23	4.74
Weight SDS	0.59	0.99	-3.20	4.80
BMI SDS	0.45	1.01	-4.46	5.56
NCGSS, China n=10,327	mean	SD	min	max
Child's age (years)	4.5	0.29	4.0	5.0
Mother's age (years)	26.1	4.3	15	49
Father's age (years)	32.8	4.5	21	60
Birth weight (kg)	3.3	0.5	3	6
Height SDS	-0.98	1.08	-5.66	4.55
Weight SDS	-0.82	0.95	-5.25	3.76
BMI SDS	-0.29	0.92	-5.75	5.77

SDS: Standard deviation score. Age and sex-adjusted SDS were calculated by comparison to the WHO 2006 growth standard up to age 5 years and the WHO 2007 growth reference from age 5+ years

UK data were adjusted for survey design hence Standard Errors (SE) and not Standard Deviations (SD) are reported

Table 2
Standardised inequalities in children's height, weight and BMI SDS in each setting

MCS, UK	SII	SE	P-value
Height SDS	0.25	0.03	<0.001
Weight SDS	0.03	0.03	0.394
BMI SDS	- 0.18	0.03	<0.001
ABIS, Sweden	SII	SE	P
Height SDS	0.17	0.04	<0.001
Weight SDS	-0.02	0.04	0.62
BMI SDS	- 0.18	0.05	<0.001
NCGSS, China	SII	SE	P
Height SDS	1.06	0.04	<0.001
Weight SDS	0.71	0.04	<0.001
BMI SDS	0.02	0.04	0.54

SDS: Standard deviation score

SII: Slope index of inequality. This value represents the modelled absolute difference in height, weight or BMI SDS between the theoretical top and bottom ranked individuals by maternal education in each study.

MCS UK data were additionally adjusted for ethnicity and survey design

Table 3
Standardised inequalities in growth outcomes in each setting

MCS, UK	Prevalence (%)	SII (%), 95%CI	RII (%)	P-value
Obese (IOTF)	4.8	−3.3, −4.7 to −2.0	− 69	<0.001
Overweight (IOTF)	20.5	−5.2, −8.1 to −2.3	− 25	0.001
UnderWT (WT < −2 SDS)	0.6	−0.3, −0.8 to 0.1	−50	0.17
Stunting (HT < −2 SDS)	2.2	−2.7, −3.7 to −1.7	− 123	<0.001
Thin (BMI < −2 SDS)	0.4	−0.1, −0.5 to 0.4	−25	0.78
ABIS, Sweden	%	SII (%), 95%CI	RII (%)	P-value
Obese (IOTF)	3.7	−2.8, −4.5 to −1.1	− 75	0.001
Overweight (IOTF)	16.5	−7.4, −10.7 to −4.2	− 45	<0.001
UnderWT (WT < −2 SDS)	0.3	−0.3, −0.8 to 0.2	−109	0.21
Stunting (HT < −2 SDS)	0.6	−0.2, −0.9 to 0.5	−28	0.62
Thin (BMI < −2 SDS)	0.6	−0.1, −0.8 to 0.6	−20	0.73
NCGSS, China	%	SII (%), 95%CI	RII (%)	P-value
Obese (IOTF)	0.4	0.3, −0.2 to 0.7	68	0.26
Overweight (IOTF)	2.9	0.1, −1.1 to 1.4	4	0.84
UnderWT (WT < −2 SDS)	9.5	−12.7, −14.9 to −10.5	− 134	<0.001
Stunting (HT < −2 SDS)	16.4	−25.8, −28.6 to −23.1	− 158	<0.001
Thin (BMI < −2 SDS)	2.6	−1.0, −2.2 to 0.2	−39	0.10

SII: Slope index of inequality. This value represents the absolute difference in the prevalence of the outcome between the theoretical top and bottom ranked individuals by maternal education.

RII: Relative index of inequality. This value represents the difference in the outcome between the theoretical top and bottom ranked individuals by maternal education relative to the overall prevalence of that condition.

All models were adjusted for maternal age. For UK, models were additionally adjusted for ethnicity and survey methodology.

Table 4
Growth of children by five categories of maternal education (lowest to highest) in each setting

Maternal Education	1	2	3	4	5	p for trend
MCS, UK n=14779	1514	5478	4329	1072	2386	
Height SDS (mean)	−0.14	−0.11	0.00	0.09	0.09	<0.0001
Weight SDS (mean)	0.37	0.39	0.45	0.50	0.41	0.004
BMI SDS (mean)	0.67	0.67	0.66	0.64	0.52	<0.0001
OR (%) Obese	1 (5.97)	0.95 (5.34)	0.80 (4.70)	0.79 (5.10)	0.44 (2.86)	<0.0001
OR (%) Overweight	1 (21.45)	1.0 (21.65)	0.95 (20.53)	0.99 (21.57)	0.72 (16.58)	0.0004
OR (%) UnderWT	1 (0.64)	1.31 (0.68)	1.04 (0.55)	1.03 (0.58)	0.78 (0.42)	0.713
OR (%) Stunting	1 (3.40)	0.89 (2.88)	0.59 (1.95)	0.53 (1.71)	0.26 (0.81)	<0.0001
OR (%) Thin	1 (0.43)	0.87 (0.35)	0.87 (0.37)	0.70 (0.32)	1.03 (0.46)	0.983
ABIS, Sweden n=6602	408	1745	2121	1413	915	
Height SDS (mean)	0.34	0.40	0.49	0.48	0.53	0.0012
Weight SDS (mean)	0.57	0.58	0.61	0.56	0.58	0.651
BMI SDS (mean)	0.53	0.49	0.45	0.39	0.37	0.003
OR (%) Obese	1 (5.64)	0.78 (4.47)	0.64 (3.68)	0.55 (3.18)	0.43 (2.51)	0.026
OR (%) Overweight	1 (19.85)	0.94 (18.85)	0.79 (16.31)	0.69 (14.58)	0.63 (13.44)	0.0005
OR (%) UnderWT	1 (0.49)	0.93 (0.46)	0.68 (0.44)	0.46 (0.21)	0.48 (0.22)	0.802
OR (%) Stunting	1 (0.98)	0.70 (0.69)	0.43 (0.42)	0.64 (0.64)	0.66 (0.66)	0.679
OR (%) Thin	1 (0.49)	1.40 (0.69)	1.45 (0.71)	1.34 (0.64)	0.92 (0.44)	0.935
NCGSS, China n=10301	528	3005	5992	645	131	
Height SDS (mean)	−1.63	−1.28	−0.83	−0.52	−0.40	<0.0001
Weight SDS (mean)	−1.24	−1.01	−0.73	−0.43	−0.35	<0.0001
BMI SDS (mean)	−0.28	−0.28	−0.31	−0.16	−0.15	0.0004
OR (%) Obese	1 (0.19)	1.9 (0.37)	2.2 (0.40)	3.4 (0.62)	4.2 (0.76)	0.747
OR (%) Overweight	1 (2.46)	1.3 (3.13)	1.1 (2.69)	1.6 (4.03)	1.6 (3.82)	0.266
OR (%) UnderWT	1 (17.99)	0.69 (13.14)	0.37 (7.48)	0.22 (4.50)	0.22 (4.58)	<0.0001
OR (%) Stunting	1 (34.28)	0.60 (23.96)	0.26 (12.03)	0.16 (7.91)	0.21 (9.92)	<0.0001
OR (%) Thin	1 (3.79)	0.70 (2.66)	0.66 (2.50)	0.41 (1.55)	0.81 (3.05)	0.218

OR: Odds ratios adjusted for maternal age. For UK, additionally adjusted for ethnicity and survey methodology

Maternal Education Categories defined as follows

MCS-UK: Age when mother left full time education 1= below 15yrs, 2= 16yrs, 3= 17/18yrs, 4= 19/20yrs, 5= above 20 years

ABIS-Sweden: Level of completed education 1= primary school, 2= vocational training, 3= academic/specialist training, 4= undergraduate, 5= university

NCGSS-China: Level of completed education 1= illiterate/semi-illiterate, 2= elementary, 3= middle, 4= high school, 5= college