Pediatric RESEARCH

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POPULATION STUDY ARTICLE

Socioeconomic disadvantage and health in early childhood: a population-based birth cohort study from Portugal

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BACKGROUND: Measuring early socioeconomic inequalities in health provides evidence to understand the patterns of disease. Thus, our aim was to determine which children's health outcomes are patterned by socioeconomics and to what extent the magnitude/direction of the differences vary by socioeconomic measure and outcome.

METHODS: Data on early childhood (4 years) health was obtained from Generation XXI birth cohort ($n = 8647$). A total of 27 health outcomes and 13 socioeconomic indicators at the individual level and neighbourhood level were used to calculate the relative index of inequality (RII).

RESULTS: Socioeconomic inequalities were evident across 21 of the 27 health outcomes. Education, occupation and income more often captured inequalities, compared with neighbourhood deprivation or employment status. Using highest maternal education as reference category, we observed that seizures (RII = 8.64), obesity (2.94), abdominal obesity (2.66), urinary tract infection (2.26), language/speech problems (2.24), hypertension (2.08) and insulin resistance (1.33) were heavily socially patterned, much more common in disadvantaged children. Contrastingly, eczema (0.26) and rhinitis (0.26) were more common among more advantaged children.

CONCLUSIONS: Socioeconomic inequalities were evident for almost every health outcome assessed, although with varying magnitude/direction according to the socioeconomic indicator and outcome. Our results reinforce that the social gradient in health manifests early in childhood.

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INTRODUCTION

Socioeconomic factors are one of the strongest predictors of morbidity and mortality.[1] It has been demonstrated that the association between socioeconomic factors and mortality is comparable in strength and consistency to established risk factors, such as hypertension, obesity or alcohol intake.[1]

To understand the mechanisms by which socioeconomic disadvantage leads to poor health, one must start looking at what happens in early childhood (if not earlier), since the effects of living in less favourable socioeconomic circumstances can become biologically embedded over their lifetimes, especially during this developmentally sensitive period.[2] Early childhood constitutes an important window of opportunity to build a strong foundation for future development and health and a growing number of studies have demonstrated that the health effects of adverse socioeconomic circumstances in childhood track into adulthood.[3,4] Poorer socioeconomic circumstances in childhood also affect future chances of personal achievement, human and social capital accumulation, and social and economic mobility. Besides, examining the existence of health inequalities early in life has the methodological advantage of almost entirely ruling out the possibility of reverse causation since any association between socioeconomic circumstances and health among children will probably reflect a causal effect and not reverse causality, as can happen in studies conducted among adult populations.[5]

Social disadvantage is commonly accepted to have a detrimental effect on children's health, and those with lower socioeconomic backgrounds generally experience more health issues, namely obesity[6,7] and other metabolic disorders,[8] psychosocial problems,[9] poorer neurocognitive and academic outcomes,[10] fatal and non-fatal injuries,[11] and detrimental health-related behaviours.[12]

Yet, it is unclear if socioeconomic inequalities in children's health are consistent across all child health outcomes. We hypothesize that some ubiquitous health conditions might not show any socioeconomic patterning (e.g. respiratory symptoms and childhood viral diseases like chickenpox or flu), and some health outcomes might even show inverse socioeconomic gradients. This later idea finds support in the hygiene hypothesis, which suggests that growing up in cleaner environments, more common in more advantaged households, might compromise the development of a child's immune system.[13]

A parallel, but equally important issue, is that research linking socioeconomic factors and child health has rarely incorporated the careful measurement of socioeconomic conditions. Studying health inequalities early in life is challenging, especially because there is no consensus on which socioeconomic indicators should be used in epidemiological research, especially because children do not hold a socioeconomic position per se. All socioeconomic indicators have their limitations and should be operationalized in

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light of a particular time, context and research question.[14] Possibly due to convenience and practical constraints, parental (usually maternal) education and, to a lesser degree, occupation and income remain the most frequently used indicators.[15] We argue that this choice should be evidence based and not simply convenience based.

Under this background, the objective of this work is to measure socioeconomic inequalities in health outcomes during early childhood in a population-based birth cohort from the Porto Metropolitan Area (Northern Portugal). More precisely, we aimed to assess (i) if children's health outcomes are socially patterned, and if so, in which direction; (ii) if the magnitude of the effect size varies by socioeconomic indicator and (iii) which health outcomes are associated with wider socioeconomic inequalities.

METHODS

Participants

Generation XXI (G21) is a birth cohort that recruited 8647 newborns delivered in 2005/2006 in the Porto Metropolitan Area, Northern Portugal.[16]

Recruitment occurred at the five public maternity units, where 95% of the births in the region occur. During the hospital stay, mothers were invited to participate, and 92% of them agreed. All who agreed were invited to be re-evaluated at 4 years of age (2009/11) and 7459 participated. Compared with the original cohort, those who did not participate in the 4 years evaluation were more likely to belong to households of lower socioeconomic background (less educated parents, occupied in blue-collar jobs and with lower income, $p < 0.001$). Data on sociodemographic characteristics, lifestyles and self-reported health and medical diagnoses were collected using structured questionnaires during face-to-face interviews. Anthropometric measurements and a fasting blood sample were collected using standardized procedures. The study was approved by the University of Porto Medical School/ Hospital S. João Ethics Committee and a signed informed consent was required for all participants. All phases of the study complied with the Ethical Principles for Medical Research Involving Human Subjects expressed in the Declaration of Helsinki.

Socioeconomic indicators

Educational attainment of the parents and the highest parental educational attainment was measured in years of schooling, and then categorized according to three classes: primary (≤9 years of education, ISCED—International Standard Classification of Education 2011 classes 0–2), which corresponds to the compulsory education in Portugal in the age cohort of the G21 parents; secondary (10–12 years, ISCED = 3); and tertiary (13 years or more, ISCED = 4–6). Occupation of each parent and the highest status occupation of the parents were classified according to the Portuguese Classification of Professions (CPP-2010), and then grouped into three ordinal classes of decreasing social prestige and economic power—upper white collar (International Standard Classification of Occupations 2008, ISCO-08 = 1–3), lower white collar (ISCO-08 = 4–5), and blue-collar (ISCO-08 = 6–9) occupations. Household monthly disposable income was collected as a categorical variable (<500, 500–1000, 1001–1500, 1501–2000, 2001–2500, 2501–3000, >3000 euros) and further grouped into three ordinal categories to guarantee a more uniform distribution of the participants across the classes: <1001, 1001–1500 and >1500 euros. The first class includes the situation when both parents receive the minimum national wage (475 euros in 2010, ~559 US Dollars). Employment status was used to assess whether the parents were unemployed (mother, father or any of the two). Home ownership was assessed by a dichotomous variable that distinguished owners from non-owners. Household crowding was the ratio between the number of household occupants and the number of rooms, and then dichotomized based on the median, which was more than one individual per room. Neighbourhood socioeconomic deprivation was assessed using the European Deprivation Index, a multivariable index developed to classify small areas according to their level of socioeconomic deprivation (1—least to 5—most deprived).[17,18]

Health outcomes

A total of 27 health outcomes encompassing both parent-reported assessments of the child's health and objective health measures were considered and grouped into the following categories: general health, anthropometrics, atopic and respiratory diseases, mental health and neurodevelopment, risk factors, infections and others.

We included the following self-reported dichotomous health outcomes ($n = 18$): episodes of sleepwalking and night terrors in the last month (parasomnias); experience of chickenpox, meningitis (bacterial or viral), eczema, wheezing (viral, transient, recurrent) and accidents (e.g. burns, falls); medical diagnoses of asthma, rhinitis, allergies and language/speech developmental problems; occurrence of gastroenteritis, seizures, ear infection/ acute otitis media, tonsillitis, pneumonia and urinary tract infection in the past 12 months; and whether the child had a health problem that required regular health service use (i.e. required medication, exams and/or regular consultations).

Objective measures ($n = 9$) included body mass index (BMI), height, waist-to-height ratio (WtHR), biomarkers measured in fasting blood samples (total cholesterol, high-density lipoprotein (HDL), C-reactive protein (CRP), triglycerides, insulin, and glucose) and systolic and diastolic blood pressure (BP). Height and BMI were transformed into age- and sex-specific *z*-scores using the World Health Organization standards as reference. Children were considered obese if their BMI *z*-score was two standard deviations (SD) above the mean. Abdominal obesity was defined using WtHR; because no national standards exist, using our population as reference, we defined abdominal obesity as ≥90th percentile for age and sex. Systolic and diastolic BP were classified according to the American Academy of Paediatrics criteria and hypertension was considered when systolic or/and diastolic BP was equal or above the 95th percentile for sex, age and height.[19] Due its skewed distribution, CRP was dichotomized in two classes (high/ low) using the 75th percentile as cut-point. Insulin resistance was assessed using the homeostasis model assessment of insulin resistance (HOMA-IR).

To guarantee comparable and homogeneous estimates between continuous variables (whose scale differs substantially and for which no clear risk thresholds exist), height and blood biomarker measurements were transformed into *z*-scores. Furthermore, because of the skewed distribution, triglycerides, cholesterol (HDL and total) and HOMA-IR were log transformed.

Statistical analysis

Generalized linear models were fitted to estimate the relative index of inequality (RII) and corresponding 95% confidence intervals (95% CIs). The RII is a summary measure of relative inequality that expresses the risk ratio of a certain outcome between those in the top and those in bottom of the social hierarchy.[20–22] The calculation of RII involves the following steps: (1) determination of the frequency of each socioeconomic category; (2) creation of a variable that expresses the hierarchical rank of each category by assigning to each category a value from 0 to 1 based on its mid-point cumulative frequency; (3) fitting generalized linear models using the previous variable as covariate and the health outcome as response. The highest socioeconomic category was used as a reference. An RII equal to 1 indicates no inequality between socioeconomic groups; an RII greater than 1 indicates those at the bottom of the social hierarchy are at higher risk; and an RII lower than 1 indicates those at the bottom of the social hierarchy are at lower risk. Although we acknowledge that

perinatal health conditions, environmental exposures and health-related behaviours may constitute important mediators in the association between socioeconomic factors and health, our aim was to measure the degree of inequality associated to each factor (total effect), rather than to estimate the effect of the exposure that acts through a given set of mediators (indirect effect) or the effect of the exposure not explained by those same mediators (direct effect).[23] Therefore, we run minimally adjusted models, where analyses were adjusted for mother's age and child's gender. Regarding the associations between neighbourhood deprivation and health outcomes, due to the hierarchical data structure, associations were estimated by mixed-effects regression models, adjusting for income, maternal education and occupation, so that the association reflects contextual effects.

RESULTS

Table 1 shows the demographic and socioeconomic characteristics of the cohort socioeconomic distribution of G21 parents and households were rather balanced with respect to education and occupational class (about one-third of the participants in each class); more than three-fourths of the households have disposable income lower than 1500 euros; most of the children resided in parent-owned homes; 26% were located in the least deprived neighbourhoods; and unemployment occurred in 23% of the households. As shown in Supplementary Fig. 1S1 (online), some socioeconomic indicators—parental education, occupation and income—were positively and moderately correlated, whereas others—employment status, neighbourhood deprivation, crowding and home ownership—showed positive but weaker correlations.

Table 2 depicts the frequency of each health outcome. Briefly, the most common health problems presented at 4 years of age were: gastroenteritis (62.9%), wheezing (52.9%), tonsillitis (45.0%), chickenpox (42.9%), and ear infection/acute otitis media (41.7%).

Tables 3 and 4 show the RII and corresponding 95% CI for each outcome and socioeconomic variable. Twenty-one (out of 27) health outcomes showed some degree (i.e. at least one RII significantly lower/higher than 1) of socioeconomic inequality. Abdominal obesity (number of significant RII = 12), eczema (n RII = 11), seizures (n RII = 11), urinary tract infection (n RII = 11), rhinitis (n RII = 10), obesity (n RII = 10), language/speech developmental problems (n RII = 9), hypertension (n RII = 8), regular health service use (n RII = 7) and HOMA-IR (n RII = 7) were associated with at least half of the 13 socioeconomic indicators employed. Although most health conditions were more common among the most disadvantaged children, some outcomes, namely rhinitis and eczema, were more prevalent among the least disadvantaged.

The magnitude, and occasionally the direction, of the associations varied according to the socioeconomic indicator. Education (n RII = 14 out of 27 outcomes, 13 and 11, for the highest, mother's and father's education, respectively), occupation (n RII = 12, 12 and 15 for the highest, mother's and father's occupation, respectively) and household income (n RII = 14) were the indicators more frequently associated with health outcomes, followed by those related with housing (crowding n RII = 9 and home ownership n RII = 9). By contrast, employment status (n RII = 6, 6 and 2) and neighbourhood deprivation (n RII = 1) were less frequently associated with children's health.

Figure 1 shows the RII and corresponding 95% CI for children's health outcomes according to the three socioeconomic indicators, which showed socioeconomic inequalities more consistently—mother's education, father's occupation and household income. Briefly, the widest social inequalities were observed for eczema, rhinitis, seizures, obesity, abdominal obesity, language/speech problems, hypertension, asthma and urinary tract infection.

Table 1. Sociodemographic characteristics of Generation XXI participants at baseline ($n = 8647$).

Variable	Number (percentage) or mean (standard deviation)
Mother's age (years) ($n = 8641$)	29.0 (5.6)
Child's gender ($n = 8647$)	
Male	4411 (51.0)
Female	4236 (49.0)
Mother education ($n = 8636$)	
High	2073 (24.0)
Medium	2314 (26.8)
Low	4249 (49.2)
Fathers education ($n = 7745$)	
High	1373 (17.7)
Medium	1924 (24.8)
Low	4448 (57.4)
Parental highest education ($n = 8643$)	
High	2368 (27.4)
Medium	2655 (30.7)
Low	3620 (41.9)
Mother occupation ($n = 7763$)	
Upper white collar	2459 (31.7)
Lower white collar	3436 (44.3)
Blue collar	1868 (24.1)
Father occupation ($n = 7555$)	
Upper white collar	2668 (35.3)
Lower white collar	1610 (21.3)
Blue collar	3277 (43.4)
Parental highest status occupation ($n = 8409$)	
Upper white collar	3523 (41.9)
Lower white collar	3058 (36.4)
Blue collar	1828 (21.7)
Home ownership ($n = 8515$)	
Owner	5778 (67.9)
Non-owner	2737 (32.1)
Household income ($n = 7738$)	
<1001	3140 (40.6)
1001–1500	3375 (43.6)
>1500	1223 (15.8)
Mother employment status ($n = 8647$)	
Employed	6958 (80.5)
Unemployed	1689 (19.5)
Father employment status ($n = 8382$)	
Employed	7956 (94.9)
Unemployed	426 (5.1)
Parental employment status (father or mother unemployed) ($n = 8647$)	
Employed	6670 (77.1)
Unemployed	1977 (22.9)
Household crowding ($n = 8364$)	
Low	4958 (59.3)
High	3406 (40.7)
Neighbourhood deprivation ($n = 8606$)	
1—least deprived	2250 (26.1)
2	1559 (18.1)
3	1333 (15.5)
4	1772 (20.6)
5—most deprived	1692 (19.7)

Table 2. Health outcomes of Generation 21 children at 4 years of age ($n = 7459$).

Indicators	Number (proportion, %) or mean (standard deviation)
Self-reported	
General health	
Regular health service use	1944 (26.2)
Atopic and respiratory diseases	
Asthma	305 (4.4)
Rhinitis	294 (4.2)
Wheezing (viral, transient, recurrent)	2972 (52.9)
Eczema	713 (12.7)
Allergies	907 (13.2)
Mental health and neurodevelopment	
Language/speech development problems	600 (8.7)
Seizures	227 (3.1)
Parasomnias, night terrors	573 (9.7)
Parasomnias, sleepwalking	73 (1.2)
Infections	
Ear infection/Acute otitis media	3088 (41.7)
Tonsillitis	3330 (45.0)
Pneumonia	170 (2.3)
Gastroenteritis	4668 (62.9)
Urinary tract infection	476 (6.4)
Chickenpox	3158 (42.9)
Meningitis (bacterial or viral)	43 (0.6)
Others	
Accidents	2213 (29.8)
Objectively assessed	
Anthropometrics	
Height (cm)	105.33 (5.06)
Obesity based on BMI	626 (10.5)
Abdominal obesity based on WtHR	553 (9.4)
Risk factors	
High-density lipoprotein cholesterol (mg/L)	49.82 (10.14)
Total cholesterol (mg/L)	167.11 (27.68)
Triglycerides (mg/L)	68.85 (30.50)
Insulin resistance (HOMA-IR)	1.03 (1.32)
C-reactive protein (mg/L)	2.07 (5.67)
Hypertension (≥95 percentile)	383 (8.1)

BMI body mass index, *WtHR* waist-to-height ratio, *HOMA-IR* homeostasis model assessment of insulin resistance.

Among the continuously measured outcomes, wider inequalities were observed for HOMA-IR.

DISCUSSION

In this study, we evaluated socioeconomic inequalities in early childhood for a wide range of health outcomes in a large population-based cohort. From the 27 outcomes evaluated, 78% showed significant socioeconomic inequalities. The widest social inequalities were observed for eczema, rhinitis, seizures, obesity, abdominal obesity, language/speech problems, hypertension, asthma and urinary tract infection. We observed that the relative risk of inequality changed considerably depending on the socioeconomic indicator employed. In general, we found that the traditional socioeconomic indicators (education, occupation and income) were better able to capture the socioeconomic inequalities in children's health than those related to unemployment and neighbourhood deprivation. We also found that, although most outcomes were more common in the most socially disadvantaged children, some, namely rhinitis and eczema, were predominant among the least disadvantaged.

Our results extend those from a few previous reviews and original studies. For instance, a recent meta-analysis found consistent associations between social disadvantage and a wide range of childhood disabling chronic conditions.[24] Comprehensive studies looking at the impact of household income on children's health also found socioeconomic inequalities among most of the health-related and severity of disease indicators.[25,26] More conservative findings were reported by another systematic review by Pillas et al.[15] focused on the European continent, where only 33% studies on socioeconomic inequalities in early childhood reported significant socioeconomic gradients. It is also important to highlight that, although health inequalities are thought to be smaller in Southern Europe, our study does not confirm that idea; 78% of the outcomes we evaluated showed some degree of socioeconomic inequality. There are reasons to believe that the relative 'advantage' of Southern Europe in terms of socioeconomic inequalities in health might have lessened due to the quick and drastic entrance of southern European countries, like Portugal, in the latest stages of the epidemiologic and demographic transition and, mostly, due to the fact that the 2000s economic recession has been particularly onerous in this part of Europe, which might have led to a greater socioeconomic polarization of health. Although we cannot directly infer this from this study, our results might to a certain extent reflect such an effect.

Particularly strong socioeconomic differentials were observed for obesity and cardiovascular risk factors. We found that more disadvantaged children had at least double the risk of being obese. These patterns have been reported elsewhere,[27] although contradictory results were also found.[28] As more than 50% of the overweight 2–5-year-old children will likely become obese in adulthood,[29] these results represent an important warning for the importance of tackling health inequalities early in life, especially because the prevalence of childhood obesity has risen dramatically during the past three decades. Socioeconomic inequalities were also evident in a considerable amount of biomarkers of cardiovascular risk, which is critical since the atherosclerotic process begins in childhood. Interestingly, we found those related to glucose metabolism showed significant socioeconomic inequalities, whereas lipid profile biomarkers did not seem to be socially patterned. Null associations with lipid biomarkers at this age were also observed by van den Berg et al.,[30] who only found socioeconomic gradients in glucose metabolism markers. Abdominal obesity causes insulin resistance and the later dyslipidemia, which might explain why inequalities in lipid profile were not evident at such an early life stage. No socioeconomic inequalities were observed for inflammation (CRP) at this early age. However, we had a limited sample size and our focus on the young children might have hindered us from finding any significant association, which others reported later in childhood.[31]

Atopic diseases like rhinitis, allergies and eczema consistently followed reverse socioeconomic gradients, being more common among advantaged children. Similar results have been reported elsewhere,[32–34] and may be explained by the more frequent exposure to microorganism among least advantaged children.[33] Yet, this theory has several opponents who believe the reverse gradients observed with respect to atopic conditions are simply the result of under-reporting and under-diagnoses among disadvantaged groups.[35,36] In fact, we observed (results not shown) that the frequency of medical visits was significantly lower among disadvantaged groups, which may provide some

Table 3. Relative index of inequality and corresponding 95% confidence interval in child's health (self-reported outcomes) according to socioeconomic position indicators.

Outcomes/ indicators	Highest education	Mother education	Father education	Highest occupation	Mother occupation	Father occupation	Income	Parental unemployment	Mother unemployment	Father unemployment	Crowding	Home ownership	Neighbourhood deprivation
General health													
Regular health service use	**1.28**[a]	1.22	**1.36**	**1.32**	**1.34**	**1.39**	**1.28**	1.15	1.06	1.22	**1.26**	1.24	0.96[b]
	1.05–1.56	0.99–1.49	**1.10–1.68**	**1.08–1.61**	**1.09–1.64**	**1.12–1.72**	**1.03–1.59**	0.89–1.48	0.81–1.39	0.75–1.96	**1.02–1.57**	0.98–1.58	0.77–1.18
Atopic and respiratory diseases													
Asthma	1.36	1.24	1.35	**1.78**	1.21	**2.75**	**2.22**	1.16	1.28	1.10	1.45	1.19	1.03
	0.87–2.12	0.79–1.95	0.84–2.20	**1.14–2.79**	0.76–1.92	**1.69–4.53**	**1.36–3.65**	0.66–1.98	0.71–2.24	0.35–2.98	0.91–2.31	0.70–1.99	0.56–1.89
Rhinitis	**0.26**	**0.26**	**0.33**	**0.35**	**0.33**	**0.46**	**0.38**	0.65	0.81	**0.25**	**0.28**	**0.34**	0.64
	0.16–0.42	**0.16–0.40**	**0.21–0.52**	**0.22–0.57**	**0.20–0.53**	**0.29–0.74**	**0.23–0.61**	0.34–1.17	0.42–1.50	**0.04–0.98**	**0.16–0.47**	**0.18–0.61**	0.38–1.08
Wheezing (viral, transient, recurrent)	**1.24**	**1.26**	1.22	**1.26**	1.09	**1.38**	1.19	1.16	1.10	1.16	1.09	1.09	1.14
	1.02–1.51	**1.03–1.54**	0.99–1.50	**1.03–1.55**	0.89–1.35	**1.12–1.71**	0.96–1.47	0.89–1.50	0.83–1.45	0.70–1.93	0.88–1.36	0.85–1.40	0.91–1.42
Eczema	**0.27**	**0.26**	**0.33**	**0.33**	**0.36**	**0.42**	**0.30**	**0.40**	**0.41**	0.51	**0.40**	**0.24**	0.98
	0.20–0.36	**0.19–0.35**	**0.24–0.45**	**0.24–0.46**	**0.26–0.49**	**0.31–0.59**	**0.22–0.42**	**0.26–0.62**	**0.26–0.65**	0.21–1.13	**0.28–0.57**	**0.16–0.37**	0.71–1.34
Allergies	0.90	0.80	0.84	0.82	**0.73**	0.99	0.87	0.92	0.83	1.18	0.90	1.06	1.01
	0.69–1.17	0.61–1.05	0.64–1.11	0.62–1.07	**0.55–0.96**	0.75–1.32	0.65–1.17	0.65–1.29	0.57–1.20	0.60–2.22	0.67–1.20	0.76–1.46	0.76–1.35
Mental health and neurodevelopment													
Language/speech development problems	**2.14**	**2.24**	**1.68**	**2.18**	**2.51**	**2.52**	**1.65**	1.16	1.12	1.38	**1.58**	**1.93**	1.39
	1.55–2.95	**1.61–3.13**	**1.18–2.39**	**1.58–3.01**	**1.79–3.51**	**1.77–3.58**	**1.16–2.35**	0.76–1.73	0.72–1.71	0.62–2.85	**1.12–2.24**	**1.32–2.81**	0.99–1.96
Seizures	**8.07**	**8.64**	**5.48**	**5.97**	**7.75**	**3.33**	**3.89**	**2.71**	**2.90**	2.56	**2.93**	**1.91**	0.74
	4.64–14.35	**4.77–16.02**	**2.93–10.62**	**3.52–10.21**	**4.40–13.84**	**1.89–5.95**	**2.17–7.03**	**1.50–4.81**	**1.57–5.24**	0.85–6.68	**1.71–5.02**	**1.06–3.43**	0.34–1.09
Parasomnias, night terrors	**0.66**	**0.66**	0.73	0.82	0.87	**0.70**	0.86	1.31	1.14	1.38	0.78	0.88	0.84
	0.47–0.91	**0.48–0.92**	0.52–1.02	0.59–1.15	0.62–1.22	**0.49–0.99**	0.61–1.23	0.86–1.98	0.72–1.77	0.62–2.89	0.54–1.12	0.58–1.34	0.60–1.19
Parasomnias, sleepwalking	1.94	1.46	2.13	1.37	0.90	1.83	1.20	1.68	1.63	4.59	1.16	0.63	2.64
	0.79–4.83	0.59–3.69	0.79–6.08	0.55–3.38	0.35–2.29	0.67–5.13	0.45–3.21	0.56–4.65	0.51–4.75	0.78–19.63	0.43–3.02	0.19–1.92	0.30–23.07
Infections													
Ear infection/ acute otitis media	1.00	0.97	1.11	1.07	0.96	1.11	**1.22**	1.04	0.97	1.18	0.86	0.93	0.89
	0.84–1.19	0.81–1.16	0.92–1.33	0.90–1.28	0.80–1.16	0.92–1.34	**1.01–1.47**	0.82–1.30	0.76–1.24	0.76–1.83	0.71–1.04	0.75–1.16	0.74–1.09
Tonsillitis	**1.41**	**1.34**	**1.43**	1.15	1.07	**1.30**	**1.40**	1.10	1.05	1.05	1.13	0.99	0.98
	1.19–1.68	**1.12–1.59**	**1.20–1.72**	0.96–1.37	0.89–1.28	**1.08–1.56**	**1.16–1.68**	0.88–1.38	0.82–1.33	0.68–1.63	0.93–1.37	0.80–1.23	0.81–1.18
Pneumonia	1.03	0.91	1.03	1.06	1.00	1.09	0.90	1.03	0.90	2.07	1.40	1.26	1.00
	0.58–1.83	0.51–1.62	0.56–1.90	0.59–1.88	0.55–1.80	0.58–2.02	0.49–1.67	0.47–2.13	0.38–1.98	0.53–6.55	0.75–2.60	0.62–2.49	0.54–1.84
Gastroenteritis	0.84	0.84	0.91	0.94	0.85	1.04	1.13	**1.35**	**1.45**	1.08	1.19	1.25	0.99
	0.70–1.00	0.70–1.01	0.75–1.10	0.79–1.13	0.71–1.03	0.86–1.25	0.93–1.37	**1.07–1.72**	**1.13–1.88**	0.69–1.71	0.8–1.45	0.99–1.55	0.81–1.20
Urinary tract infection	**2.13**	**2.26**	**1.65**	**1.79**	**1.61**	**1.51**	**1.85**	**1.61**	**1.75**	1.06	**1.68**	**1.65**	1.32
	1.48–3.06	**1.56–3.29**	**1.11–2.45**	**1.24–2.56**	**1.10–2.34**	**1.03–2.23**	**1.25–2.74**	**1.04–2.48**	**1.10–2.74**	0.42–2.43	**1.14–2.47**	**1-07-2.51**	0.89–1.95
Chickenpox	0.92	0.87	0.88	0.85	0.85	**0.79**	0.86	0.89	0.85	1.06	1.17	0.94	1.12
	0.77–1.09	0.73–1.03	0.73–1.06	0.71–1.01	0.71–1.02	**0.66–0.96**	0.71–1.04	0.71–1.12	0.67–1.08	0.68–1.64	0.96–1.41	0.76–1.17	0.92–1.35
Meningitis (viral or bacterial)	2.02	2.17	1.31	2.81	1.44	3.45	1.79	1.24	1.43	0.25	1.03	1.23	0.93
	0.65–6.48	0.68–7.35	0.40–4.57	0.89–8.92	0.43–4.78	0.97–13.22	0.51–6.38	0.27–4.88	0.28–5.89	0.01–5.42	0.28–3.56	0.29–4.67	0.26–3.38
Others													
Accidents (e.g. falls, burns)	0.89	0.91	1.08	1.03	0.94	1.02	1.01	1.16	1.11	1.57	1.05	1.25	1.17
	0.74–1.08	0.75–1.10	0.89–1.32	0.85–1.25	0.77–1.15	0.83–1.25	0.83–1.25	0.91–1.48	0.85–1.43	0.99–2.47	0.86–1.30	0.99–1.57	0.95–1.43

Bold indicates statistically significant results.
[a]Relative index of inequality was calculated using the most socioeconomically advantaged as a reference group and adjusted for child's gender and mother's age
[b]Relative index of inequality was calculated using the most socioeconomically advantaged as a reference group and adjusted for child's gender and mother's age and individual-level socioeconomic indicators using a multilevel analysis.

Table 4. Relative index of inequality and corresponding 95% confidence interval in child's health (objectively assessed outcomes) according to socioeconomic position indicators.

Outcomes/ indicators	Highest education	Mother education	Father education	Highest occupation	Mother occupation	Father occupation	Income	Parental unemployment	Mother unemployment	Father unemployment	Crowding	Home ownership	Neighbourhood deprivation
Anthropometrics													
Height-for-age (*z*-score)	0.98[a]	0.99	1.03	0.99	1.05	0.98	0.94	0.97	1.01	0.90	**0.89**	0.97	1.03
	0.89–1.07	0.90–1.09	0.93–1.13	0.90–1.09	0.95–1.15	0.89–1.08	0.85–1.04	0.86–1.09	0.89–1.15	0.72–1.13	**0.81–0.99**	0.86–1.09	0.94–1.14
Obesity (BMI)	**2.85**	**2.94**	**2.40**	**2.69**	**2.68**	**2.22**	**1.75**	**1.63**	**1.58**	1.48	1.26	**1.60**	1.24
	2.07–3.93	**2.12–4.09**	**1.70–3.43**	**1.96–3.70**	**1.93–3.74**	**1.57–3.14**	**1.24–2.47**	**1.10–2.40**	**1.04–2.38**	0.69–3.00	0.89–1.77	**1.09–2.34**	0.91–1.70
Abdominal obesity (WtHR)	**2.72**	**2.66**	**2.32**	**2.41**	**2.17**	**1.87**	**1.77**	**1.91**	**1.57**	**2.40**	**1.49**	**1.67**	1.27
	1.95–3.82	**1.88–3.76**	**1.61–3.38**	**1.72–3.37**	**1.53–3.08**	**1.30–2.70**	**1.23–2.55**	**1.27–2.86**	**1.01–2.42**	**1.45–4.77**	**1.04–2.14**	**1.12–2.49**	0.87–1.81
Risk factors													
High-density lipoprotein cholesterol (*z*-score)	1.07	1.03	1.09	0.93	1.01	0.95	0.96	0.94	0.93	1.01	1.01	0.92	1.00
	0.88–1.30	0.85–1.25	0.89–1.34	0.76–1.13	0.82–1.23	0.77–1.16	0.78–1.18	0.74–1.19	0.72–1.20	0.65–1.57	0.82–1.24	0.73–1.15	0.82–1.23
Total cholesterol (*z*-score)	0.98	1.02	1.03	0.94	1.14	0.92	0.99	0.94	0.94	1.18	0.86	0.90	**0.79**
	0.81–1.19	0.84–1.23	0.84–1.26	0.77–1.15	0.93–1.39	0.75–1.12	0.81–1.22	0.74–1.18	0.73–1.21	0.76–1.83	0.70–1.05	0.72–1.13	**0.64–0.98**
Triglycerides (*z*-score)	**1.27**	**1.38**	1.17	1.21	**1.27**	1.09	**1.31**	0.94	0.99	1.00	**1.29**	**1.31**	0.84
	1.05–1.53	**1.13–1.67**	0.95–1.43	0.99–1.47	**1.04–1.54**	0.89–1.33	**1.07–1.61**	0.74–1.19	0.77–1.27	0.65–1.54	**1.05–1.58**	**1.05–1.65**	0.69–1.04
Insulin resistance, HOMA-IR (log *z*-score)	**1.24**	**1.33**	**1.23**	**1.18**	**1.29**	**1.19**	**1.29**	1.10	1.15	0.90	1.13	1.07	1.01
	1.06–1.44	**1.14–1.55**	**1.04–1.44**	**1.01–1.37**	**1.11–1.51**	**1.02–1.40**	**1.10–1.52**	0.91–1.33	0.94–1.40	0.63–1.27	0.96–1.33	0.89–1.28	0.86–1.17
C-reactive protein (percentile 75)	0.98	0.98	1.22	0.99	0.88	1.07	1.27	1.21	1.22	1.26	0.94	1.07	0.99
	0.63–1.54	0.62–1.54	0.75–1.98	0.62–1.56	0.55–1.40	0.67–1.72	0.79–2.06	0.70–2.07	0.68–2.17	0.45–3.31	0.59–1.52	0.63–1.81	0.61–1.61
Hypertension (≥95 percentile)	**2.15**	**2.08**	**2.18**	**1.96**	**2.35**	**2.07**	**1.77**	1.19	1.11	0.89	1.08	**1.68**	1.19
	1.44–3.21	**1.38–3.15**	**1.41–3.41**	**1.32–2.93**	**1.55–3.55**	**1.35–3.18**	**1.14–2.74**	0.71–1.95	0.64–1.89	0.31–2.26	0.70–1.66	**1.04–2.68**	0.70–1.66

BMI body mass index, *WtHR* waist-to-height ratio, *HOMA-IR* homeostasis model assessment of insulin resistance.
Bold indicates statistically significant results.
[a]Relative index of inequality was calculated using the most socioeconomically advantaged as reference group and adjusted for child's gender and mother's age.
[b]Relative index of inequality was calculated using the most socioeconomically advantaged as reference group and adjusted for child's gender and mother's age and individual-level socioeconomic indicators using a multilevel analysis.

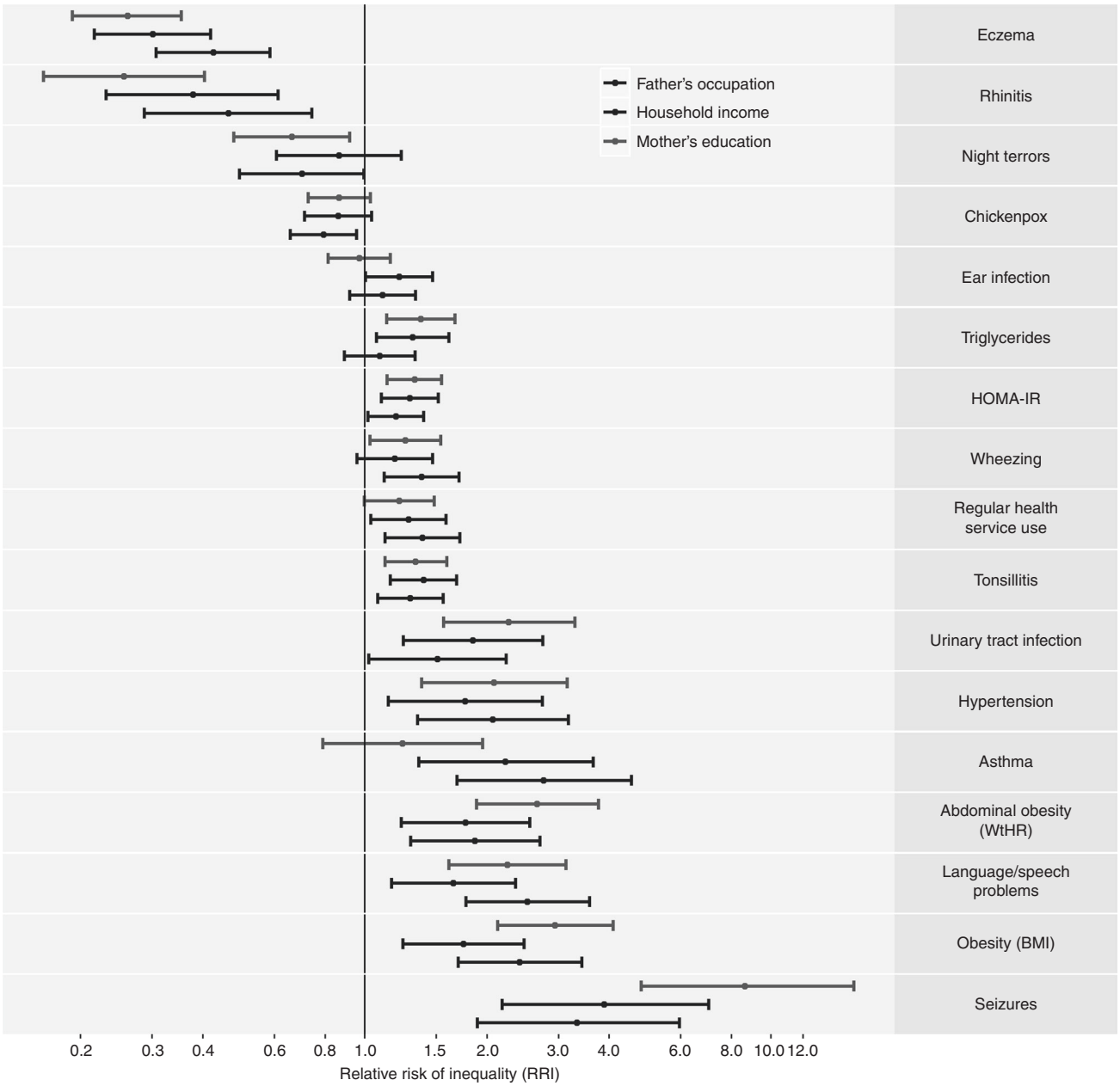

Fig. 1 Relative index of inequality (RII) and 95% confidence intervals (95% CIs) according to mother's education, father's occupation and household income (*x*-axis in log-scale). Only for the child's health outcomes with statistically significant socioeconomic inequalities.

tentative evidence that some of these inverse gradients could be the result of differential evaluation of these conditions or underuse of healthcare resources.

Another important finding of this study is the fact that at such an early life stage we found socioeconomic inequalities in language/speech development, which might impact school performance and the chances of future professional and economic achievement.[37] This finding demonstrates how important it is to act in early life to intercept the intergenerational transmission and perpetuation of the socioeconomic inequalities in health, especially because most of these developmental problems can be reversed if diagnosed prematurely.

Regarding the differential impact of socioeconomic indicators, we found that the traditional trio, parental education, occupation class and income, revealed the strongest associations. Most of the studies still rely on single socioeconomic indicators and, according to our findings, that fact might affect study results and be insufficient to control confounding by socioeconomic conditions. We also found that less frequently used indicators of household characteristics, crowding and home ownership, were also important.

Strengths

The broad nature of the study and the systematic evaluation of a wide range of socioeconomic and health indicators represents a major advantage. It helps to inform the literature about socioeconomic inequalities in health in early childhood providing a Southern Europe perspective, where very limited evidence exists. Moreover, it allowed us to compare the magnitude of those inequalities and to assess which health problems are more socially patterned. Some of these outcomes were self-reported, whereas others were objectively measured, which also allowed us to rebut the idea that health inequalities are a consequence of response bias. Multiple socioeconomic measures were used and we

established a core set (education, income and occupation), which was better at capturing health inequalities in early childhood in this period. This information can now be used as a guide for those that aim to incorporate socioeconomic indicators in their studies.

Limitations

Some of the health outcomes were self-reported, which raises concerns about potential response bias as the chances of diagnosis and reporting might be conditioned by the parental and family socioeconomic characteristics. Between baseline and the 4-year evaluation, 14% of the original cohort did not participate, which may lead to selection bias and to an underestimation of the socioeconomic inequalities, particularly since those from lower educational backgrounds were more likely to drop out. Our results are also affected by the fact that our socioeconomic indicators have different number of classes, although the calculations of RII (contrasting with other measures of association) minimize the problem of dealing with classes of unequal dimension. Finally, in this study, we did not assess the underlying mechanisms by which socioeconomic factors influence children' health outcomes (e.g. diet, birth weight, gestational age); subsequent studies conducted in this cohort should address these mediating variables.

CONCLUSIONS

Our results reinforce that the social gradient in health manifests early in childhood, meaning that current health inequalities in adulthood and late life may be part of a long causal chain with its roots in early childhood socioeconomic inequality. Therefore, early life health policies and interventions should be design to target all societal groups, but especially the most disadvantaged.

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AUTHOR CONTRIBUTIONS

Substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data: A.I.R. and H.B. Drafting the article or revising it critically for important intellectual content: A.I.R., S.F., L.C.-C., C.M. and H.B. Final approval of the version to be published: A.I.R., S.F., L.C.-C., C.M. and H.B.

ADDITIONAL INFORMATION

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