Effects of early-life poverty on health and human capital in children and adolescents: analyses of national surveys and birth cohort studies in LMICs

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Associated Data

Supplementary Materials

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Summary

The survival and nutrition of children and, to a lesser extent, adolescents have improved substantially in the past two decades. Improvements have been linked to the delivery of effective biomedical, behavioural, and environmental interventions; however, large disparities exist between and within countries. Using data from 95 national surveys in low-income and middle-income countries (LMICs), we analyse how strongly the health, nutrition, and cognitive development of children and adolescents are related to early-life poverty. Additionally, using data from six large, long-running birth cohorts in LMICs, we show how early-life poverty can have a lasting effect on health and human capital throughout the life course. We emphasise the importance of implementing multisectoral anti-

poverty policies and programmes to complement specific health and nutrition interventions delivered at an individual level, particularly at a time when COVID-19 continues to disrupt economic, health, and educational gains achieved in the recent past.

This is the second in a **Series** of four papers about optimising child and adolescent health and development

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Introduction

Massive inequalities in the distribution of wealth, both between and within countries, are a key challenge to sustainable development.[1] Despite progress in the alleviation of poverty in most parts of the world over the past three decades, wealth inequalities still exist, and several low-income countries have seen the incomes of the bottom 40% stagnating, or even decreasing.[2, 3] In a time trend analysis of 83 countries, the global average Gini index—weighted by national population size—increased from 36·7 in 2000 to 40·8 in 2015. This finding indicates that the average person was living in a country where inequality was on the rise.[4]

Addressing inequality is at the core of the Sustainable Development Goals[5] target of leaving no one behind.[6] Economic inequality is not only important per se, but it is also a major driver of health status, as is emphasised by initiatives aimed at tackling the social determinants of health.[7] In addition to how the poorest communities are at increased risk of illness and malnutrition, inequality affects the health of entire populations. Social gradients in health are ubiquitous, with stepwise increases in illness and mortality down the socioeconomic spectrum.[8]

There is ample literature on the effect of poverty during the life course in high-income societies. Birth cohort analyses, from countries such as the UK, New Zealand, USA, and Norway, point to the lifelong effects of material and psychosocial exposures on health and human capital.[9] By contrast, the literature from low-income and middle-income countries (LMICs) on such topics is scarce. Nevertheless, many (if not most) children currently living in LMICs experience suboptimal nurturing care,[10, 11] an innovative concept that encompasses child health, nutrition, learning, relationships, security, and safety. These five components of nurturing care are largely determined by poverty; a "cause of the causes"[12] of poor health and development. Exposure to adversity in early life,[9, 13] for which poverty is a proxy measure, is postulated to be a major driver of adequate nurturing care and of its consequences on human capital.

Key messages

- Data from low-income and middle-income countries (LMICs) substantiate the negative effects of early-life poverty on the survival, nutrition, and cognitive development of children and adolescents

- Analyses of long-term birth cohorts in LMICs show that early-life poverty is strongly and inversely associated with human capital indicators, such as adult height, achieved schooling, and intelligence

- By contrast, some risk factors for non-communicable diseases, including overweight and signs of metabolic syndrome in adults, are less common in men, but not in women, exposed to early-life poverty than in the rest of the population

- Broad and multisectoral anti-poverty policies and programmes need to be urgently strengthened to offset the impact of COVID-19 on poverty and to promote the health and development of children and adolescents, both in the short term and long term

The first paper in this Series used evidence from longitudinal studies to consider conditions of survival, growth, disability, and education in world regions and their effects on crucial periods in the lifecycle before adulthood that build the foundation for human capital.[11] In this second Series paper, we review data on key conditions related to human capital in children, adolescents, and adults, and analyse how early-life poverty contributes to their enduring prevalence throughout the life course. Using data from 95 national surveys in LMICs, we assess the presence and magnitude of social gradients in the health, nutrition, and cognitive development of children and adolescents, reflecting the accrual of human capital. Additionally, we use data from six large, long-running birth cohorts in LMICs to explore the long-term associations between early-life poverty and health and human capital outcomes in adulthood. In both sets of analyses, we use indicators related to the constructs of nurturing care and of human capital, including survival, health, nutrition, and cognition. We also report on selected conditions that affect an individual's ability to contribute to society, including stunted height[14] and obesity[15] in adulthood, teenage motherhood,[16] and psychological symptoms.[17] This information informs consideration of interventions, intersectoral approaches, and policies, which are addressed in the third[18] and fourth[19] papers of this Series.

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An analysis of 95 national surveys

The analyses of national surveys addressed the following five outcomes related to human capital in children and adolescents: mortality rate and prevalence of growth stunting in children younger than 5 years, not being on track for development in children aged 3–5 years (based upon the Early Childhood Development Index),[20] teenage motherhood (the proportion of women aged 20–29 years who had become mothers before age 20 years), and completion of primary school in girls aged 15–19 years. Teenage motherhood was included as a human capital indicator because it is associated with poor linear growth and with attained schooling, in not only mothers but also their children.[21, 22, 23]

National surveys with individual-level information on these outcomes and on household-level socioeconomic position, dated 2010 or later, were available for 95 LMICs. These countries included 28 (90%) of 31 low-income countries, 37 (79%) of 49 lower-middle-income countries, and 30 (50%) of 60 upper-middle-income countries. The median date for the surveys was 2014 (IQR 2013–2016). Details on the surveys, indicator definitions, and countries included in the analyses are available in the appendix (pp 1–8). Table 1 shows the median slope index of inequality (SII) values for each of the five outcomes, comparing across country income groups. Countries were arranged using the World Bank classification at the time of the survey,[24] with all estimates weighted by the number of children younger than 5 years in each country as of 2015.[25] Four of the five outcomes show the highest prevalence in low-income countries and lowest prevalence in upper-middle-income countries, with intermediate prevalence in lower-middle-income countries. The exception is teenage motherhood, which is frequent in some upper-middle-income countries with large populations, such as Mexico, Angola, South Africa, and Iraq. Spearman correlation coefficients for national-level associations with log gross domestic product per capita were negative and highly significant for all five outcomes. The full correlation matrix is available in the appendix (pp 9–109).

Table 1

Population-weighted slope index of inequality values for child and adolescent outcomes and Spearman correlation coefficients with national GDP per capita and Gini index for income distribution

	Mortality rate, deaths per 1000 live births[*†]	**Prevalence of growth stunting, percentage points**[†]	**Not-on-track development, percentage points**[‡]	**Teenage motherhood, percentage points**[§]	**Incomplete primary schooling, percentage points**[¶]
Number of countries	78	86	62	88	94

	Mortality rate, deaths per 1000 live births[*†]	**Prevalence of growth stunting, percentage points**[†]	**Not-on-track development, percentage points**[‡]	**Teenage motherhood, percentage points**[§]	**Incomplete primary schooling, percentage points**[¶]
with available data					
Country income group					
Low-income					
Median (IQR)	86·7 (75·1–98·3)	36·0 (33·2–38·9)	38·7 (34·8–42·7)	50·4 (45·9–54·8)	18·5 (10·4–26·6)
Number of countries	27	27	20	28	28
Lower-middle-income					
Median (IQR)	57·9 (49·9–65·8)	35·9 (33·4–38·4)	31·9 (26·7−37·1)	34·1 (30·0–38·1)	11·3 (6·4–16·1)
Number of countries	35	34	20	37	37
Upper-middle-income					
Median (IQR)	37·3 (25·4–49·3)	16·3 (12·5–20·2)	18·0 (15·1–20·8)	34·7 (29·7–39·7)	2·3 (0·9–3·6)
Number of countries	16	25	22	23	29
Log per capita GDP					
Correlation coefficient	−0·703	−0·667	−0·778	−0·617	−0·626
p value	<0·0001	<0·0001	<0·0001	<0·0001	<0·0001
Gini index					
Correlation coefficient	−0·148	−0·334	−0·375	−0·411	0·070
p value	0·22	0·0025	0·044	0·0001	0·56

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Estimates were weighted by the number of children younger than 5 years in each country, as of 2015. GDP=gross domestic product.

*Deaths in the 10 years preceding the date of the survey.

†Assessed in children aged <5 years.

‡Assessed in children aged 36–59 months.

§Assessed as the proportion of women aged 20–29 years who had become mothers before age 20 years.

¶Assessed in girls aged 15–19 years.

Additionally, we investigated the magnitude of inequalities within each country. Stratification by deciles produce more granular results than does breakdown by quintiles, and sample sizes for most national surveys allow for this more detailed analysis.[26] Analyses were done separately for each country (appendix pp 11–13). National results were then aggregated by world regions using the UNICEF classification,[27] with countries weighted by the number of children younger than 5 years or adolescents (aged 10–19 years) in 2015.[25] Results are presented as equiplots, in which each marker corresponds to the value of the outcome in each decile. The SII was calculated for each region; this index represents the slope, or beta statistic, of a regression of the outcome on the household wealth variable. SII might be interpreted as the difference between the richest and poorest extremes of wealth distribution, expressed in deaths per 1000 live births for mortality and in percentage points for the other four outcomes. For detrimental outcomes, SII values tend to be negative, indicating a decrease with increasing wealth (appendix pp 14–15). The SII is not a simple difference between prevalence or mortality in the wealthiest and poorest deciles, but a regression-based difference between the top and the bottom of the wealth scale.

The national Gini index for income distribution was inversely correlated with the SII for growth stunting, not being on track for development, and teenage motherhood (table 1), indicating that a larger inequality in income was associated with wider inequalities in these three adverse outcomes. Correlations between the Gini index and the mortality rate for children younger than 5 years or incomplete primary schooling were weak and non-significant. The full correlation matrix is shown in the appendix (p 10). Limitations of correlation analyses include potential bias introduced by missing data (although missing data are infrequent in most surveys) and by uncertainty in outcome measures. We opted not to adjust for confounding factors because both independent variables were deemed to be distal determinants of health and human capital outcomes, and we wanted to avoid adjustment for mediating factors. In relation to inequalities within each country, all SII values were negative, substantiating inverse associations between the five outcomes and family wealth (table 2). For example, the mortality rate for children younger than 5 years in west and central Africa was 85·7 deaths per 1000 live births lower for children at the top of the wealth scale than for those at the bottom, and the corresponding difference in prevalence of growth stunting was 35·9 percentage points. Further details on the SII values and full results are presented in the appendix (pp 8, 14–15).

Table 2

Population-weighted SII values for child and adolescent outcomes

	West and central Africa	**Eastern and southern Africa**	**Middle East and north Africa**	**Eastern Europe and central Asia**	**South Asia**	**East Asia and the Pacific**	**Latin America and the Caribbean**
Mortality rate in children aged <5 years, deaths per live births							
SII	−85·7	−26·2	−25·7	−26·2	−58·6	−54·4	−25·3
p value	<0·0001	<0·0001	<0·0001	<0·0001	<0·0001	<0·0001	<0·0001
Prevalence of growth stunting in children aged <5 years, percentage points							
SII	−35·9	−24·5	−12·3	−6·6	−35·8	−27·3	−25·8
p value	<0·0001	<0·0001	<0·0001	0·0003	<0·0001	<0·0001	<0·0001
Not-on-track development in children aged 36–59 months, percentage points							
SII	−30·6	−21·4	−10·1	−5·4	−23·6	−11·7	−12·2
p value	<0·0001	<0·0001	<0·0001	0·0005	<0·0001	<0·0001	<0·0001

	West and central Africa	Eastern and southern Africa	Middle East and north Africa	Eastern Europe and central Asia	South Asia	East Asia and the Pacific	Latin America and the Caribbean
Teenage motherhood, percentage points*							
SII	−47·3	−43·0	−30·1	−13·4	−34·9	−36·2	−42·6
p value	<0·0001	<0·0001	<0·0001	<0·0001	<0·0001	<0·0001	<0·0001
Incomplete primary schooling in girls aged 15–19 years, percentage points							
SII	−41·6	−22·9	−23·7	−0·7	−33·0	−4·7	−3·0
p value	<0·0001	<0·0001	<0·0001	0·0003	<0·0001	0·018	<0·0001

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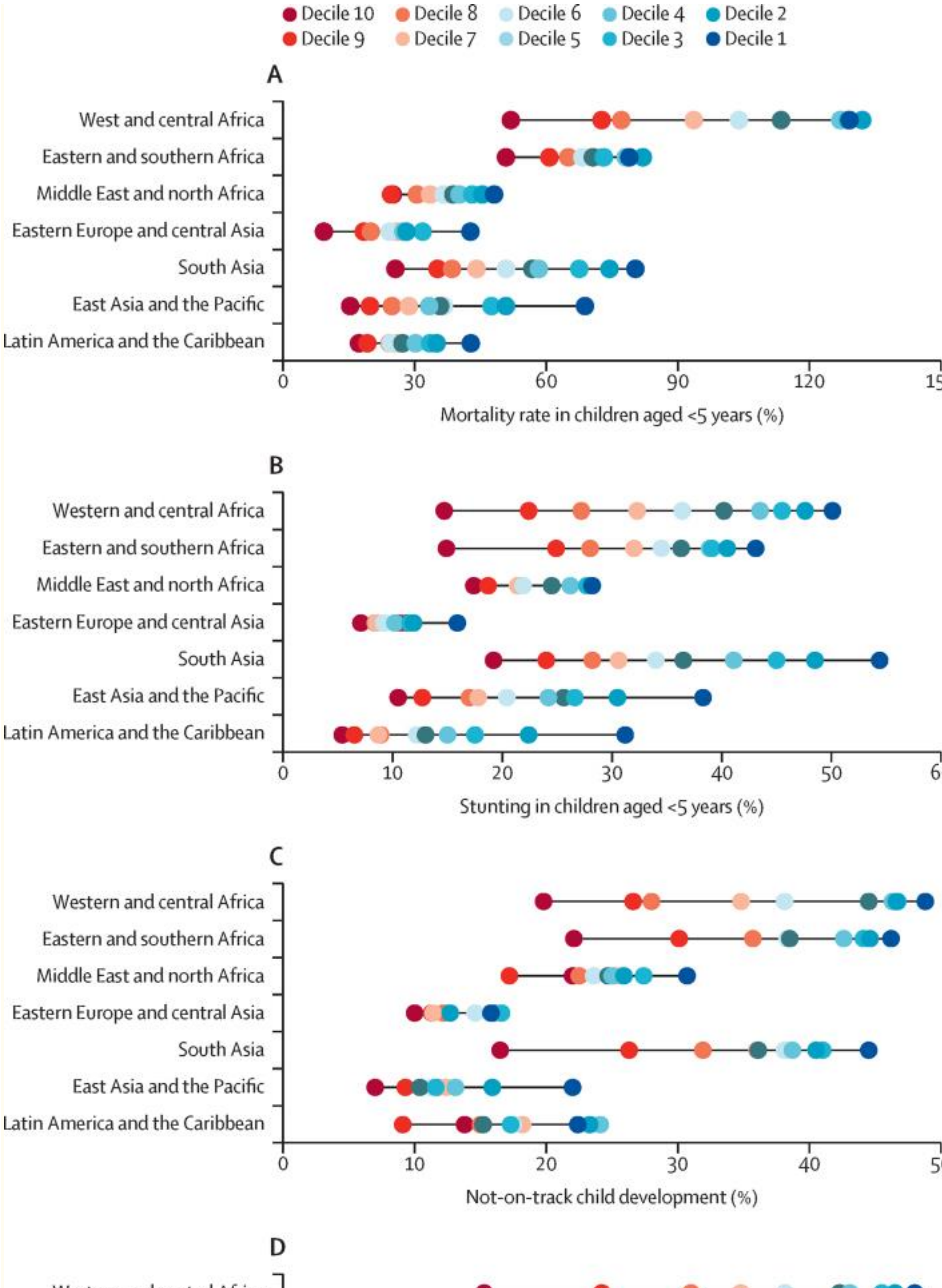
SII=slope index of inequality.

*Teenage motherhood was assessed as the proportion of women aged 20–29 years who had become mothers before age 20 years.

There were clear gradients in the mortality rate in children younger than 5 years by wealth decile in all regions, with the widest absolute gaps observed in west and central Africa, south Asia, and east Asia and the Pacific (table 2; figure 1). The SII, expressing the difference in the number of deaths per 1000 live births between the upper and lower ends of the wealth spectrum, ranged from –25·3 in Latin America and the Caribbean to –85·7 in west and central Africa (table 2). Comparing across regions, the mortality rates for children younger than 5 years ranged from 9·3 deaths per 1000 live births in the wealthiest decile in eastern Europe and central Asia to 132·0 deaths per 1000 live births in the second poorest decile in west and central Africa, a 14-times difference (appendix p 14). For benchmarking purposes, the mortality rate for children younger than 5 years in western Europe is currently estimated to be four deaths per 1000 live births,[28] which is lower than the rate in even the richest deciles in this analysis.



Decile 10
Decile 9
Decile 8
Decile 7
Decile 6
Decile 5
Decile 4
Decile 3
Decile 2
Decile 1
A
West and central Africa
Eastern and southern Africa
Middle East and north Africa
Eastern Europe and central Asia
South Asia
East Asia and the Pacific
Latin America and the Caribbean
0
30
60
90
120
Mortality rate in children aged <5 years (%)
B
Western and central Africa
Eastern and southern Africa
Middle East and north Africa
Eastern Europe and central Asia
South Asia
East Asia and the Pacific
Latin America and the Caribbean
0
10
20
30
40
50
Stunting in children aged <5 years (%)
C
Western and central Africa
Eastern and southern Africa
Middle East and north Africa
Eastern Europe and central Asia
South Asia
East Asia and the Pacific
Latin America and the Caribbean
0
10
20
30
40
Not-on-track child development (%)
D

Figure 1
Child and adolescent indicators according to wealth deciles by world region

Data taken from 95 national surveys performed between 2010 and 2019. Indicators include mortality rate (A) and prevalence of growth stunting (B) in children younger than 5 years, not-on-track development in children aged 36–59 months (C), teenage motherhood in women aged 20–29 years who had become mothers before age 20 years (D), and incomplete primary schooling among girls aged 15–19 years (E). Wealth by decile is presented in decreasing order from decile 10, representing the wealthiest decile, to decile 1, representing the poorest.

Gradients in prevalence of growth stunting were present in all regions, with the SII ranging from –6·6 percentage points in eastern Europe and central Asia to –35·9 percentage points in west and central Africa (figure 1). Different inequality patterns were observed in the two regions of sub-Saharan Africa (where inequality was largely driven by lower prevalence in the wealthiest decile than in the rest of the population), compared with the patterns observed in the regions of east Asia and the Pacific, and in Latin America and the Caribbean (where inequality was mostly driven by higher prevalence in the poorest decile relative to all other deciles). Across regions, stunting prevalence showed a ten-times difference, ranging from 5·5% in the wealthiest decile in Latin America and the Caribbean to 54·4% in the poorest decile in south Asia. In a well nourished population, around 2·5% of children would be classified as having stunted growth based on the normal distribution,[29] a prevalence that is well below those described in table 2 for any decile.

Data on early child development were available for 66 countries (figure 1), with national surveys that applied the Early Childhood Development Index (appendix p 7).[20] There were marked socioeconomic inequalities in most regions, with inverse associations between family wealth and developmental delays. Compared with 19·8% in the wealthiest decile, 48·8% of children in the poorest decile across west and central Africa presented developmental delays, with the SII equalling –30·6 percentage points. In the Middle East and north Africa and in Latin America and the Caribbean, prevalence of these delays did not decrease monotonically with growing wealth; however, inverse associations were significant (SII −10·1 percentage points for the Middle East and north Africa and −5·4 percentage points for Latin America and the Caribbean). Across the world's regions, prevalence of developmental delays ranged from 7·0% in the wealthiest decile in east Asia and the Pacific to 48·8% in the poorest decile in west and central Africa, a seven-times difference.

Four outcome indicators were also analysed by sex. In most regions, boys were more likely to die, have stunted growth, and present developmental delays than were girls. Similar findings on mortality[30] and stunting[31] have been reported previously. Data on schooling for both sexes were available for 56 countries. In south Asia and in west and central Africa, boys were more likely to have completed primary school than were girls; however, this was not the case for the remaining regions (appendix p 16).

In all regions, girls from poor families were the most likely to become teenage mothers (figure 1D). The widest gap was in west and central Africa, where frequency of teenage motherhood in the poorest decile was 67·2% and that in the wealthiest decile was 21·4%. The narrowest gap was observed in eastern Europe and central Asia, where overall frequency of teenage motherhood was the lowest of all regions, ranging from 23·6% in the poorest decile to 9·4% in the wealthiest decile. Across regions, frequency of teenage motherhood ranged from 5·7% in the wealthiest decile in east Asia and the Pacific region to 67·2% in the poorest decile in west and central Africa, a 12-times difference.

Except in regions where primary schooling was universal or nearly so (figure 1)—including eastern Europe and central Asia, Latin America and the Caribbean, and east Asia and the Pacific—there were substantial gaps in education for girls according to wealth. In west and central Africa, the proportion of girls who did not complete primary education ranged from 44·0% in the poorest decile to 5·7% in the wealthiest decile. In south Asia, the corresponding range was 35·0% to 1·9%.

The analyses of national surveys have limitations. First, deciles are relative rather than absolute measures of socioeconomic position. The poorest decile in a given country might correspond, in terms of absolute wealth, to the third or fourth decile in a low-income country. However, relative poverty is as important in predicting deprivation[32] and health status[33] as is absolute poverty. Second, weighted results are heavily influenced by countries with large populations, such as India; however, unweighted results would give each country (eg, Nigeria and São Tomé and Príncipe) equal weights in the west and central Africa region. Third, there are data gaps in terms of countries that do not have standardised surveys from 2010 onwards, including half of upper-middle-income countries, such as China and Brazil. Finally, although the early indicator for child development used in national surveys is not sufficiently validated, it has proven to be useful for comparing groups of children, as opposed to comparing individual children.[34]

Previous analyses of child mortality,[35] nutritional status,[36, 37] and development[34, 38] used stratification by wealth quintiles rather than deciles, with the exception of an analysis of growth stunting that included surveys up to 2013.[26] Use of deciles has shown distinctive social gradients in these three outcomes within every region of the world, particularly in the two sub-Saharan Africa regions and in south Asia. By contrast, the narrowest gaps were found in eastern Europe and central Asia, which had the lowest prevalence for all outcomes.

Additionally, use of deciles has allowed us to identify groups at particularly high risk. In east Asia and the Pacific, children in the poorest decile were at substantially higher risk of mortality, growth stunting, and developmental delay than those in the second poorest decile. The same finding was observed for growth stunting in Latin America and the Caribbean. In the two sub-Saharan African regions, children in the poorest four deciles or so had similar levels of risk for most outcomes, indicating that the widespread poverty in this region affects a large proportion of their populations.

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Effects of women's empowerment

Early-life poverty is a comprehensive indicator of early child adversity,[13] for which plentiful data are available. Family wealth is used as the main marker for early-life adversity in our analyses; however, there are other important dimensions of adversity, including women's empowerment, which is associated with mortality rates and prevalence of growth stunting in their children younger than 5 years (figure 2).

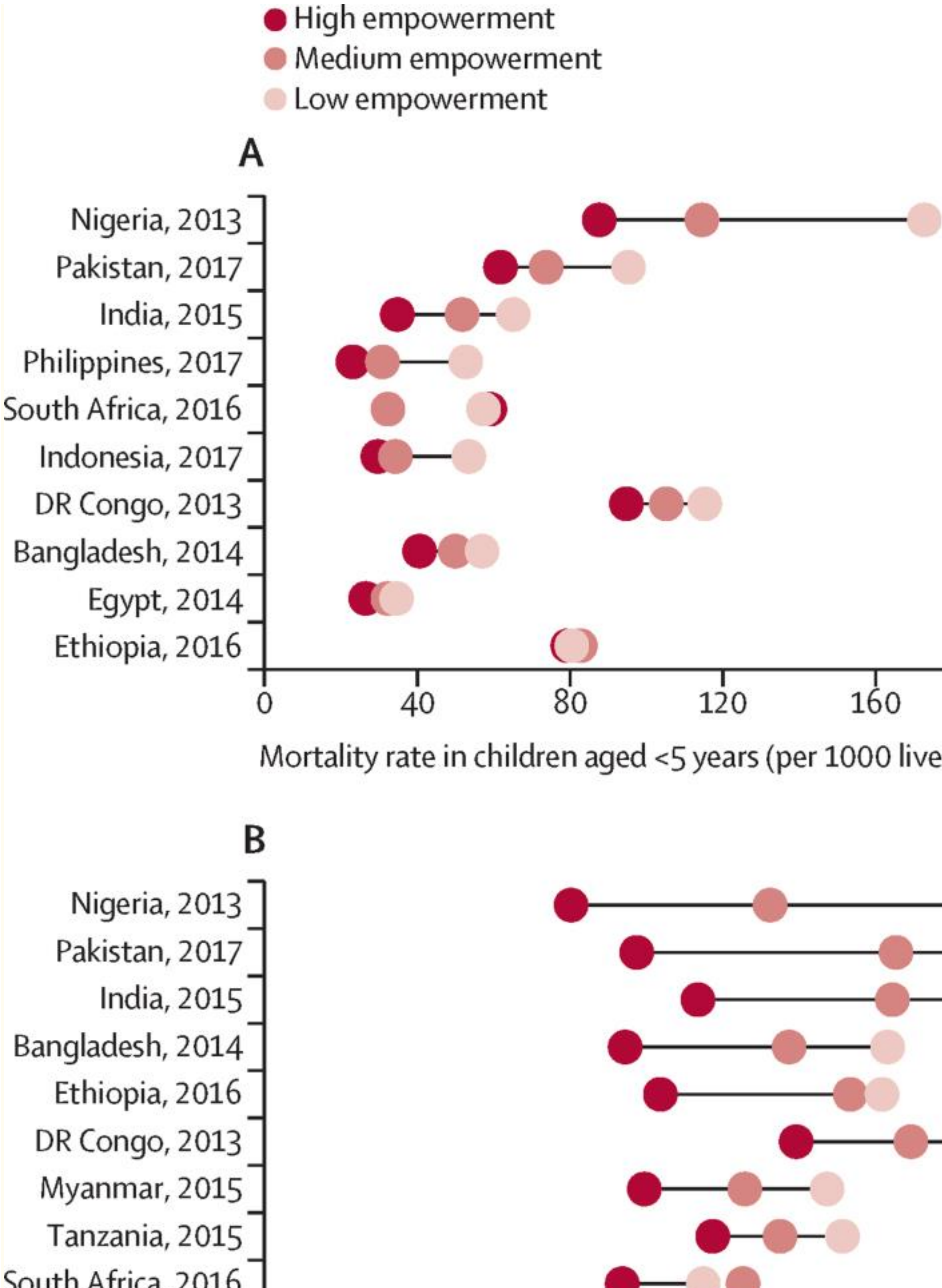
High empowerment
Medium empowerment
Low empowerment
A
Nigeria, 2013
Pakistan, 2017
India, 2015
Philippines, 2017
South Africa, 2016
Indonesia, 2017
DR Congo, 2013
Bangladesh, 2014
Egypt, 2014
Ethiopia, 2016
0
40
80
120
160
Mortality rate in children aged <5 years (per 1000 live
B
Nigeria, 2013
Pakistan, 2017
India, 2015
Bangladesh, 2014
Ethiopia, 2016
DR Congo, 2013
Myanmar, 2015
Tanzania, 2015

Figure 2
Associations between women's empowerment and child indicators in the ten most populous countries with available data

Indicators include the mortality rate (A) and prevalence of growth stunting (B) in children younger than 5 years.

We used the Survey-based Women's emPowERment (SWPER) global index[39] to categorise women in terciles according to their level of empowerment, and correlated these terciles with mortality and prevalence of growth stunting in their children in the ten most populous countries with available data (figure 2). We opted to use the social independence domain of the SWPER score because it is more closely associated with child health outcomes than are the other two domains—namely, attitudes towards violence and decision making.[39] Growth stunting and mortality in children younger than 5 years were selected as the outcomes because large numbers of countries have data available.

Social independence reflects a woman's level of educational attainment, frequency of reading information (ie, newspapers or magazines), age at first childbirth, and age at first cohabitation, as well as differences in educational attainment and age between a woman and her partner (appendix p 8). In nearly all countries studied, there were stepwise increases in mortality and prevalence of growth stunting in children younger than 5 years as maternal empowerment decreased.

Our findings represent a likely effect of the level of maternal empowerment on mortality in children younger than 5 years, which is consistent with published results on women's empowerment and child mortality in 59 countries.[40] Furthermore, these findings show that similar, if not stronger, associations exist between the level of maternal empowerment and prevalence of growth stunting in offspring. Interventions aimed at empowering women have an important role in improving the health and nutrition of their children.

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Analyses of six birth cohort studies

To assess how strongly exposure to early-life poverty predicted adult health and human capital outcomes in LMIC contexts, we reanalysed data from the six longest-running births cohorts in LMICs, the COHORTS consortium, which had at least 1000 participants at recruitment and frequent visits in early life (table 3).[41] All cohorts were population-based, yet socioeconomic inequality was less marked in the urban poor cohort from Soweto, South Africa, and in the rural poor cohort from Guatemala than in the other four settings.

Table 3

SII values for health, nutrition, and human capital outcomes according to early-life poverty

	Men						**Women**					
	Cebu	**Delhi**	**Guatemala**	**Pelotas (1982)**	**Pelotas (1993)**	**Soweto**	**Cebu**	**Delhi**	**Guatemala**	**Pelotas (1982)**	**Pelotas (1993)**	**Soweto**
Desirable outcomes												
Length at age 2 years, Z score												
SII	1·01	1·73	0·53	1·80	1·51	0·81	0·56	1·68	0·47	1·6	1·07	0·66
p value	<0·0001	<0·0001	0·0033	<0·0001	<0·0001	<0·0001	<0·0001	<0·0001	0·0073	<0·0001	<0·0001	<0·0001
Height at age 4 years, Z score												
SII	0·65	1·5	0·35	1·68	1·16	0·71	0·56	1·64	0·44	1·49	0·94	0·36
p va	<0·0001	<0·0001	0·016	<0·0001	<0·0001	<0·0001	<0·0001	<0·0001	0·0022	<0·0001	<0·0001	0·0013

	Men						Women					
	Cebu	**Delhi**	**Guatemala**	**Pelotas (1982)**	**Pelotas (1993)**	**Soweto**	**Cebu**	**Delhi**	**Guatemala**	**Pelotas (1982)**	**Pelotas (1993)**	**Soweto**
lue												
Cognitive quotient at age 4·0–8·5 years, Z score												
SII	0·80	..	0·28	1·24	0·98	0·98	0·58	..	0·28	1·44	1·00	0·43
p value	<0·0001	..	0·057	<0·0001	<0·0001	<0·0001	<0·0001	..	0·036	<0·0001	<0·0001	0·0044
Adult height, cm												
SII	3·1	4·2	4·3	6·8	5·0	2·3	1·9	3·1	1·5	5·4	3·0	−0·9
p value	<0·0001	<0·0001	<0·0001	<0·0001	<0·0001	0·018	0·0021	0·0005	0·0404	<0·0001	<0·0001	0·32
Achieved schooling, years												
SII	3·7	4·7	1·9	6·5	3·6	0·3	1·7	3·7	2·0	8·0	2·9	0·4
p value	<0·0001	<0·0001	0·0005	<0·0001	<0·0001	0·18	<0·0001	<0·0001	<0·0001	<0·0001	<0·0001	0·035
Adult intelligence, intelligence quotient points*												
SII	13·2	..	4·8	22·1	20·5	9·8	6·9	..	4·7	24·8	16·0	6·9
p value	<0·0001	..	0·054	<0·0001	<0·0001	<0·0001	0·0019	..	0·0070	<0·0001	<0·0001	0·0023
Undesirable outcomes												
Teenage motherhood, percentage points												
SII	..	..	..	..	..	..	11·7	6·8	2·4	−39·6	−24·9	..

	Men						Women					
	Cebu	Delhi	Guatemala	Pelotas (1982)	Pelotas (1993)	Soweto	Cebu	Delhi	Guatemala	Pelotas (1982)	Pelotas (1993)	Soweto
p value	..	..	..	..	..	..	0·063	0·057	0·72	<0·0001	<0·0001	..
Psychological symptoms, number of symptoms												
SII	−0·4	..	0·5	−1·1	−1·1	0·2	0·8	..	0·6	−2·6	−1·4	0·6
p value	0·28	..	0·31	<0·0001	<0·0001	0·73	0·099	..	0·26	<0·0001	<0·0001	0·40
Prevalence of overweight or obesity, percentage points												
SII	30·4	26·7	5·9	11·6	20·7	14·5	17·3	9·0	−10·4	−16·2	−18·3	1·3
p value	<0·0001	0·0008	0·48	0·0050	<0·0001	0·0092	0·016	0·37	0·060	<0·0001	<0·0001	0·84
Metabolic score, number of signs												
SII	−0·3	0·5	−0·1	0·2	0·1	0·1	0·1	0·2	−0·3	−0·2	−0·4	−0·2
p value	0·10	0·049	0·59	0·0402	0·54	0·29	0·42	0·48	0·078	0·0059	<0·0001	0·24

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Values represent the difference in the outcome between the wealthiest and poorest ends of the socioeconomic distribution of households. SII=slope index of inequality.

*Normalised score (mean 100 [SD 15]).

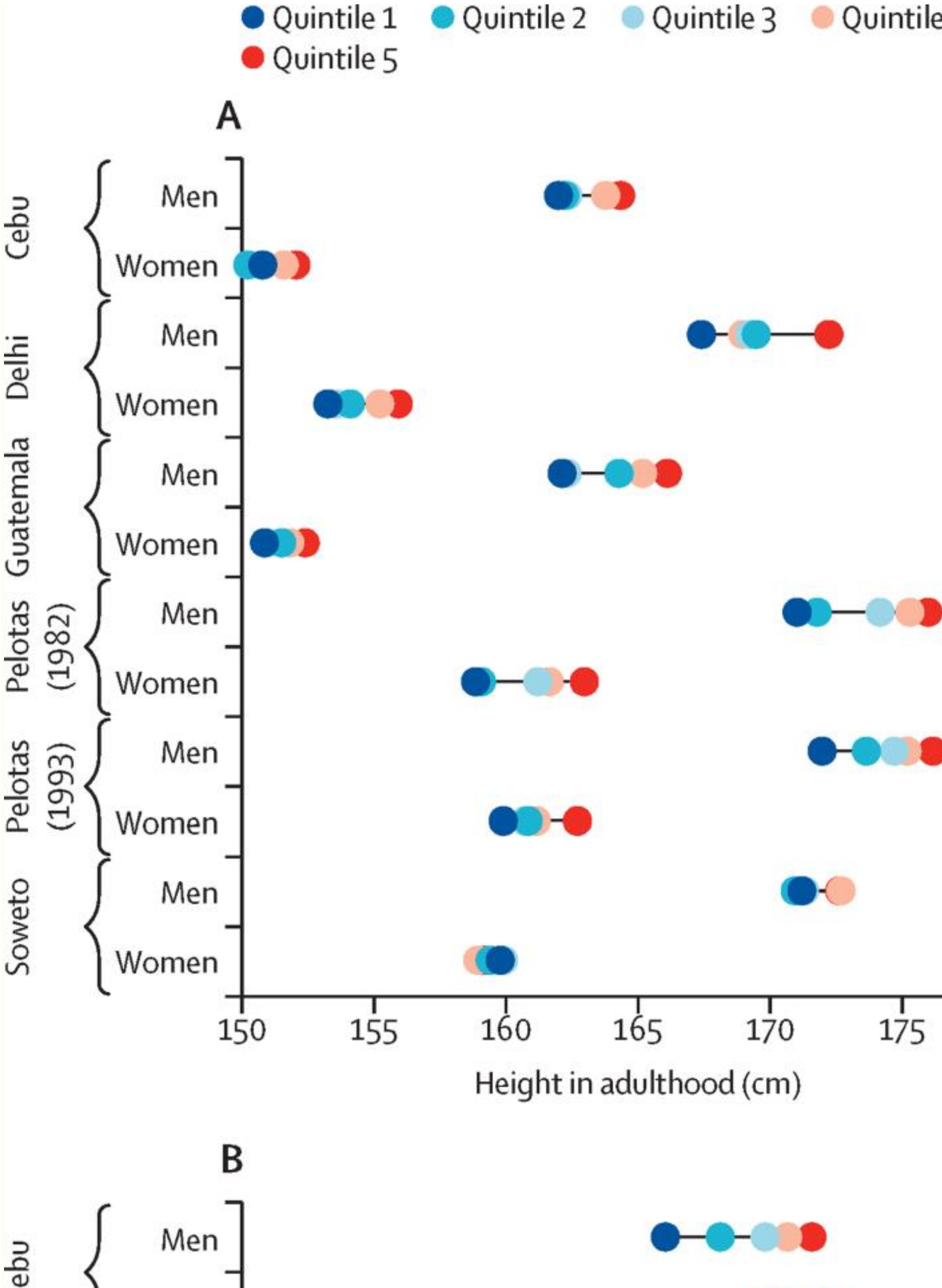
Information on early-life socioeconomic position was based on family income in Cebu, Philippines; Delhi, India; and Pelotas, Brazil, in the 1982 and 1993 cohorts, and on asset indices in Guatemala and Soweto. Quintiles rather than deciles were used in the analyses because of sample size limitations. All analyses were stratified by sex. Details on the samples, variables, and analytical methods are available in the appendix (pp 17–19).

The first step was to verify whether the social patterns for child length and development, which were measured in the 1990s or earlier in each cohort, were consistent with the results from the survey analyses. Length measures were taken during early childhood (age 1·0–2·0 years) and height was measured in middle childhood (age 4·0–8·5 years). Different child development scales were used in each site at age 4·0–8·5 years and were converted into cognitive quotient Z scores, with a mean of 0 (SD 1) in each site (appendix p 18).

The SII was calculated to express the difference in outcome measures between the upper and lower ends of the scale of socioeconomic position (table 3). In all cohorts with data, results were consistent with the national survey analyses, showing important social gradients in child height and development (appendix pp 20–22). The SII values suggest that social gradients were widest in Pelotas and Delhi, intermediate in Cebu and Soweto, and narrowest in Guatemala.

Indicators were selected to cover different components of human capital—namely, health, nutrition, and intelligence, for which data were available for adults from most or all cohorts at ages ranging from 22 years to 57 years (appendix p 17). Outcomes included height, years of schooling, intelligence quotient, teenage motherhood, psychological symptoms (using the Self-Reported Questionnaire scale), prevalence of overweight or obesity (body-mass index ≥25 kg/m^2), and the number of signs of metabolic syndrome. More information on definitions and tests used are available in the appendix (p 18).

Positive significant social gradients in height were found in all six cohorts for men and in five cohorts for women, with Soweto as the exception (table 3; figure 3). Similar gradients were observed for attained schooling in the six cohorts for women and in five cohorts for men, again except for Soweto where there was little variability in this indicator (mean 11·7 years [SD 1·5]). Intelligence results were available in all cohorts except for in Delhi, showing positive social gradients in all studies. Of note, the SII value for men from Guatemala had a significance level of p=0·0537.



Quintile 1
Quintile 2
Quintile 3
Quintile
Quintile 5
A
Cebu
Men
Women
Delhi
Men
Women
Guatemala
Men
Women
Pelotas (1982)
Men
Women
Pelotas (1993)
Men
Women
Soweto
Men
Women
150
155
160
165
170
175
Height in adulthood (cm)
B
ebu
Men

Figure 3
Distribution of adult indicators by wealth quintile in the six birth cohorts

Indicators include height (A), attained schooling (B), and intelligence quotients (C) in adulthood in both men and women. Wealth by quintile is presented in increasing order from quintile 1, representing the poorest quintile, to quintile 5, representing the richest.

Social gradients for teenage motherhood, prevalence of overweight or obesity, number of metabolic signs, and number of psychological symptoms were not clear (table 3; appendix pp 23–26). Both cohorts in Pelotas showed inverse social gradients for teenage motherhood, yet results were not significant for the other cohorts. Number of psychological symptoms was inversely related to wealth in men and women from Pelotas, but again not in the other cohorts.

Prevalence of overweight and obesity tended to be directly associated with wealth in men in five cohorts, and metabolic signs showed a similar social patterning in men from the Delhi cohort and the Pelotas 1982 cohort. By contrast, prevalence of overweight and obesity and number of metabolic signs were inversely and significantly associated with wealth in both cohorts of women from Pelotas. In the cohort from Guatemala, there were borderline inverse associations with overweight and obesity (p=0·06) and for metabolic signs (p=0·08). In Cebu, prevalence of overweight and obesity was directly associated with wealth in men and women.

Additional evidence on the effects of early-life poverty is provided by the Young Lives study,[42] which included cohorts of children from Ethiopia, India, Peru, and Vietnam recruited at age 6–18 months. A social gradient in growth stunting was present at recruitment and persisted until the final measurement at age 12 years.[43] Similar social gradients were present for the children's vocabulary, from first measurement at age 5 years to final measurement at age 12 years.[43] Trajectory analyses based on measurements at age 1–15 years showed that high wealth quartiles were protective against trajectories of stunting; however, high wealth and urban residence quartiles predicted trajectories of overweight.[44]

A limitation of our analyses is that we used either income or asset indices to measure poverty on the basis of available data from each cohort. Although both indicators are closely related, their constructs are different. For most variables, socioeconomic gaps were wider in the two cohorts from Pelotas than in other sites. These gaps were likely to be due to the remarkable scale of income inequality in Brazilian society and to how both cohorts covered the whole population of a city. In 1982 and 1993, average income in the richest quintile was 12 or more times higher than in the poorest quintile. The larger sample sizes for both Pelotas cohorts also increased the likelihood of obtaining statistically significant differences. The selective nature of some cohort samples was made evident by a comparison of results of national surveys with those from the cohorts in the same country. For example, the survey in Guatemala showed remarkably wide inequality in growth stunting in children (appendix p 11), whereas there was relatively little inequality in the cohort from four rural villages (table 3).

There were instances of heterogeneity in the magnitude and sometimes the direction of associations between early-life poverty and adult outcomes. It is reassuring that for key outcomes, such as height, schooling, and intelligence, results were highly consistent; however, this was not the case for the indicators of morbidity. Like all long-term cohorts, particularly in LMICs, losses to follow-up can be substantial.[41] Of note, the median age of cohort members at the most recent follow-up ranged from 22 years in the 1993 Pelotas cohort to 57 years in Guatemala, a difference that should be taken into account when considering outcomes, such as prevalence of overweight and obesity, number of psychological symptoms, and number of metabolic signs. In addition, metabolic signs included five separate indicators and future analyses are required to reach conclusions on their causes. Furthermore, our analyses on early-life poverty did not consider socioeconomic trajectories, and there is evidence that adult outcomes might differ between individuals whose socioeconomic position remains the same and those whose socioeconomic position improves over time.[45]

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Conclusions and implications

Our analyses provide considerable documentation of pervasive social gradients in the survival, health, nutrition, and cognitive development of children, as well as in teenage motherhood and in girls' education. The analyses of 95 national surveys confirmed the importance of gross domestic product in predicting levels of the five outcomes under study. Within countries, we were able to document consistent, stepwise social gradients in human capital indicators in children and adolescents from LMICs. Of the 35 analyses of five outcomes in seven world regions, 30 (86%) showed at least a doubling of the risk of the detrimental outcome in the poorest decile compared with the richest decile, and in 17 (49%) comparisons, the ratio was more than three times higher. Furthermore, the magnitude of inequality in child mortality, nutrition, and development was positively associated with the degree of economic inequality in each country. These analyses substantiate that children and adolescents are being gravely affected by socioeconomic inequality between and within countries.

Results from six large population-based birth cohorts in five LMICs substantiate that the effects of early-life poverty are—for the most part—persistent, generating wide gaps in health and human capital across the life course. Linear growth and cognitive development in early life showed well defined social gradients in all cohorts. These outcomes, measured between the 1970s and 1990s, support our findings from national surveys. As cohort participants became older, social gradients varied according to the type of outcomes. Indicators related to a narrower definition of human capital, such as the one adopted by the World Bank,[46] including survival, growth, schooling, and intelligence, showed clear positive gradients in virtually all analyses by cohort and sex. Some differences were striking; for example, intelligence quotient was around 20 points higher in individuals at the top of the wealth scale than in those at the bottom in the two cohorts from Pelotas. As reported in the first paper in this Series,[11] and supported by the national survey analyses in this second Series paper, social gradients in cognition are already present in young children (aged <5 years). Although differences in the length and quality of schooling are likely to play a key role, many factors in the environment that disadvantaged children face, starting in gestation, contributes to their underperformance.[10]

By contrast, adult outcomes reflecting a broader definition of human capital, which also incorporates physical and mental health, did not present such clear results. There were inverse social gradients for teenage motherhood and psychological symptoms in the cohorts from Pelotas, but not in the other cohorts. The negative effect of early-life poverty on mental health, at least in some settings, could be an important mechanism for intergenerational transmission of poverty by affecting parental ability to provide nurturing care to their children.[47]

Prevalence of overweight and obesity in men tended to increase with early-life socioeconomic position in most cohorts, and similar patterns were present for metabolic signs in the two cohorts from Pelotas. In our analyses, these outcomes were the only ones that were detrimental in adults, and had the highest prevalence in the wealthiest deciles. By contrast, in women from Pelotas and Guatemala, but not Cebu, the findings for number of metabolic signs and prevalence of overweight and obesity were in the opposite direction. The literature suggests that the social patterns of overweight prevalence change as the nutrition transition progresses.[48] When undernutrition is common, men and women from wealthy deciles tend to show the highest prevalence of overweight and obesity. Over time, this pattern reverses in women, whereas the original pattern remains for men in the same population. Furthermore, when the transition is complete, both men and women show inverse social gradients.[49, 50] Our findings suggest that the six cohorts could have been at different stages in the transition, with Cebu showing the traditional pattern of increasing overweight with wealth, Soweto and Delhi in a phase where there was a direct association for men but no social patterning for women, and Guatemala and Pelotas showing a direct association in men and an inverse association in women. None of the cohorts had reached the final stage in the transition when both men and women showed inverse patterns. The Sustainable Development Goals include targets related to both non-communicable diseases and human capital.[51] We have shown that, although early-life poverty is clearly detrimental for human capital, it might be paradoxically associated with a decreased risk of some chronic conditions, at least in men.

Taken together, our findings show clear and positive social gradients in the traditional outcomes of human capital (eg, attained height, intelligence, and attained schooling); mixed results for a broader set of outcomes, including teenage pregnancy and mental health; and increased risk of overweight or obesity and other metabolic conditions in men born to wealthier families. Although early-life poverty has a negative effect on most indicators of adult human capital, the social gradients can be inverted, at least regarding overweight, obesity, and signs of metabolic syndrome in men.

We observed sex differences in several outcomes, which might reflect biological differences and gender norms. In children, boys were more likely to die,[52] have growth stunting,[53] and present developmental delays than were girls,[54] which is probably due to their greater biological frailty.[55] In all but one world region, and in five of the six cohorts, girls had higher schooling than did boys, which is a common finding in many countries and probably reflects gender norms associated with the early entry of boys in the labour market and possibly with compliance with school discipline.[56] In terms of adult outcomes, as found in studies from many parts of the world, women presented more psychological symptoms than did men in all cohorts. This finding is attributed to a combination of higher levels of stress experienced by women and reluctance to report mental health difficulties in men.[57,58] Furthermore, in five of the cohorts, men in the wealthiest decile had the highest prevalence of overweight and obesity, whereas the reverse was observed in women in three cohorts.

Without a considerable reduction in social disparities, particularly in countries with high poverty and inequality, the world is unlikely to meet the Sustainable Development Goal of ending extreme poverty by 2030. Although global poverty has decreased since 1990,[3] most of the world's population nowadays is likely to live in an economy with higher inequality than they did 25 years ago.[4] In addition, national levels of inequality were more widely variable around the global mean in the past than they are now, as highly unequal countries become more equal, and more egalitarian countries become less so.[4] The health effects of socioeconomic inequality are likely to be felt worldwide.

Our findings should be interpreted in conjunction with the results of the other papers in this Series.[11, 18, 19] In particular, the third Series paper[18] reviews effective interventions within the health and nutrition sectors aimed at improving human capital. It also reviews broader intersectoral interventions aimed at social determinants, which are supported by the findings presented here showing how early-life poverty shapes the development of human capital. Achieving high and effective coverage with specific interventions is essential, and their effect will be complemented and amplified by broader anti-poverty interventions, including conditional and unconditional cash transfers, minimum wage policies, child benefits, and universal health care. Our analyses are intended to contribute to policies and programmes aimed at reducing poverty and promoting equity through targeting interventions at children and adolescents who are currently being left behind.

Early-life poverty affects children within a context that is increasingly defined by war and conflict,[59] global inequality,[7] climate change,[60] disparities between ethnic groups,[61] and damaging gender norms.[62] On top of such pre-existing threats, interactions between the COVID-19 syndemic and social determinants[63] have resulted in the exacerbation of socioeconomic inequalities, thus threatening recent, albeit modest, progress in the health and education of children and adolescents. The challenges that children of today will confront during their life course are unparalleled. A fair start in life is essential to ensure that all children are optimally enabled to face these global challenges.

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Search strategy and selection criteria

For analyses of the associations between poverty and health, nutrition, and development outcomes in children and adolescents, we searched the comprehensive Countdown to 2030 survey database, which is also included in WHO's Health Equity Monitor website. The Countdown to 2030 database includes over 450 publicly available demographic and health surveys from over 120 countries. We identified 440 nationally representative surveys with publicly available data from 127 countries, from which we selected all surveys done between 2010 and 2019 with information on household socioeconomic position and the indicators for children and adolescents required for our analyses. 95 countries had these surveys and were included in the analyses.

Analyses of the associations between early-life poverty and outcomes in adulthood were based on collaborative data collection of six birth cohorts from low-income and middle-income countries. In 2006, in preparation for the 2008 *Lancet* Maternal and Child Undernutrition Series, we carried out a systematic search of large long-term, prospective birth cohort studies in LMICs with information on early life and adult variables. We excluded studies with fewer than 1000 subjects or with poor methodological quality. Only five studies qualified for the original pooled analyses. In 2021, a sixth study was included when the 1993 birth cohort study from Pelotas, Brazil, completed 18 years of follow-up. The six studies provided the data for the present analyses.

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Declaration of interests

REB serves on the Board of Vitamin Angels, a non-profit charitable organisation supporting maternal and child nutrition services in LMICs. AS and ADS report grants from Bill and Melinda Gates Foundation. AS reports grants from the Wellcome Trust. ZAB reports grants from the International Development Research Centre (reproductive, maternal, newborn, child, and adolescent health in conflict settings: case studies to inform implementation of interventions) and Countdown to 2030–UNICEF. All other authors declare no competing interests.

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Contributors

CGV conceptualised and coordinated the analyses, prepared the first draft of the paper, responded to reviewer comments, and incorporated all revisions until publication. REB, ZAB, ADS, RM, and LMR contributed to the conceptualisation and overall guidance of the analyses and writing of the report. FPH, LPV, AJDB, and CO contributed to the data analyses. The main investigators of the COHORTS consortium—including LSA, FCB, SKB, BLH, MFK-L, NRL, AMBM, JM, SAN, HSS, ADS, AS, and JSV—provided the data. All authors have reviewed and approved the final version of the manuscript. CGV had full access to all the data in the study and final responsibility for the decision to submit for publication.

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Supplementary Material

Supplementary appendix:
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