Pervasive inequality threatens the future of today's children:

Short and long-term effects of early-life poverty

(analyses of national surveys and birth cohort studies in LMICs)

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Unstructured Abstract

The survival and nutrition of children, and to a lesser extent of adolescents, improved substantially in the past two decades. Improvement has been linked to the delivery of effective biomedical, behavioral and environmental interventions, among others. Yet, large disparities remain between and within countries. Using data from 95 recent national surveys in low- and middle-income countries (LMICs), we document how strongly the health, nutrition and cognitive development of children and adolescents are related to early-life poverty. Next, using data from six large, long-running birth cohorts in LMICs, we show how early-life poverty can have a lasting effect along the life course in terms of health and human capital. We highlight the importance of broad, multi-sectorial antipoverty policies and programs, as complementary to specific health and nutrition interventions delivered at individual level, particularly at a time when COVID-19 is disrupting economic, health and educational gains achieved in the recent past.

Key messages

- Recent data from low and middle-income countries (LMICs) confirm the negative impact of early-life poverty to the survival, nutrition, and cognitive development of contemporary 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.
- In contrast, some risk factors for non-communicable diseases – including adult overweight and metabolic syndrome signs - are less common among children exposed to early-life poverty than among the rest of the population.
- Broad, multi-sectoral antipoverty policies and programs 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 and long term.

Introduction

Massive inequalities in the distribution of wealth, 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 the past decades, wealth inequalities remain rampant, and several low-income countries have seen the incomes of the bottom 40 percent stagnating, or even declining.[2,3] In a recent time-trend analysis of 83 countries, the global average Gini index - weighted by national population size - increased from 36.7 to 40.8 from 2000 to 2015. This 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] motto of "leave no one behind".[6] Economic inequality is not only important per se, but it is also a major driver of health status as is emphasized by initiatives aimed at tackling the social determinants of health.[7] Moreover, it is not only the poorest of the poor who are at increased risk of illness and malnutrition, but inequality affects the health of entire populations. Social gradients in health are ubiquitous, with stepwise increases in illness and mortality as one moves 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 the United Kingdom, New Zealand, United States and Norway, among others, point to the life-long effects of material and psychosocial exposures on health and human capital.[9] In contrast, the literature from low and middle-income countries (LMICs) on such topics is scarce. Yet, many if not most children currently living in LMICs suffer from 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.

In this paper, we review recent data on key conditions related to human capital in children, adolescents and adults, and document how early-life poverty contributes to their enduring prevalence along the life course. We assess the presence and magnitude of social gradients in child and adolescent health and human capital, using data from 95 recent national surveys. Moving along the life course, we use data from LMIC birth cohorts to explore long-term associations between early-life poverty and adult human capital outcomes. 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, teen motherhood[16] and psychological symptoms.[17]This information informs consideration of interventions, inter-sectoral approaches and policies in the remaining articles in this series.

Early poverty and child/adolescent health and human capital: analyses of 95 national surveys

The analyses of national surveys addressed five outcomes related to human capital in children and adolescents: mortality and stunting prevalence among children under five years of age, not being on track for development among children aged 36-59 months (based upon the Early Childhood Development Index),[18] teen motherhood (giving birth before the age of 20 years) and primary school completion among girls aged 15-19 years. Teen motherhood was included as a human capital indicator because it is associated with poor linear growth and with attained schooling, not only among the mothers themselves but also in their children.[19-21]

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 included 28 low-income, 37 lower-middle-income and 30 upper-middle-income countries, which correspond to 90%, 79% and 50% of all countries in these categories, respectively. The median date for the surveys is 2014. Details on the surveys, indicator definitions, and countries included in the analyses are available in the Supplementary Materials (pages 1-8).

Table 1 shows the average values of the five outcomes comparing across country income groups. Countries were arranged using the World Bank classification at the time of the survey[22], with results weighted by the number of children under five years of age or adolescents as of 2015. https://www.who.int/nutgrowthdb/estimates2018/en/. Four of the five outcomes show higher prevalence in low-income countries and lower prevalence in upper-middle income countries, with intermediate levels in lower-middle income countries. The exception is teen motherhood, which is frequent in some upper-middle income-countries with large populations such as Mexico, Angola, South Africa and Iraq. Pearson 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 Supplementary Materials (pages 9-109).

Next, we investigated the magnitude of within-country inequalities. Stratification by deciles produce more granular results than breakdown by quintiles, and sample sizes for most national surveys allow for this more detailed analysis.[23] Analyses were carried out separately for each country (Supplementary materials pages 11-13). National results were then aggregated by world regions using the UNICEF classification[24], with countries weighted by the number of children under five years of age or adolescents in 2015. https://www.who.int/nutgrowthdb/estimates2018/en/. Results are presented as equiplots (www.equidade.org/equiplot) where each marker corresponds to the value of the outcome in each decile. The slope index of inequality (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. It may be interpreted as the difference between the richest and poorest extremes of the wealth distribution, expressed in deaths per thousand births for mortality, and in percent points for the other four outcomes. For detrimental outcomes, SII values tend to be negative, indicating a decline with increasing wealth (Supplementary materials, pages 14-15).

Table 1. Population weighted averages of child and adolescent outcomes according to country income groups, and Pearson correlation coefficients with national gross domestic product per capita and Gini index for income distribution.

Country groups	Under-five mortality (deaths per 1,000)*	Stunting prevalence (%)	Not on track for child development (%)	Teen (<20 y) motherhood (%)	Incomplete primary school for girls (%)
Low income	86.7	36.0	38.7	50.4	18.5
Lower-middle income	57.7	35.9	31.9	34.0	11.0
Upper-middle income	37.3	16.3	18.0	34.7	2.3
Correlation coefficients between log per capita GDP and frequency of the outcomes (p value)	-0.696 (<0.001)	-0.686 (<0.001)	-0.797 (<0.001)	-0.625 (<0.001)	-0.490 (<0.001)
Correlation coefficients between Gini index and slope index of inequality for the outcomes (p-value)	-0.089 (0.458)	-0.321 (0.004)	-0.305 (0.022)	-0.359 (0.001)	0.107 (0.375)
Number of countries	**78**	**86**	**62**	**88**	**94**

(*) Deaths in the ten years preceding the date of the survey.

The bottom row in Table 1 shows that the national Gini index for income distribution was inversely correlated with the SII for stunting, not being on track for development and teen motherhood, indicating that income inequality was associated with wider inequalities in these three outcomes. Correlations between the Gini index and U5MR or incomplete primary schooling were weak and non-significant. The full correlation matrix is shown in the Supplementary Materials (page 10).

Still in relation to within-country inequalities, Table 2 shows that all SII values were negative, confirming the inverse associations of the five outcomes with family wealth. For example, the under-five mortality rate (U5MR) in West and Central Africa was 85.7 deaths per thousand lower for children at the top of the wealth scale than for those at the bottom, and the corresponding difference in stunting prevalence was 35.9 percent points. Further details on the SII and full results are presented in the Supplementary Materials, pages 8 and 14-15).

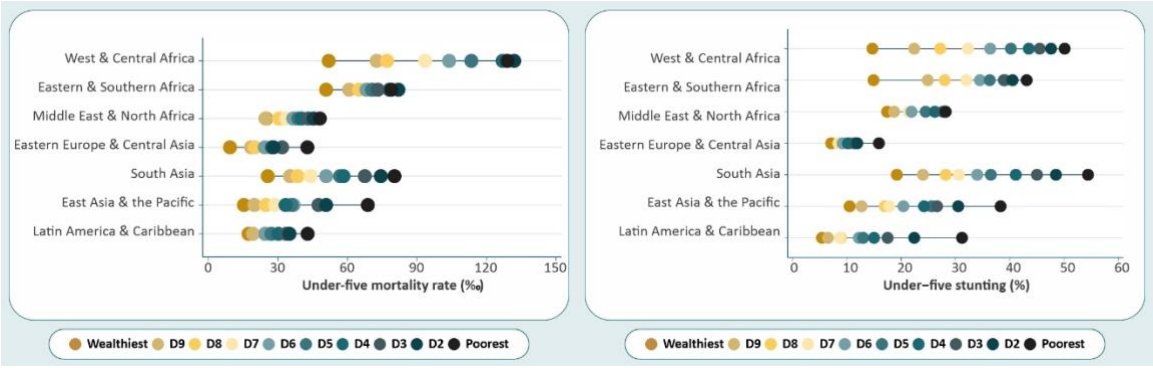
There were clear gradients in underfive mortality by wealth decile in all regions, with the widest absolute gaps observed in West & Central Africa, South Asia, and East Asia & Pacific (Table 2 and Figure 1). The slope index of inequality, which expresses the difference in deaths per thousand live births between the upper and lower ends of the wealth spectrum, ranged from -25.3 in Latin America & Caribbean to -85.7 in West & Central Africa (Table 2). Comparing across regions, underfive mortality rates ranged from 9.3 in the wealthiest decile in Eastern Europe & Central Asia to 132.0 in the second poorest decile in West & Central Africa, a 14-fold difference (Supplementary Materials, page 14). For benchmarking purposes, U5MR in Western Europe is currently estimated at 4 per thousand live births,[25] which is lower than even in the richest deciles in our analyses.

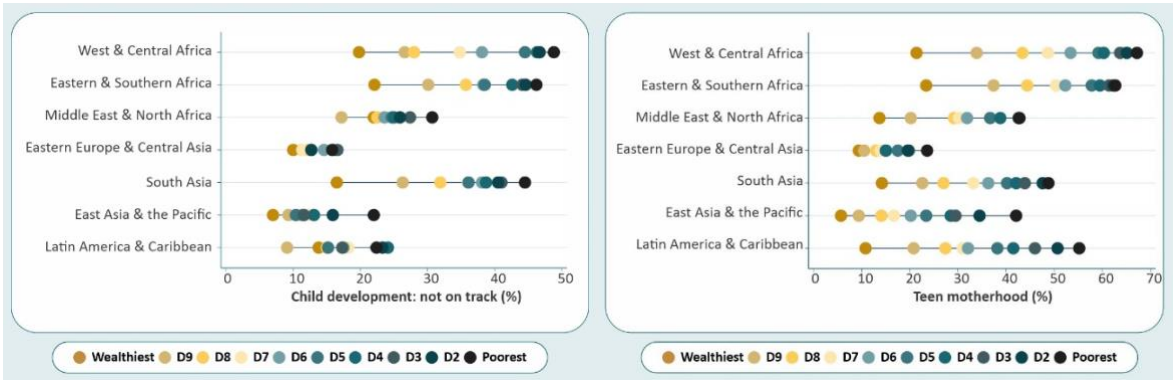
Table 1. Population-weighted average values of the slope index of inequality (SII) for five child and adolescent outcomes, by region of the world. SII values in bold indicate significant associations with wealth.

Outcome	SII units	West & Central Africa	Eastern & Southern Africa	Middle East & North Africa	Eastern Europe & Central Asia	South Asia	East Asia & the Pacific	Latin America & Caribbean
Under-five mortality	1,000 births	**-85.7**	**-26.2**	**-25.7**	**-26.2**	**-58.6**	**-54.4**	**-25.3**
		P < 0.0001	P < 0.0001	P < 0.0001	P < 0.0001	P < 0.0001	P < 0.0001	P < 0.0001
Stunting	% points	**-35.9**	**-24.5**	**-12.3**	**-6.6**	**-35.8**	**-27.3**	**-25.8**
		P < 0.0001	P < 0.0001	P < 0.0001	p = 0.0003	P < 0.0001	P < 0.0001	P < 0.0001
Not on track for development	% points	**-30.6**	**-21.4**	**-10.1**	**-5.4**	**-23.6**	**-11.7**	**-12.2**
		P < 0.0001	P < 0.0001	P < 0.0001	p = 0.0005	P < 0.0001	P < 0.0001	P < 0.0001
Teen motherhood*	% points	**-47.3**	**-43.0**	**-30.1**	**-13.4**	**-34.9**	**-36.2**	**-42.6**
		P < 0.0001	P < 0.0001	P < 0.0001	P < 0.0001	P < 0.0001	P < 0.0001	P < 0.0001
Incomplete primary*	% points	**-41.6**	**-22.9**	**-23.7**	**-0.7**	**-33.0**	**-4.7**	**-3.0**
		P < 0.0001	P < 0.0001	P < 0.0001	p = 0.0003	P < 0.0001	p = 0.0178	P < 0.0001

(*) Girls only

Figure 1. Child and adolescent indicators according to wealth deciles by world region. Data from 95 national surveys, 2010-2019.





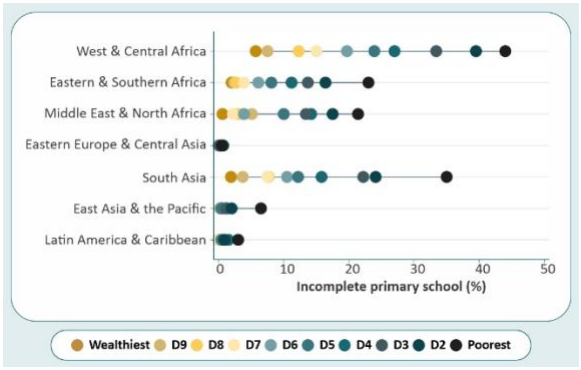


Figure 1 shows that gradients in stunting prevalence are present in all regions, with slope indices of inequality ranging from -6.6 percent points in Eastern Europe & Central Asia to -35.9 percent points in West & Central Africa. Whereas in the two Sub-Saharan African regions the wealthiest deciles showed prevalence well below all other deciles, in South Asia, East Asia & Pacific and Latin America & Caribbean the poorest deciles were lumped together, showing substantially higher prevalence than the rest of the child population. Across regions, stunting prevalence showed a 10-fold difference, ranging from 5.5% in the wealthiest decile in Latin America & Caribbean to 54.4% in the poorest decile in South Asia. In a well-nourished population, about 2.5% of children would be classified as stunted based on the normal distribution,[26] 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.[18] This is detailed in the Supplementary Materials (page 7), where results by decile are presented. There were marked socioeconomic inequalities in most regions, with inverse associations between family wealth and developmental delays. In West & Central Africa, 48.8% of children in the poorest decile presented delays, compared to 19.8% in the wealthiest decile, with the SII equaling -30.6 percent points. In the Middle East & North Africa and the Latin America & Caribbean regions, prevalence did not decrease monotonically with growing wealth, although inverse associations were significant (SII's -10.1 and -5.4 percent points). Across the world's regions, the prevalence of developmental delays ranged from 7.0% in the wealthiest decile in East Asia & Pacific region to 48.8% in the poorest decile in West & Central Africa, a 7-fold difference.

Four outcome indicators were also analyzed by sex of the child. In most regions, boys were more likely to die, to be stunted and to present developmental delays than girls. Similar findings on mortality[27] and stunting[28] were reported in the past. Data on schooling for both sexes were available for 56 countries. In South Asia and in West & Central Africa, boys were more likely to have completed primary school than girls, but this was not the case for the remaining regions (Supplementary materials, page 16).

Teen motherhood was assessed as the proportion of women aged 20-29 years who had become mothers before the age of 20 years. In all regions, girls from poor families were markedly more likely to become teen mothers (Figure 1). The widest gap was in West & Central Africa, where prevalence in the poorest and wealthiest deciles was 67.2% and 21.4%, respectively. The narrowest gap was observed in Eastern Europe & Central Asia, where overall frequency of teen motherhood was the lowest of all regions, ranging from 23.6% in the poorest to 9.4% in the wealthiest quintile. Across regions, prevalence of teen motherhood ranged from 5.7% in the wealthiest decile in East Asia & Pacific region to 67.2% in the poorest decile in West & Central Africa, a 12-fold difference.

Except in regions where primary schooling was universal or nearly so (Figure 1) – including Eastern Europe & Central Asia, Latin America & Caribbean and East Asia & Pacific – there were substantial gaps in girls' education according to wealth. In West & Central Africa, the proportions of girls who did not complete primary education ranged from 44.0% to 5.7% in the poorest and wealthiest deciles, and in South Asia the corresponding range was 35.0% to 1.9%.

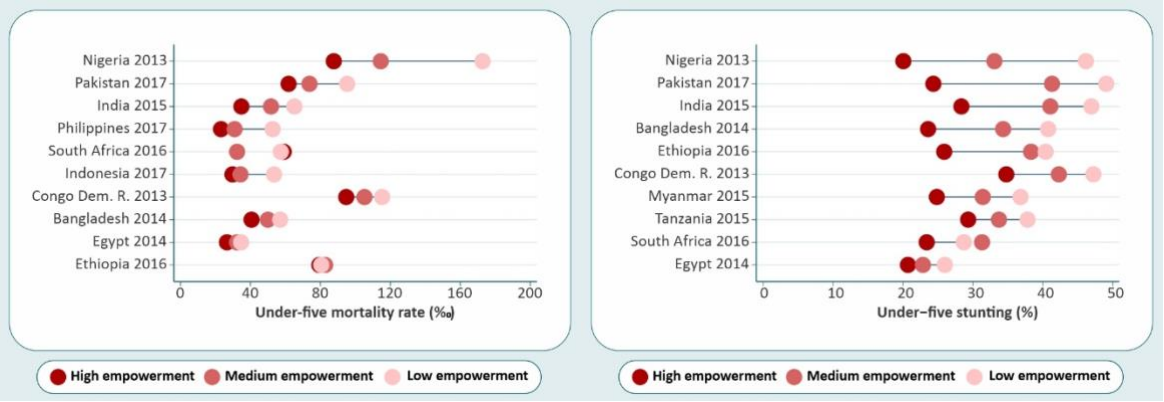
The analyses of national surveys have limitations. Firstly, deciles are relative, rather than absolute measures of socioeconomic position; the poorest decile in a given country may correspond, in terms of absolute wealth, to the third or fourth decile in a poorer country. However, relative poverty is as important in predicting deprivation[29] and health status[30] as is absolute poverty. Secondly, weighted results are heavily influenced by countries with large populations like India, yet unweighted averages would give each country, say Nigeria and São Tomé e Príncipe, equal weights in the West & Central Africa region. Third, there are data gaps in terms of countries that do not have recent standardized surveys, including one half of upper-middle-income countries – among them China and Brazil. Lastly, despite the early child development indicator used in national surveys not being sufficiently validated, it has proven useful for comparing groups of children, as opposed to individual children.[31]

Earlier analyses of child mortality,[32] nutritional status[33,34] and development[31,35] used stratification by wealth quintiles rather than deciles, with the exception of an analysis of stunting that included surveys up to 2013.[23] Use of deciles has revealed 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. In contrast, the narrowest gaps were found in Eastern Europe & Central Asia, which had the lowest prevalence levels for all outcomes.

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

Early-life poverty is a comprehensive indicator of early child adversity[13] for which plentiful data are available, yet there are other important dimensions of adversity. Panel 1 shows the associations between women's empowerment and stunting prevalence among their children.

Panel 1: Women's empowerment and child stunting



Family wealth is used as the main marker for early-life adversity in our analyses, but there are also other important dimensions of adversity including women's empowerment. We used the Survey-based Women's emPowERment (SWPER) global index[36] to categorize women in terciles, and correlated these with mortality and stunting prevalence among their children in the ten most populous countries with available data (see Figure). We opted to use the social independence domain of the SWPER score, as it is more closely associated with child health outcomes than the other two domains, namely attitudes to violence and decision-making. [36] Child stunting and mortality were selected as the outcomes because large numbers of countries have data.

Social independence reflects women's education, information (frequency of reading newspaper or magazine), age at first childbirth and at first cohabitation, and differences between the woman and her partner in terms of education and age (see Supplementary Materials, page 8, for more information). In nearly all countries studied, there were stepwise increases in child mortality and stunting with lower maternal empowerment.

Our findings on a likely impact of empowerment on child stunting are consistent with published results on women's empowerment and under five mortality in 59 countries[37], while also showing that similar, if not stronger associations exist for stunting prevalence. Interventions aimed at empowering women have an important role in improving the health and nutrition of their children.

--- END OF PANEL 1 ----

Early poverty and adult health and human capital: analyses of six birth cohort studies

We now turn to the question of how strongly exposure to early-life poverty predicts adult health and human capital outcomes in LMIC contexts. For this purpose, we reanalyzed data from the six longest-running births cohorts in LMICs, with at least 1,000 participants at recruitment and with frequent visits in early life – the COHORTS consortium (Table 3).[38] All cohorts were population based, yet socioeconomic inequality was less marked in the Soweto (urban poor, black) and Guatemala (rural poor) cohorts than in the other four settings.

Information on early-life socioeconomic position was based on family income in Cebu, Delhi and Pelotas, Brazil (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 Supplementary Materials (pages 17-19).

The first step was to verify whether the social patterns for child length and development – that were measured in the 1990s or earlier in each cohort - are consistent with the results from the survey analyses reported above. Length measures were taken during early childhood (1-2 years), height was measured in middle childhood (4-8.5 years). Different child development scales were used in each site at 4-8.5 years, and these have been converted into cognitive quotients or CQ Z scores with a mean of zero and standard deviation of one, in each site (see Supplementary Materials, page 18).

The slope index of inequality was calculated to express the difference in outcome measures between the upper and lower scale of socioeconomic position (Table 3). In all cohorts with data, results were consistent with the recent national survey analyses, showing important social gradients in child height and development (see figures in the Supplementary Materials, pages 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 intellectual performance, for which data were available for adults from most or all cohorts, at ages ranging from 22 to 57 years (Supplementary Materials, page 17). The outcomes included height, years of schooling, intelligence quotient, teen 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 the metabolic syndrome. More information on definitions and tests used are available in the Supplementary Materials (page 18).

Table 3 and Figure 2 show positive, significant social gradients in height in all six cohorts for men, and in five cohorts for women, with Soweto as the exception. Similar gradients were observed for attained schooling in the six cohorts for women and in five cohorts for men, except again for Soweto where there was very little variability in this indicator (mean of 11.7 and a standard deviation of only 1.5 year). Intelligence results were available in all cohorts except in Delhi,

showing positive social gradients in all studies (noting that the P level for the slope index in Guatemala men was equal to 0.0537).

Social gradients for teen motherhood, overweight/obesity prevalence, metabolic signs and psychological symptoms were not clear cut (Table 3 and figures in the Supplementary Materials, pages 23-26). Both Pelotas cohorts showed inverse social gradients for teen motherhood, but results were not significant for the other cohorts. Psychological symptoms were inversely related to wealth in Pelotas men and women, but again not in the other cohorts.

Overweight and obesity tended to be directly associated with wealth among men in five cohorts, and metabolic signs showed a similar social patterning in men from the Delhi and Pelotas 1982 cohorts. In contrast, overweight and obesity prevalence as well as metabolic signs were inversely associated with wealth among Pelotas women from both cohorts as well as in Guatemala (with P levels of 0.06 and 0.08, respectively, for the two outcomes). In Cebu, overweight and obesity were directly associated with wealth among men and women.

Additional evidence on the impact of early-life poverty is provided by the Young Lives study which includes cohorts of children from Ethiopia, India, Peru, Vietnam who were recruited when aged 6-18 months. A social gradient in stunting was present at recruitment, and persisted unitil the last measurement at 12 years.[39] Similar social gradients were present for the children's vocabulary, from its first measurement at age five years until the age of 12 years.[39] Trajectory analyses based on measurements from ages 1 to 15 years showed that higher wealth quartiles were protective against stunting trajectories, but higher wealth and urban residence predicted overweight trajectories.[40]

A limitation of our analyses is that we used either income or asset indices to measure poverty, based on data available from each cohort. While both indicators are closely related, their constructs are different. For most variables, socioeconomic gaps were wider in the two Pelotas cohorts than in other sites. This is likely due to the remarkable scale of income inequality in Brazilian society and to the fact that both cohorts covered the whole population of a city. Both in 1982 and 1993, average income in the richest quintile was 12 or more times greater than in the poorest quintile. The larger sample sizes for both Pelotas cohorts also increase the likelihood of obtaining significant differences. The selective nature of some cohort samples is made evident by a comparison of results of national surveys with those from the cohorts in the same country. For example, the Guatemalan survey shows remarkably wide inequality in child stunting (Supplementary materials, page 11), whereas in the cohort from four rural villages there is relatively little inequality (Table 3).

There were instances of heterogeneity in the magnitude and sometimes in the direction of associations between early poverty and adult outcomes. It is reassuring that for key outcomes such as height, schooling and intelligence, results were highly consistent, but this was not the case for the morbidity indicators. Like all long term cohorts, particularly in LMICs, losses to follow up may be substantial, as discussed in detail elsewhere.[38] One should consider that the age of cohort members at the most recent follow up ranged from 22 years in the 1993 Pelotas cohort to up to 57 years in Guatemala, and this difference has to be born in mind when considering the prevalence of outcomes such as overweight/obesity, psychological symptoms and metabolic signs. In addition, metabolic signs include five separate indicators, and further analyses are required to tease out

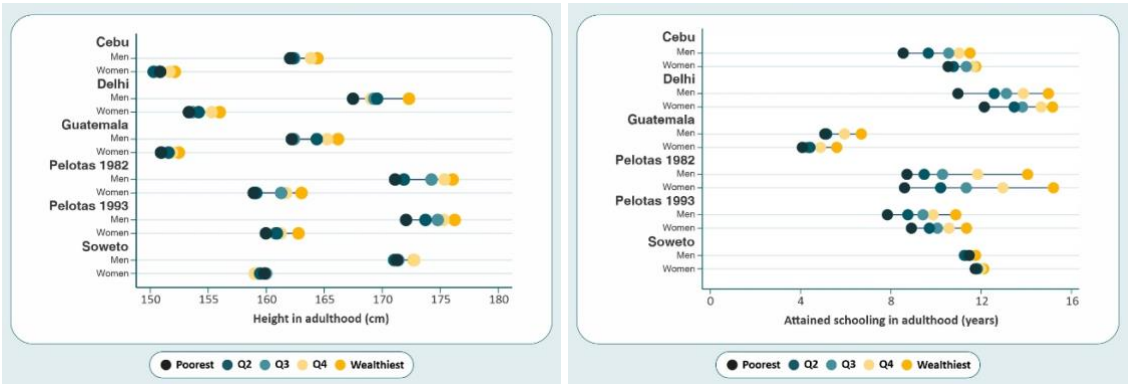
their etiologies. Lastly, our analyses on early poverty did not consider socioeconomic trajectories, and there is evidence that adult outcomes may differ among individuals who remained poor and those whose socioeconomic position improved over time.[41]

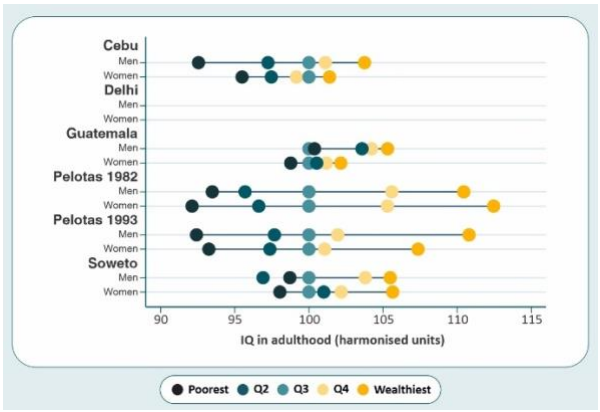
Table 3. Slope index of inequality for health, nutrition and human capital outcomes according to early-life poverty. Values represent the difference in the outcome between the wealthiest and poorest ends of the socioeconomic distribution of households. The first six indicators represent desirable outcomes, and the last four undesirable outcomes. SII values in bold indicate significant associations with wealth.

		Men							Women					
Outcome	SII units	Cebu	Delhi	Guate-mala	Pelotas 1982	Pelotas 1993	Soweto		Cebu	Delhi	Guate-mala	Pelotas 1982	Pelotas 1993	Soweto
DESIRABLE OUTCOMES														
Length at 2 y	Z scores	**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<0.0001	P<0.0001	P=0.0033	P<0.0001	P<0.0001	P<0.0001		P<0.0001	P<0.0001	P=0.0073	P<0.0001	P<0.0001	P<0.0001
Height at 4 y	Z scores	**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<0.0001	P<0.0001	P=0.0163	P<0.0001	P<0.0001	P<0.0001		P<0.0001	P<0.0001	P=0.0022	P<0.0001	P<0.0001	P=0.0013
Cognitive quotient at 4-8.5 y	Z scores	**0.80**	**.**	**0.28**	**1.24**	**0.98**	**0.98**		**0.58**	**.**	**0.28**	**1.44**	**1.00**	**0.43**
		P<0.0001	.	P=0.0569	P<0.0001	P<0.0001	P<0.0001		P<0.0001	.	P=0.0359	P<0.0001	P<0.0001	P=0.0044
Adult height	Cm	**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<0.0001	P<0.0001	P<0.0001	P<0.0001	P<0.0001	P=0.0182		P=0.0021	p=0.0005	P=0.0404	P<0.0001	P<0.0001	P=0.3225
Achieved schooling (years)	Years	**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<0.0001	P<0.0001	P=0.0005	P<0.0001	P<0.0001	P=0.1767		P<0.0001	P<0.0001	P<0.0001	P<0.0001	P<0.0001	P=0.0352
Adult intelligence	IQ points*	**13.2**	.	4.8	**22.1**	**20.5**	**9.8**		**6.9**	**.**	**4.7**	**24.8**	**16.0**	**6.9**
		P<0.0001	.	P=0.0537	P<0.0001	P<0.0001	P<0.0001		P=0.0019	.	P=0.0070	P<0.0001	P<0.0001	P=0.0023
UNDESIRABLE OUTCOMES														
Teen motherhood	Pct points	.	.	.	.	.	.		11.7	6.8	2.4	**-39.6**	**-24.9**	.
		.	.	.	.	.	.		P=0.0632	P=0.0572	P=0.7173	P<0.0001	P<0.0001	.
Psychological symptoms	Number of symptoms	-0.4	.	0.5	**-1.1**	**-1.1**	0.2		0.8	.	0.6	**-2.6**	**-1.4**	0.6
		P=0.2805	.	P=0.3121	P<0.0001	P<0.0001	P=0.7254		P=0.0986	.	P=0.2604	P<0.0001	P<0.0001	P=0.4000
Overweight/ obesity	Pct points	**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<0.0001	p=0.0008	P=0.4777	P=0.0050	P<0.0001	P=0.0092		P=0.0161	P=0.3666	P=0.0600	P<0.0001	P<0.0001	P=0.8449
Metabolic score	Number of signs	-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=0.1050	P=0.0488	P=0.5899	P=0.0402	P=0.5430	P=0.2928		P=0.4194	P=0.4798	P=0.0788	P=0.0059	P<0.0001	P=0.2444

(*) Normalized score with mean = 100 and standard deviation = 15

Figure 2. Distribution of adult height, attained schooling and intelligence quotients by wealth quintile in the six birth cohorts.





Conclusions and implications

Our analyses provide ample documentation of pervasive social gradients in the survival, health, nutrition and cognitive development of children, as well as in teen motherhood and girls' education. The between-country analyses of 95 national surveys confirmed the importance of GDP in predicting levels of the five outcomes under study. Within countries, we were able to document consistent, stepwise social gradients in human capital indicators among children and adolescents from all regions of the developing world. Of the 35 within-country comparisons (five outcomes in seven world regions), 30 showed at least a doubling of the risk of the detrimental outcome in the poorest compared to the richest decile, and in 17 comparisons the ratio was greater than three-fold. 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 confirm that contemporary 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 confirm that the effects of early 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, confirm our findings from recent national surveys. As cohort participants became older, social gradients in outcomes fell into two groups. Those related to a narrower definition of human capital such as the one adopted by the World Bank,[42] including survival, growth, schooling and intelligence showed clear positive gradients in virtually all analyses by cohort and sex. Some differences were striking – for example, IQ was about 20 points higher among individuals at the top of the wealth scale than among those at its bottom in the two Pelotas cohorts. As reported in the first article in this series[43] and confirmed by the national survey analyses above, social gradients in cognition are already present among in young children. Although differences in the length and quality of schooling likely play a key role, many factors in the environment that disadvantaged children experience, starting in gestation, contributes to their underperformance.[10]

In contrast, adult outcomes reflecting a broader definition of human capital that also incorporates physical and mental health did not present such clear-cut results. There were inverse social gradients for teen motherhood and psychological symptoms in the Pelotas cohorts, but not in the other cohorts. The negative impact of early poverty on mental health, at least in some settings, may be an important mechanism for intergenerational transmission of poverty by affecting parental ability to provide nurturing care to their children.[44]

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 two cohorts. In our analyses, these were the only detrimental adult outcomes with higher prevalence among the better-off. In contrast, among Pelotas and Guatemala women – but not in Cebu - the findings for overweight/obesity and metabolic signs were in the opposite direction. The literature suggests that the social patterns of overweight prevalence change as the nutrition transition progresses.[45] When undernutrition is common, wealthier men and women tend to show higher prevalence. Over time, this pattern is reversed among women, whereas the original pattern remains for men in the same population. And when the transition is complete, both men and women show inverse

social gradients.[46,47] Our findings suggest that the six cohorts may be 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 is a direct association for men but no social patterning for women, and lastly Guatemala and Pelotas showing a direct association among men, and an inverse association among women. None of the cohorts have reached the final stage in the transition when both men and women show inverse patterns. The Sustainable Development Goals include targets related to non-communicable diseases as well as to human capital.[48] We show that although early life poverty is clearly detrimental for human capital, it may be paradoxically associated with lower risk for some chronic conditions, at least among men.

Taken together our findings show clear, positive social gradients in the more traditional human capital outcomes, a mixed picture for a broader set of outcomes that include teen pregnancy and mental health, and increased risk of overweight/obesity and metabolic conditions among men who were born to wealthier families. Although early-life poverty has a negative effect on most indicators of adult human capital, the social gradients may be inverted, at least regarding overweight, obesity and metabolic syndrome signs among men.

We observed sex differences in several outcomes, which may reflect biological differences as well as gender norms. Among children, boys were more likely than girls to die,[49] to be stunted[50] and to present developmental delays,[51] which is likely due to their greater biological frailty.[52] In all but one world region, and in five of the six cohorts, girls had higher schooling than boys, which is a common finding in many countries and likely reflects gender norms associated with early entry in the labor market and possibly with compliance with school discipline.[53] In terms of adult outcomes, as found in studies from many parts of the world, women presented more psychological symptoms than men in all cohorts. This finding is attributed to a combination of higher levels of stress experienced by women and reluctance among men to report mental health difficulties.[54,55] Lastly, as noted above in four of the cohorts, wealthy men and poor women were more likely to present overweight or obesity.

Without a significant 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 declined since 1990,[3] most of the world population today 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 becoming less so.[4] The health impact of socioeconomic inequality are likely to be felt throughout the world.

Our findings should be interpreted in conjunction with the results of the remaining articles in this series. In particular, the third article 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 our current findings showing how early life poverty shapes the development of human capital. Achieving high and effective coverage with specific interventions is essential, and their impact will be complemented and amplified by broader antipoverty interventions, including conditional and unconditional cash transfers, minimum wage policies, child benefits and universal health care. Our current analyses are

intended to contribute to policies and programs aimed at reducing poverty and at promoting equity through targeting of interventions at children and adolescents who are being left behind.

Early life poverty affects children within a context that is increasingly defined by war and conflict,[56] global inequality,[7] climate change,[57] ethnic-group disparities[58] and damaging gender norms.[58] On top of such pre-existing threats, the COVID-19 syndemic interaction with social determinants[59] has resulted in the exacerbation of socioeconomic inequalities, thus threatening recent, albeit modest, progress in child and adolescent health and education. The challenges that today's children 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 up to these global challenges.

Search strategy and selection criteria

For analyses of the associations between poverty and child/adolescent outcomes we searched the comprehensive *Countdown to 2030* survey database (www.equidade.org) which is also the one included in the *World Health Organization Health Equity Monitor* website (https://www.who.int/data/gho/health-equity). We identified 440 nationally representative surveys with publicly available data from 127 countries, from which we selected all surveys carried out from 2010-2019 with information on household socioeconomic position and the child and adolescent indicators required for our analyses. 95 countries had such surveys and were included in the analyses.

Analyses of the associations between early poverty and adult outcomes were based on collaborative data collection of six birth cohorts from LMICs. In 2006, in preparation for the *2008 Lancet Nutrition Series* (https://pubmed.ncbi.nlm.nih.gov/18206223/) we carried out a systematic search of large long-term, prospective birth cohort studies in LMICs with information on early life and adult variables. The search was undertaken in the Medline, Embase, CINAHL, EconLit, Psychinfo, and PsychArticles databases without any language or date restrictions. We identified more than 15,000 original articles and 700 reviews. The search was narrowed down to 28 relevant articles from LMICs in which outcomes were measured at ages 18 years or older. We excluded studies with fewer than 1,000 subjects or poor methodological quality. We complemented the search by contacting investigators involved in long-term cohort studies in LMICs to identify relevant original or review articles and book chapters, and by searching our own personal files. Only five studies qualified for the original pooled analyses; in 2021 a sixth study was included as the 1993 birth cohort study from Pelotas, Brazil, completed 18 years of follow up. The six studies provide the data for the present analyses.

Contributors

CGV conceptualized 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 LR contributed to the conceptualization and overall guidance of the analyses and writing up. FPH, LPV, AJDB and CO contributed with the data analyses. The main investigators of the COHORTS consortium – including LA, FCB, SKB, BLH, MFK-L, NRL, AMBM, JM, SN, HSS, ADS, AS, and JSV – provided the data. All authors have reviewed and approved the final version of the manuscript.

Declaration of Interests

REB serves on the Board of Vitamin Angels, a non-profit charitable organization supporting maternal and child nutrition services in LMIC. As corresponding author, CGV states that he had full access to all data and final responsibility for the decision to submit for publication.

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