

# Risk of poor development in young children in low-income and middle-income countries: an estimation and analysis at the global, regional, and country level



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## Summary

**Background** A 2007 study published in *The Lancet* estimated that approximately 219 million children aged younger than 5 years were exposed to stunting or extreme poverty in 2004. We updated the 2004 estimates with the use of improved data and methods and generated estimates for 2010.

**Methods** We used country-level prevalence of stunting in children younger than 5 years based on the 2006 Growth Standards proposed by WHO and poverty ratios from the World Bank to estimate children who were either stunted or lived in extreme poverty for 141 low-income and middle-income countries in 2004 and 2010. To avoid counting the same children twice, we excluded children jointly exposed to stunting and extreme poverty from children living in extreme poverty. To examine the robustness of estimates, we also used moderate poverty measures.

**Findings** The 2007 study underestimated children at risk of poor development. The estimated number of children exposed to the two risk factors in low-income and middle-income countries decreased from 279·1 million (95% CI 250·4 million–307·4 million) in 2004 to 249·4 million (209·3 million–292·6 million) in 2010; prevalence of children at risk fell from 51% (95% CI 46–56) to 43% (36–51). The decline occurred in all income groups and regions with south Asia experiencing the largest drop. Sub-Saharan Africa had the highest prevalence in both years. These findings were robust to variations in poverty measures.

**Interpretation** Progress has been made in reducing the number of children exposed to stunting or poverty between 2004 and 2010, but this is still not enough. Scaling up of effective interventions targeting the most vulnerable children is urgently needed.

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## Introduction

Early child development forms the foundation of adult health and wellbeing and is a necessary component of the Sustainable Development Goals (SDGs). Recognition of the formative aspect of early childhood has increased emphasis on reducing risks for poor child development.<sup>1</sup> Improvement of measures for global prevalence of children at risk of poor development is necessary to accurately assess challenges, effectiveness of interventions, gauge progress, and plan future investment.

Quantification of young children with poor development is challenging because there are, as yet, no established global standards for measuring child development, nor are there population-representative data for children's early skills in low-income and middle-income countries. Available evidence from low-income and middle-income countries suggests that children's early exposure to stunting and poverty is closely associated with deficits in their subsequent cognitive and social-emotional development, their educational performance, adulthood income, and risks of chronic diseases.<sup>2–10</sup> In the 2007 *Lancet* Child Development in Developing Countries Series,<sup>2</sup> stunting and poverty were used to estimate the

number of children aged younger than 5 years who were at risk of not fulfilling their developmental potential, an indicator of poor child development. About 219 million children, 39% of children younger than 5 years in low-income and middle-income countries in 2004, were estimated to be exposed to one of these two risk factors.<sup>2</sup> The estimated average deficit in adult annual income, resulting from deficits in schooling associated with stunting or extreme poverty, was 19·8%.<sup>2</sup>

Major advances in the availability of data have occurred since 2007 when the 2004 estimates were made. New data for stunting and poverty have become available with a revised definition of stunting (WHO)<sup>11</sup> and extreme poverty (World Bank),<sup>12,13</sup> leading to upward revised estimates of both.<sup>11–13</sup> As a result of improved data availability and use of micro-level data, we were able to produce better quality data for generating direct measures of country-level estimates for stunting and poverty. With use of the most updated data and the new definitions of stunting and extreme poverty, we updated the 2004 estimates and applied the same methods to produce estimates for 2010—the year that most developing countries had stunting and poverty data



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### Research in context

#### Evidence before this study

The 2007 *Lancet* Child Development in Developing Countries Series estimated that, in 2004, approximately 219 million children younger than 5 years were at risk of not fulfilling their developmental potential because of their exposure to stunting or poverty. We searched PubMed for studies in English published between Jan 1, 2008, and Dec 31, 2015, measuring the number and prevalence of children exposed to stunting or extreme poverty at the global level, with the keywords “early child development” in abstracts. Our search yielded no publications during the period.

#### Added value of this study

With use of the most updated data for stunting and extreme and moderate poverty based on revised definitions and improved estimation methods, our study adds to the body of knowledge about the prevalence of children at risk of poor development, measured by children at risk of not fulfilling their development potential resulting from exposure to stunting or extreme poverty, by updating the 2004 estimates and producing estimates for 2010. We also expanded the definition of children at risk of poor development by producing a set of estimates including children exposed to moderate poverty. The analysis enables us to estimate the progress in reducing

children at risk of poor development between 2004 and 2010. With expanded availability of micro-level and macro-level data, we were able to develop estimation and validation methods for missing data and we produced the first set of child-level poverty ratios for a subset of countries. We did sensitivity tests for estimates with the use of various poverty measures. These efforts improved the accuracy and comparability of the estimates, and allowed disparity analyses across and within countries.

We found that progress has been made during the period, but unevenly across regions, with sub-Saharan Africa having the smallest reduction and the highest prevalence of children at risk of poor development. A significant disparity in exposure to risk factors of early development between income groups has been observed, and disproportionate exposure to the risk of poor development was found in low-income countries.

#### Implications of all the available evidence

The evidence in this study taken together with previous evidence clearly indicates that the challenge to improve child development is large and requires immediate action, such as political prioritisation of efforts to scale up effective interventions targeting the most vulnerable children.

available at the time of this analysis. The exercise allowed us to examine whether progress has been made over time in reducing the prevalence of young children at risk of poor development. With available nationally representative household surveys, we were able to improve estimation for missing data and produce estimates of the percentage of children younger than 5 years living in extreme poverty or moderate poverty for a subset of countries. We also did sensitivity tests with the use of various poverty measures.

## Methods

### Definitions and data sources

We followed the strategy used previously<sup>2</sup> and measured the number of children aged younger than 5 years who had been exposed to stunting or extreme poverty. Estimation was done in 2004 and 2010 at the country, regional, and global levels for 141 low-income and middle-income countries, including 40 low-income countries, 56 lower-middle-income countries, and 45 upper-middle-income countries, classified by the World Bank in 2010<sup>14</sup> (appendix p 1).

Child stunting was defined as height-for-age below  $-2$  SDs from the median of the international reference population recommended by WHO in 2006.<sup>11</sup> We took the definition of extreme poverty by the World Bank (living on less than US\$1.25 per day at 2005 international prices) to measure children living in extreme poverty.<sup>15</sup> To test the sensitivity of estimates, we also expanded our

estimation of children at risk by including children living in moderate poverty (living on less than \$2 per day, according to the World Bank<sup>15</sup>).

Data sources for country-level populations younger than 5 years, stunting prevalence of children younger than 5 years, and the percentage of the population living in extreme or moderate poverty are presented in the appendix (p 1). We chose to use estimates of stunting prevalence and their uncertainties published in *The Lancet* because these data have the largest number of countries with available estimates (126 countries in our sample; appendix p 1) in 2004 and 2010.<sup>16</sup> We imputed the stunting prevalence for the remaining 15 countries (2% of total child populations in the 2 years; appendix p 2).

Data for the percentage of children aged younger than 5 years living in extreme poverty were not available. We addressed this issue in two ways. First, we used the 2007 assumption and used population-level poverty ratios produced by the World Bank;<sup>2</sup> and second, we generated child-level poverty ratios using nationally representative population-based surveys for a subset of countries.

Of the 141 countries analysed, the World Bank had estimates for 109 countries between 2000 and 2012 (median for years with available data: 2006 [IQR 2003–09]) on the percentage of the total population living below the extreme (\$1.25) or moderate (\$2) poverty line; 48 countries had poverty measures in 2004 (49.3% of the

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total population younger than 5 years) and 42 countries had poverty measures in 2010 (45·3% of the total population younger than 5 years). For countries without poverty measures in 2004 and 2010, we estimated poverty as described in the appendix (p 3).

Evidence has shown that children younger than 12 years have the highest poverty rates among all age groups, especially in low-income countries.<sup>17</sup> The assumption that poverty ratios in children younger than 5 years are the same as those for the total population could lead to underestimation of children aged younger than 5 years living in poverty. We estimated country-level percentages of children aged younger than 5 years exposed to extreme or moderate poverty for a subset of countries using micro-level data such as the Demographic and Health Surveys<sup>18</sup> or the Multiple Indicator Cluster Surveys.<sup>19</sup> Estimation details are presented in the appendix (p 10). The mean of child-level poverty ratios across the countries was not significantly different from the mean of population-level poverty ratios across the same countries, which might be because more than half of the countries in this subset were in the middle-income group.

#### Estimation of children at risk of poor development

When we added numbers of children stunted to numbers of children living in poverty, to avoid counting children exposed to both stunting and extreme poverty twice, we constructed a dichotomous variable indicating a child exposed to poverty but not stunting using household surveys in 86 countries and obtained the percentage of children living in poverty but not stunting with 95% CIs for the 86 countries. Children jointly exposed to stunting and extreme poverty were excluded from children living in extreme poverty. For the 55 countries without micro-level data (approximately 23% of the total child population), we replaced their missing values in the 2 years with the average percentage of children living in poverty but not stunted by their income groups (appendix, p 13).

With the use of stunting prevalence (with 95% CIs) and the percentage of children living in extreme or moderate poverty but not stunted (with 95% CIs) for the 141 low-income and middle-income countries, we generated two sets of estimates with uncertainty levels for the number and prevalence of children at risk in 2004 and 2010 at the country, regional, and global levels. For the subset of countries with estimates of child-level poverty ratios, we also produced two sets of estimates in 2004 and in 2010. We analysed the change in level, prevalence, and trends of children at risk between 2004 and 2010 and examined the robustness of results by comparing the estimates derived from various poverty measures.

#### Role of the funding source

The funders of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report. The corresponding author had full

	2004	2010
Total number of children in population aged younger than 5 years (in millions)	547·0	575·6
Children at risk of poor development (in millions)		
Stunting or extreme poverty	279·1 (250·4–307·4)	249·4 (209·3–292·6)
Stunting or moderate poverty	353·7 (322·3–384·8)	324·2 (281·4–370·1)
Prevalence of children at risk (%)		
Stunting or extreme poverty	51% (46–56)	43% (36–51)
Stunting or moderate poverty	65% (59–70)	56% (49–64)

Data are n (95% CI) or % (95% CI), unless otherwise specified.

**Table 1: Children at risk of poor development based on stunting or living in extreme or moderate poverty in 141 countries in 2004 and 2010**

access to all the data in the study and had final responsibility for the decision to submit for publication.

#### Results

Although our recalculation of the 2004 estimate included fewer countries (141) than were included in the calculation by Grantham-McGregor and colleagues (156),<sup>2</sup> our 2004 estimate of children at risk (279 million) is higher than the Grantham-McGregor and colleagues' estimate (219 million), suggesting that improved data availability showed higher estimates of children with poor development. Our analysis of the driving forces behind the difference is shown in the appendix (p 21).

Although the population of children aged younger than 5 years in the 141 low-income and middle-income countries has risen from 547 million in 2004 to 576 million in 2010; there was a decline in both the level and prevalence of children at risk of poor development during this period. When extreme poverty ratios were used, the number of children at risk fell from 279·1 million (95% CI 250·4 million–307·4 million) in 2004 to 249·4 million (209·3 million–292·6 million) in 2010 (table 1). The prevalence of children at risk fell from 51% (95% CI 46–56) in 2004 to 43% (36–51) in 2010.

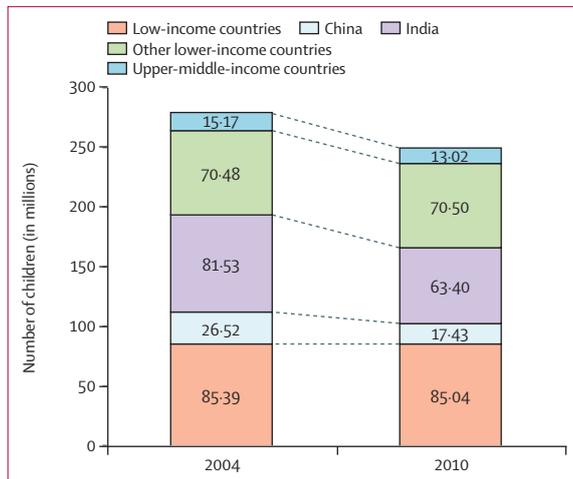
The use of moderate poverty ratios led to a considerable increase in the number and prevalence of children at risk in both 2004 and 2010 compared to the estimates using extreme poverty, but a decrease in the number of children at risk from 2004 (353·7 million [95% CI 322·3 million–384·8 million]) to 2010 (324·2 million [281·4 million–370·1 million]) was still observed. A decrease in prevalence between 2004 and 2010 was also noted (table 1).

The prevalence of stunting reduced from 190·6 million (35% of child population) in 2004 to 173·7 million (30%) in 2010, and the prevalence of extreme poverty reduced from 174·3 million (32%) in 2004 to 141·8 million (25%) in 2010. In children exposed to both stunting and extreme poverty, the difference between children at risk and the sum of children stunted and living in extreme poverty reduced from 85·8 million in 2004 (16%) to 66·1 million in 2010 (12%). The number of children living in extreme

	Total population aged younger than 5 years (in millions)		Prevalence of stunting (in millions)		Number living with <US\$1.25 per day (in millions)		Number living with <\$2 per day (in millions)		Number at risk (\$1.25; in millions)		Number at risk (\$2; in millions)	
	2004	2010	2004	2010	2004	2010	2004	2010	2004	2010	2004	2010
East Asia and the Pacific	136.2	145.7	34.1 (25%)	29.6 (20%)	30.2 (22%)	18.2 (12%)	62.0 (46%)	43.5 (30%)	54.7 (40%)	41.7 (29%)	75.5 (55%)	58.7 (40%)
Europe and central Asia	25.4	27.9	4.8 (19%)	4.8 (17%)	1.1 (4%)	0.8 (3%)	3.0 (12%)	2.0 (7%)	5.6 (22%)	5.4 (19%)	7.0 (28%)	6.3 (23%)
Latin America and the Caribbean	56.8	54.1	9.1 (16%)	8.0 (15%)	4.9 (9%)	3.0 (6%)	10.1 (18%)	6.0 (11%)	11.6 (21%)	9.7 (18%)	15.3 (27%)	11.9 (22%)
Middle east and north Africa	32.3	36.5	8.0 (25%)	8.6 (24%)	1.1 (3%)	1.0 (3%)	5.9 (18%)	5.3 (15%)	8.7 (27%)	9.1 (25%)	11.9 (37%)	12.1 (33%)
South Asia	171.4	168.1	80.6 (47%)	67.6 (40%)	69.5 (41%)	46.5 (28%)	126.6 (74%)	105.8 (63%)	110.9 (65%)	88.8 (53%)	140.8 (82%)	119.7 (71%)
Sub-Saharan Africa	124.9	143.3	53.9 (43%)	55.1 (38%)	67.5 (54%)	72.3 (50%)	94.9 (76%)	104.4 (73%)	87.6 (70%)	94.8 (66%)	103.3 (83%)	115.5 (81%)
Total	547.0	575.6	190.6 (35%)	173.7 (30%)	174.3 (32%)	141.8 (25%)	302.5 (55%)	267.0 (46%)	279.1 (51%)	249.4 (43%)	353.7 (65%)	324.2 (56%)

Data are n (%), unless otherwise specified.

**Table 2: Regional estimates of number (in millions) and prevalence of children at risk of poor development in 2004 and 2010 using extreme or moderate poverty ratios in 141 countries**



**Figure 1: Number of children exposed to stunting or extreme poverty by country income group**

poverty but not stunted (calculated from the difference between number of children living in extreme poverty and number of children with joint exposure) reduced from 88.5 million (16%) in 2004 to 75.7 million (13%) in 2010. The number of children stunted but not in poverty increased from 104.8 million (19%) in 2004 to 107.6 million (19%) in 2010.

The prevalence of both risk factors declined in all regions during the period. South Asia had the largest drop in both the number and prevalence of children exposed to stunting or extreme poverty, followed by east Asia and the Pacific region. Accompanied by about a 16% increase in the population aged younger than 5 years in the region, sub-Saharan Africa had a rise in the number of children

exposed to stunting and poverty, but the prevalence of the two risk factors also declined. Sub-Saharan Africa remained the region with the highest prevalence of children at risk in both years (table 2). The findings were robust when the moderate poverty measure was used.

With the use of extreme poverty measures, we observed a decrease in number of children at risk in all three income groups from 2004 to 2010 (figure 1). Lower-middle-income countries (including China and India) had the largest fall among the three income groups, from 178.5 million to 151.3 million. Upper-middle-income countries fell from 15.17 million in 2004 to 13.02 million in 2010, whereas low-income countries had almost no change (figure 1). China and India are the two countries with the largest populations of children younger than 5 years and have made substantial progress in reducing poverty in the past decade. If India and China were excluded from the lower-middle-income countries, almost no reduction in risk in lower-middle-income countries would be noted during this period (70.48 million in 2004 vs 70.50 million in 2010; figure 1). In 2004, 31% of children at risk were from low-income countries, and this increased to 34% in 2010 when extreme poverty measures were used. The findings were robust when using the moderate poverty measure (appendix p 22), suggesting that India and China were the leading force for the reduction of children at risk.

From 2004 to 2010, the prevalence of children at risk of poor development was reduced in all three income groups; low-income countries had the smallest rate of decline. There was a striking disparity in the prevalence across income groups. In 2004, when the extreme poverty measures were applied, the percentage of children at risk was 71% in low-income countries, 39% in

lower-middle-income countries, and 18% in the upper-middle-income countries. The large difference in prevalence between country income groups remained unchanged in 2010. The findings were robust when moderate poverty measures were used (figure 2).

Country-level percentage change in the prevalence of children at risk between 2004 and 2010 when extreme poverty measures were used is shown in figure 3. Of the 141 countries assessed, 123 had reductions in prevalence. Among 27 countries with reduction of 20% or more, 23 were middle-income countries including Vietnam (45%, the largest rate of decline), China (40%, the second largest rate of decline), and India at margin (by 20%). Six sub-Saharan countries also declined by more than 20% (Angola, Botswana, Cape Verde, Congo Brazzaville, Mauritania, and South Africa). Of the 17 countries with no change or an increase in prevalence of children at risk of poor development, 11 were in sub-Saharan Africa.

In 2010, 34 countries had a prevalence of children at risk of 60% or higher: 30 from the low-income group and 28 from sub-Saharan Africa (figure 3). The top ten countries with the largest number of children at risk in 2010 were India, China, Nigeria, Bangladesh, Indonesia, Pakistan, Ethiopia, DR Congo, Tanzania, and the Philippines, the same countries identified in 2004. The sum of children at risk in these ten countries accounted for 64% of all children at risk in 2010. Country-level estimates of children at risk in 141 countries between 2004 and 2010 are presented in the appendix (p 22).

Use of child-level poverty ratios yielded higher numbers of children living in poverty and at risk of poor development than did the population-level poverty ratio. For example, for 68 countries in 2004, the number of children living in extreme poverty was 130 million when using population-level poverty ratio and 145 million when using the child-level poverty ratio. The number of children at risk derived from the child-level extreme poverty ratio was 7 million higher than that derived from the population-level extreme poverty ratio (appendix p 26). The findings were consistent when moderate poverty measures were used.

## Discussion

Driven by the decline in both stunting and poverty prevalence in children younger than 5 years between 2004 and 2010, especially in China and India, a noticeable reduction was observed in both number and prevalence of children at risk of poor development in the 141 low-income and middle-income countries between 2004 and 2010, even though the child population has increased in this time. The declining trend and regional profile remained unchanged when the two different poverty measures (extreme and moderate) were used.

Progress, however, was uneven across regions, with sub-Saharan Africa having the smallest reduction and the highest prevalence of children at risk during this time period. One notable concern is that disparity in exposure to risk factors between income groups improved little during

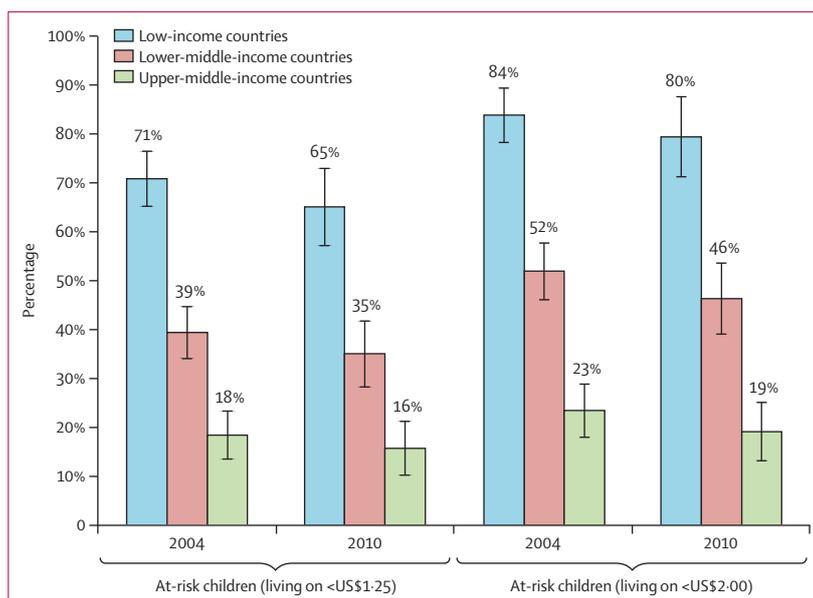
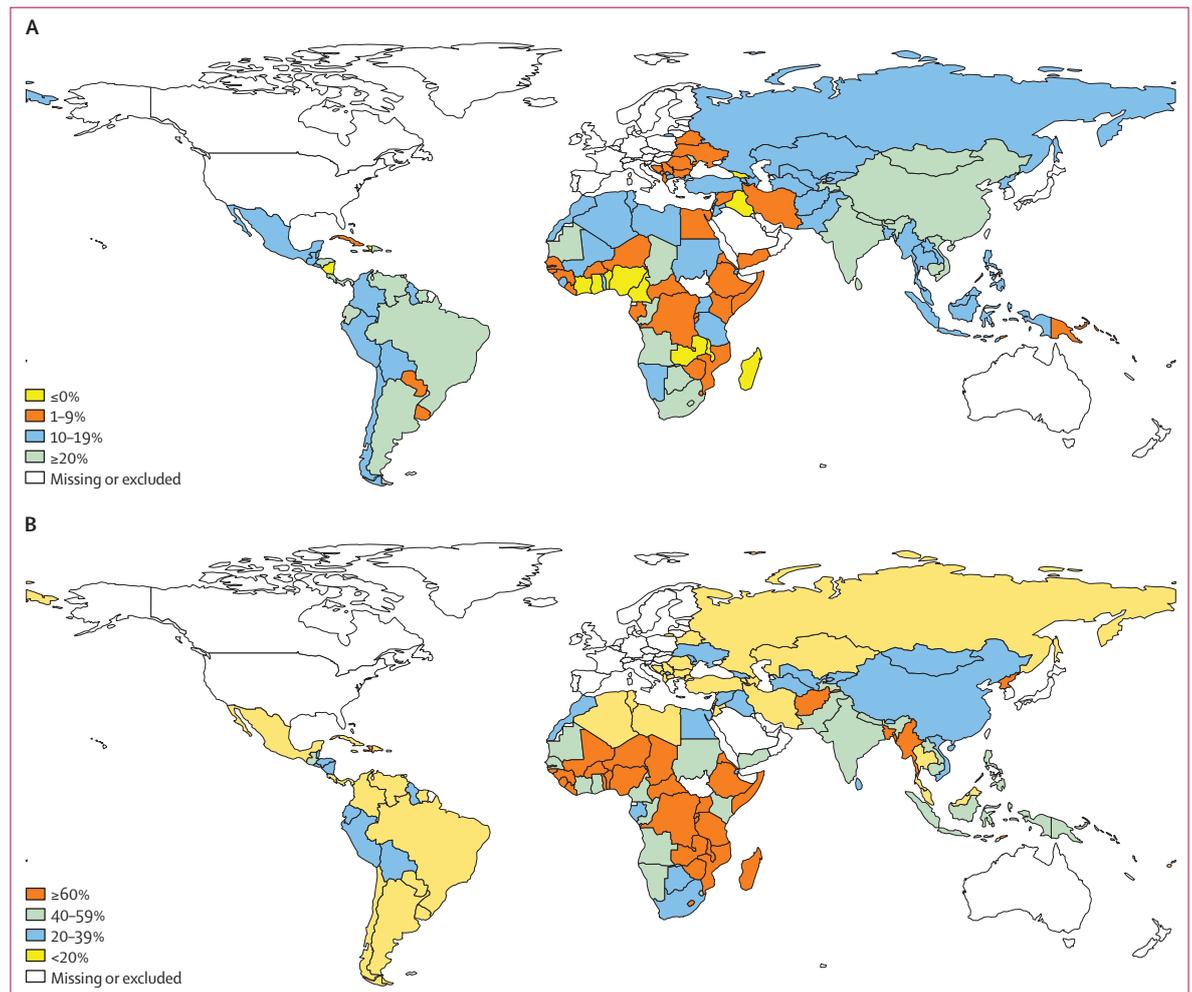


Figure 2: Prevalence of children at risk of poor development by country income group in 2004 and 2010 using extreme and moderate poverty measures

this period, with a disproportionate exposure to the risks for poor child development in low-income countries.

This study shows encouraging, yet insufficient, progress in reducing risks for poor child development from 2004 to 2010. In 2010, at least 43% of children aged younger than 5 years were at risk of not fulfilling their development potential because of exposure to stunting or extreme poverty; and the prevalence increased to 56% when extreme poverty measures were replaced with moderate poverty measures. Even in south Asia, a region with the greatest progress during the period, more than half of the children were exposed to stunting or extreme poverty in 2010. The evidence clearly indicates that the challenge to improve child development, and thereby human capital and health, remains large in the next decade. The pace of reducing stunting and poverty will have to increase substantially for the vulnerable children, especially in low-income countries.

The present study extended the availability of data in the study by Grantham-McGregor and colleagues<sup>2</sup> and applied updated methods. However, two limitations remain. First, although poverty and stunting are strongly associated with risks for poor child development, other risks for poor development exist that are not necessarily associated with poverty and stunting, such as maternal depression, violence against children, or adverse environmental conditions. Low maternal schooling affects the amount and quality of cognitive stimulation provided to young children.<sup>20,21</sup> Recent reviews on studies of violence against children concluded that the prevalence of child maltreatment worldwide is high and puts millions of children at risk of poor development.<sup>22,23</sup> Children exposed to multiple risk factors have a greater likelihood of poor adult health and wellbeing.<sup>24</sup> A pioneering study in the 15 countries with available data on low maternal schooling



**Figure 3:** Country-level percentage of children younger than 5 years at risk of poor development in 141 countries (A) Reduction between 2004 and 2010. (B) Prevalence in 2010.

and child maltreatment showed that estimates of children at risk in all 15 countries in 2010 increased substantially from 63% (associated with stunting and extreme poverty) to 75% when low maternal schooling and child maltreatment were added.<sup>25</sup> Because of the insufficient data for these risk factors in low-income and middle-income countries and insufficient validation studies of the existing variables, we were not able to introduce these risk factors into the global estimation. This limitation highlights the need to develop global standards and broad-scale data to measure risk and protective factors for early child development. Although we improved the accuracy and comparability of the estimates across countries and between years with improved data and methods, estimates could go beyond 2010 as the frequency of macro-level and micro-level data increases and time to access the data improves.

Elimination of risks in early child development is a formidable challenge and requires a comprehensive understanding of the state of children's development.

Although exposure to risk factors is an effective predictor for poor child development, proximal indicators of child development, such as direct measures of early child development, including intervention coverage and access to protective factors, would complement our knowledge about risk factors and shed light on how to effectively reduce risk factors for poor early child development through interventions.

Future recommendations include continuing to monitor global progress in reducing the number of children aged younger than 5 years at risk of poor development by addressing the limitations of the current methods and investing in data and research strategies to develop standardised indicators for measuring child development. With increased knowledge of evidence-based interventions on maternal health and early child development,<sup>26-30</sup> immediate actions are needed to scale up effective interventions, such as improving maternal and child nutrition, targeting the most vulnerable children in sub-Saharan Africa and south Asia.

**Contributors**

CL designed the study, conducted the analysis, and wrote the first draft of the manuscript. MMB and LMR interpreted results, made critical comments, and wrote the paper. All authors reviewed the draft versions and approved the final submission.

**Declaration of interests**

We declare no competing interests.

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**References**

- Shonkoff J, Richter L, Van Der Gaag J, Bhutta Z. An integrated scientific framework for child survival and early childhood development. *Pediatrics* 2012; **129**: e460–72.
- Grantham-McGregor S, Cheung YB, Cueto S, Glewwe P, Richter L, Strupp B. Developmental potential in the first 5 years for children in developing countries. *Lancet* 2007; **369**: 60–70.
- Hoddinott J, Maluccio JA, Behrman JR, Flores R, Martorell R. Effect of a nutrition intervention during early childhood on economic productivity in Guatemalan adults. *Lancet* 2008; **371**: 411–16.
- Victora CG, Adair L, Fall C, et al, for the Maternal and Child Undernutrition Study Group. Maternal and child undernutrition: consequences for adult health and human capital. *Lancet* 2008; **371**: 340–57.
- Stein AD, Wang M, Martorell R, et al. Growth patterns in early childhood and final attained stature: data from five birth cohorts from low- and middle-income countries. *Am J Hum Biol* 2010; **22**: 353–59.
- Chang SM, Walker SP, Grantham-McGregor S, Powell CA. Early childhood stunting and later behaviour and school achievement. *J Child Psychol Psychiatry* 2002; **43**: 775–83.
- Adair LS, Fall CH, Osmond C, et al. Associations of linear growth and relative weight gain during early life with adult health and human capital in countries of low and middle income countries: findings from five birth cohort studies. *Lancet* 2013; **382**: 525–34.
- Hoddinott J, Behrman JR, Maluccio JA, et al. Adult consequences of growth failure in early childhood. *Am J Clin Nutr* 2013; **98**: 1170–78.
- Denboba A, Sayre RK, Wodon Q, Elder L, Rawlings L, Lombardi J. Stepping up early childhood development: investing in young children with high returns. Washington, DC: The World Bank, 2014.
- Gertler P, Heckman J, Pinto R, et al. Labor market returns to an early childhood stimulation intervention in Jamaica. *Science* 2014; **1014**: 998–1001.
- WHO, Multicentre Growth Reference Study Group. WHO child growth standards: length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age: methods and development. Geneva: World Health Organization, 2006.
- Chen S, Ravallion M. The developing world is poorer than we thought, but no less successful in the fight against poverty. *Q J Econ* 2010; **125**: 1577–625.
- Chen S, Ravallion M. How have the world's poorest fared since the early 1980s? *World Bank Res Obs* 2004; **19**: 141–70.
- World Bank. World Bank list of economies. January 2011. <http://librarians.acm.org/sites/default/files/Jan%202011%20World%20bank%20list%20of%20Economies.pdf> (accessed Sept 6, 2014).
- World Bank. Poverty headcount ratio at \$1.90 a day (2011 PPP) (% of population). <http://data.worldbank.org/indicator/SI.POV.DDAY> (accessed Sept 29, 2014).
- Stevens GA, Finucane MM, Paciorek CJ, et al. Trends in mild, moderate, and severe stunting and underweight, and progress towards MDG 1 in 141 developing countries: a systematic analysis of population representative data. *Lancet* 2012; **380**: 824–34.
- Olinto P, Beegle K, Sobrado C, Uematsu H. The state of the poor: where are the poor, where is extreme poverty harder to end, and what is the current profile of the world's poor? Washington, DC: World Bank, 2013.
- United States Agency for International Development. Demographic and Health Surveys, data. <http://www.dhsprogram.com/data/> (accessed Sept 6, 2014).
- UNICEF. Multiple indicator cluster surveys. 2014. <http://www.childinfo.org/mics.html> (accessed Oct 8, 2014).
- Walker SP, Wachs TD, Gardner JM, et al. Child development: risk factors for adverse outcomes in developing countries. *Lancet* 2007; **369**: 145–57.
- Carvalho L. Childhood circumstances and the intergenerational transmission of socioeconomic status. *Demography* 2012; **49**: 913–38.
- Child Protection Monitoring and Evaluation Reference Group. Measuring violence against children: inventory and assessment of quantitative studies. 2014. [http://www.unicef.org/ecuador/CP\\_MERG\\_REPORT.pdf](http://www.unicef.org/ecuador/CP_MERG_REPORT.pdf) (accessed Sept 6, 2014).
- Stoltenborgh M, Bakermans-Kranenburg MJ, Alink Lenneke RA, Ijzendoorn MH. The prevalence of child maltreatment across the globe: review of a series of meta-analyses. *Child Abuse Rev* 2015; **24.1**: 37–50.
- Evans G, Li D, Sepanski WS. Cumulative risks and child development. *Psychol Bull* 2013; **139**: 1342–96.
- Richter LM, Darmstadt G, Daelmans B, et al, with the Paper 3 Working Group, for the Lancet Early Childhood Development Steering Committee. Investing in the foundation of sustainable development: pathways to scale up for early childhood development. *Lancet* 2016; published online Oct 4. [http://dx.doi.org/10.1016/S0140-6736\(16\)31698-1](http://dx.doi.org/10.1016/S0140-6736(16)31698-1).
- Engle PL, Fernald LC, Alderman H, et al. Strategies for reducing inequalities and improving developmental outcomes for young children in low-income and middle-income countries. *Lancet* 2011; **378**: 1339–53.
- Bhutta ZA, Das JK, Rizvi A, et al. Evidence-based interventions for improvement of maternal and child nutrition: what can be done and at what cost? *Lancet* 2013; **382**: 452–77.
- Bhutta ZA, Das JK, Rizvi A, et al. Can available interventions end preventable deaths in mothers, newborn babies, and stillbirths, and at what cost? *Lancet* 2014; **384**: 347–70.
- Ruel MT, Alderman H, and the Maternal and Child Nutrition Study Group. Nutrition-sensitive interventions and programmes: how can they help to accelerate progress in improving maternal and child nutrition? *Lancet* 2013; **382**: 536–51.
- Lassi ZS, Das JK, Salam RA, Bhutta ZA. Evidence from community level inputs to improve quality of care for maternal and newborn health: interventions and findings. *Reprod Health* 2014; **11** (suppl 2): S2.