Significant Cognitive Delay among 3-4 Year Old Children in Low and Middle Income Countries: Prevalence Estimates and Potential Impact of Preventative Interventions

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Abstract

Background: We sought to: (1) estimate the prevalence of significant cognitive delay (a marked delay in the development of general cognitive functioning) among nationally representative samples of young children in middle and low income countries; (2) estimate the total number of children under five years of age with significant cognitive delay living in low and middle income countries; and (3) estimate the potential impact of five preventative interventions.

Methods: Secondary analysis of data collected in Rounds 4 and 5 of UNICEF's Multiple Cluster Indicators Surveys in 51 countries involving 163,293 3-4 year old children. Adjusted population attributable fractions were used to estimate the potential impact of five interventions based on Sustainable Development Goals (SDGs).

Results: The prevalence of significant cognitive delay in 3-4 year old children in middle and low income countries was 10.1% (95% CI 9.7%-10.4%). Prevalence was strongly inversely related to country economic wealth. The estimated total number of children under 5 with significant cognitive delay living in low and middle income countries was just under 55 million. This number could be reduced by over 60% if three separate SDGs were achieved; every mother had secondary level education, every household had access to improved water and sanitation, every child had an acceptable level of home stimulation.

Conclusions: Our results provide additional evidence in support of a range of specific preventative interventions in early childhood to reduce the loss of developmental potential among children in low and middle income countries.

Key Messages:

- Little is known about the prevalence or predictors of significant cognitive delay in low and middle income countries.
- Our estimates suggest that just under 55 million children living in low and middle income countries under age 5 have significant cognitive delay
- This disproportionate loss of developmental potential could be meaningfully reduced by implementing specific preventative interventions in early childhood
- Prevalence of significant cognitive delay in children under 5 could be reduced by over 60% if: 1) every mother had secondary level education, 2) every household had access to improved water and sanitation, and 3) every child had an acceptable level of home stimulation.

Keywords: Cognitive delay, intellectual disability, prevention, low and middle income countries, young children

Introduction

It has been estimated that 250 million children under the age of 5 years who live in low or middle-income countries do not reach their developmental potential.(1) Loss of developmental potential largely arises from exposure to a range of nutritional, environmental and social risks that are typically associated with growing up in poverty.(1-8) A proportion of this group of young children are likely to have delayed a developmental delay in relation to their general cognitive functioning as evidenced by delays in expressive and receptive language, literacy, numeracy and independence.(9) Marked delays in general cognitive functioning demonstrated at an early age may that persist across middle childhood and consequently may be associated with either intellectual disability (ID: typically defined as an IQ below 70) or borderline intellectual functioning (BIF: typically defined as an IQ between 70 and 84 inclusive).(10, 11) Indeed, most approaches to screening for children in low or middle-income countries who may be at risk of ID are based on either the direct or indirect assessment of language, literacy, numeracy and independent functioning in young children.(12) Both ID and BIF of these conditions are associated with poor educational attainment, unemployment, social exclusion, poor health and reduced life expectancy.(10, 11, 13-15)

Little is known about the prevalence or predictors of significant cognitive delay or intellectual disabilityID or BIF in low and middle income countries. For example, a recent WHO commissioned review of the prevalence of intellectual disabilities identified 26 studies that used regional, provincial or national sampling frames.(16) All but one of these studies were undertaken in high income countries. As a result, little is known about the extent to which the prevalence of ID (or marked significant cognitive delay in young children that may subsequently be associated with ID) varies by such factors as geographical location and country economic status. However, the available evidence on between-country variation in the risk of exposure to established determinants of significant cognitive delayID or BIF (e.g., household poverty, undernutrition) suggests that the incidence of ID significant cognitive delay is likely to be much higher in lower income countries.(1, 5, 7) Although methodologically limited, the sparse available evidence on prevalence supports this hypothesis.(16)

The aims of the present paper were: (1) to estimate the prevalence of significant cognitive delay among nationally representative samples of young children in a range of middle and low income countries; (2) to use these estimates to provide global estimates of the prevalence of significant cognitive delay; and (3) to estimate for low and middle income countries the potential impact of a range of preventative interventions specified in the Sustainable Development Goals (SDGs).(17)

Method

We undertook secondary analysis of data collected in Rounds 4 and 5 of UNICEF's Multiple Cluster Indicators Surveys (MICS).(18) The MICS programme seeks to generate robust country-specific data on the wellbeing of young children and mothers. It has formed the basis of measuring progress toward the achievement of the Millennium Development Goals and the Sustainable Development Goals.(18) Following approval by UNICEF, MICS data were downloaded from http://mics.unicef.org/. At the end of the download period (January 2018), data from nationally representative surveys were available for 55 countries.

MICS contains a number of questionnaire modules. Data used in the present paper were extracted from the household module and the module applied to all children under five living in the household. Details of the sampling procedure used in each country are available at http://mics.unicef.org/. Countries used cluster sampling methods to derive samples representative of the national population of mothers and young children.

Identification of children with significant cognitive delay

The child under five module contained the Early Child Development Index (ECDI), a ten item scale based on milestones that children are expected to achieve by ages 3 and 4.(19) The ECDI contains four domains; literacy-numeracy, physical, social emotional, and learning. ECDI data were~~as~~ collected on children in the age range 36-59 months. We used all five items from the literacy-numeracy and learning domains to identify children with significant cognitive delay. All items are based on key informant (primarily maternal) report with simple binary (yes/no) response options.

- *Literacy-numeracy:* Can the child: (1) identify/name at least ten letters of the alphabet; (2) read at least four simple, popular words; (3) name and recognize the symbols of all numbers from 1 to 10?
- *Learning*: Can the child: (4) follow simple directions on how to do something correctly; (5) when given something to do, do it independently?

Previously, McCoy and colleagues used just the two ECDI *learning* items to identify children with cognitive delay, defining delay in terms of the reported inability to complete either or both items.(9) We adopted a significantly more stringent approach to identifying cognitive delay, defining delay in terms of the reported inability to complete all five items. Our decision to ~~, hence the~~ use ~~of~~ the prefix 'significant' to describe the extent of cognitive delay was driven by our concern to highlight the difference between our approach to operationalising cognitive delay in EDCI data and that previously used by McCoy and colleagues. The five items demonstrated an acceptable degree of internal consistency across the whole sample (alpha=0.66), although there was some marked between country variation (alpha range 0.38-0.77). This variation was unrelated to country economic status (see below). Percentage of missing data on individual ECDI items ranged from 1.5%-1.7%. Complete data to determine s~~S~~ignificant cognitive delay ~~based on complete data was~~ were available for 96.8% of children. In the majority of ~~these~~ cases in which data were incomplete (2.1% of the total) data were~~as~~ missing on only one or two of the ECDI items. As a result, we used linear regression methods to impute missing ECDI data (with present ECDI data as the predictor variables) for all children for whom data ~~was~~ were available on the majority of ECDI items. Significant cognitive delay classification based on the collected and imputed items was available for 98.9% of participants. Four countries were excluded as ECDI items were not collected. Analyses were undertaken on the remaining 51 countries.

Country Economic Status

Given the commonly reported association between child wellbeing and national wealth in low and middle income countries,(20) we used World Bank criteria as of July 2016 to classify countries as upper middle income, lower middle income and low income.(21) These classifications are based on per capita Gross National Income (pcGNI; expressed as current US$ rates) using the World Bank's Atlas Method. We downloaded 2015 Atlas Method pcGNI from the World Bank.(22, 23) For one country (the State of Palestine) these data were not available. In this instance pcGNI was estimated from 2011 pcGNI data reported in the 2015 Human Development Report.(24) The estimation involved rank ordering the countries included in our analyses on the basis of Atlas method pcGNI, identifying the two countries included in our analyses that in the 2015 Human Development Report had a pcGNI immediately above and below the country for which pcGNI was not available and estimating pcGNI as the mid-point between the countries immediately above and below in country rankings.

In addition we downloaded country level World Bank GINI Index, a measure of income inequality, for 2015 or, if not available, the most recent year since 2010. These data were available for 39 of the 51 countries. Level of income inequality has been associated with variations in health and wellbeing, including among children, in higher income countries.(25)

Potential Interventions

We identified five risk factors for cognitive delay in young children about which data were~~are~~ available in the MICS and which are related to specific SDG goals: these were 1) relative household poverty, 2) maternal education, 3) access to improved water and improved sanitation, 4) stunting, and 5) child stimulation.

Relative Household Poverty

Relative household poverty is likely to also be associated with variations in children's health and wellbeing. MICS data includes a wealth index for each household. To construct the wealth index, principal components analysis is performed by using information on the ownership of consumer goods, dwelling characteristics, water and sanitation, and other characteristics that are related to the household's wealth, to generate weights for each item. Each household is assigned a wealth score based on the assets owned by that household weighted by factors scores. The wealth index is assumed to capture underlying long-term wealth through information on the household assets.(26, 27) These data were available for 50 countries. There was no missing data in the countries in which the data were~~as~~ collected. We defined relative household poverty as living in a household in the bottom two quintiles of the country-specific distribution of wealth.

Intervening to change relative household poverty is relevant to SDG 1 (end poverty in all its forms everywhere).(28)

Maternal Education

The highest level of education received by the child's mother was recorded using country-specific categories. These data were available for all 51 countries. Data were missing for 0.9% of children. We recoded these data into a binary measure of receipt of secondary or higher level education. Increasing level of maternal education is associated with child wellbeing. Intervention for girls education is relevant to SDG 4.1 (ensure that all girls and boys complete free, equitable and quality primary and secondary education).(28)

Stunting

Child weight and height data ~~was~~ were collected by direct measurement using anthropometric equipment recommended by UNICEF. Following WHO, UNICEF and World Bank procedures, height for age data were transformed into z scores from the median reference population; WHO growth standards.(29-32) These data were available for 43 countries. Data were missing for 0.4% of children in these countries. Stunting (as an indicator of likely undernutrition) was defined as scoring more than two standard deviations below the reference population median score. Decreasing incidence of stunting is relevant to SDG 2.2 (end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age).(28)

Access to Improved Water & Improved Sanitation

Access to improved water was defined as the main source of drinking water being piped, public tap/standpipe, tube well/borehole, protected well, protected spring or rainwater collection (MICS4 indicator 4.1). *Access to improved sanitation* was defined as sanitation facilities which are not shared and are based on flush to piped sewer system/septic tank/pit(latrine), ventilated improved pit latrine, pit latrine with slab, composting toilet (MICS4 indicator 4.3). These data were available for 43 countries. Data were missing for 0.7% of children in these countries. We recoded these data into a simple binary measure of the household having access to both improved water and improved sanitation. SDG Goal 6 is ensure availability and sustainable management of water and sanitation for all.(28)

Child Stimulation

Respondents were asked 'In the past 3 days, did you or any household member over 15 years of age engage in any of the following activities with (*name*): (a) read books to or looked at picture books with (*name*)?; (b) told stories to (*name*)?; (c) sang songs to (*name*) or with (*name*), including lullabies?; (d) took (*name*) outside the home, compound, yard or enclosure?; (e) played with (*name*)?; (f) named, counted, or drew things to or with (*name*)? *Support for learning* was defined as an adult having engaged in four or more activities to promote learning and school readiness in the past 3 days (MICS4 indicator 6.1).

Respondents were also asked 'How many children's books or picture books do you have for (*name*)?' and 'I am interested in learning about the things that (*name*) plays with when he/she is at home. Does he/she play with: (a) homemade toys (such as dolls, cars, or other toys made at home)? (b) toys from a shop or manufactured toys? (c) household objects (such as bowls or pots) or objects found outside (such as sticks, rocks, animal shells or leaves)?'. An adequate number of books (MICS4 indicator 6.3) was defined as having three or more children's books. An adequate number of playthings (MICS4 indicator 6.4) was defined as having two or more playthings. These two items were combined into a single item of having adequate books **and** having adequate playthings. We defined low child stimulation as the presence of either low support for learning **or** inadequate books and playthings in the home. These data were available for 49 countries. Data were missing for 1.1% of children in these countries. Level of child stimulation is relevant to SDG 4.2 (ensure that all girls and boys have access to quality early childhood development, care and pre-primary education).(28)

Approach to Analysis

In the first stage of analysis we used simple bivariate descriptive statistics to estimate the prevalence of significant cognitive delay (with 95% confidence intervals) among 3/4 year old children for each country and pooled estimates for each country economic classification group. In the second stage of analysis we used non-parametric correlation coefficients to examine the association between country pcGNI, GINI Index scores and country level prevalence of significant cognitive delay. These analyses were undertaken using IBM SPSS v24 using the complex samples facility to take account of the clustering of observations by country and within country sampling clusters. All within-country analyses used UNICEF's country-specific child-level weights to take account of biases in sampling frames and household and individual level non-response. For pooled analyses we recalibrated the country specific weights to take account of between country differences in the child sampling fraction and the estimated population of children under the age of 5 years.

In the final stage of analysis we applied pooled prevalence ratios for each country income group to current global population estimates of the number of children under five living in upper middle, lower middle and low income countries.(33) We then estimated for each country group the adjusted population attributable fraction (PAF) of significant cognitive delay associated with the five SDG interventions described above. The PAF is commonly considered an estimate of either (1) the proportion of instances of a health condition or impairment causally explained by, or attributable to, the risk factor(s) being considered, or (2) the proportion of instances of a health condition or impairment that could be eliminated from the population if exposure to the risk factor were eliminated (or if exposure was were no longer associated with any increased risk).(34) As such, PAFs can provide estimates of the potential impact of interventions in reducing the prevalence of health conditions or impairments in a given population. Given the potential of confounding between risk factors we used multivariate statistical techniques (Poisson regression) to estimate the adjusted prevalence rate ratio for significant cognitive delay associated with each risk factor.(35, 36) The statistical modelling was undertaken in Stata v12 using the generalised linear modelling procedures with svyset and syv commands to take account of the clustering of observations by country and within country sampling clusters. Finally, we used the results of the multivariate analysis to estimate for each country the adjusted PAF for each risk factor using the formula (proportion of children exposed)*(adjusted prevalence ratio – 1)/ (adjusted prevalence ratio).(37)

As reported above, we imputed some missing data on the ECDI. No other missing data were imputed. To test the robustness of the results of the analyses we repeated the analyses on three sets of data: (1) using imputed ECDI data to determine significant cognitive delay classification and including all enumerated 3-4 year old children; (2) using only participants for which we had complete ECDI data to determine significant cognitive delay classification and including all enumerated 3-4 year old children; (3) using imputed ECDI data to determine significant cognitive delay classification but including only the first enumerated child for each household. The latter set of analyses were undertaken in order to estimate the potential impact of including multiple children per household on the adjusted prevalence rate ratios (more than one child was enumerated in 14.6% of households). Unless specified all results are based on the first set of data (imputed ECDI data including all enumerated 3-4 year old children).

Results

The total sample included information on 163,293 3-4 year old children (59,137 in 22 upper middle income countries, 53,243 in 18 lower middle income countries and 50,413 in 11 low income countries). Overall, 49.5% of the children were 4 years of age (95%CI 48.9%-50.2%). The percentage of 4 year olds was lower in poorer countries as follows: 52.1% (50.4%-53.7%) in upper middle income countries, 49.4% (48.7%-50.2%) in lower middle income countries and 46.3% (45.7%-46.9%) in low income countries. Overall, 49.7% (49.1%-50.4%) of the children were girls. There was no clear association between gender balance and national income groupings (girls 50.8% (49.1%-52.5%) in upper middle income countries, 49.0% (48.2%-49.9%) in lower middle income countries and 50.1% (49.5%-50.7%) in low income countries). For detailed age and gender prevalence rates by country, please see Supplementary Table 1.

Information on the prevalence of significant cognitive delay is presented in Table 1 and Figure 1.

[insert Table 1]

[insert Figure 1]

In analyses pooled across countries, the overall prevalence of significant cognitive delay was 10.1% (95%CI 9.7%-10.4%). Prevalence rates varied by: (1) country economic status, 2.7% (2.5%-3.0%) in upper middle income countries, 10.6% (10.0%-11.2%) in lower middle income countries and 19.1% (18.4%-19.9%) in low income countries; (2) child age, 12.9% (12.4%-13.4%) among three year old children, 7.2% (6.8%-7.6%) among four year old children; and (3) child sex, 10.5% (10.1%-11.0%) among boys, 9.6% (9.1%-10.1%) among girls.

Inspection of the association between country pcGNI and prevalence of significant cognitive delay (Figure 1) suggests that the association is non-linear and the data for Chad wais a marked outlier. The rank-order correlation between country pcGNI and prevalence of significant cognitive delay was -0.79 (95%CI -0.66 - -0.88) for all countries and -0.78 (95%CI -0.64 - -0.87) if Chad were excluded. Given the association between country economic groupings and child age (see above), we used ordered logistic regression to estimate the strength of association between country pcGNI and prevalence of significant cognitive delay before and after controlling for the percentage of four year old children (before regression coefficient -0.510 (-0.304 - -0.706), after -0.485 (-0.279 - - 0.691). As can be seen, the association between pcGNI and prevalence of significant cognitive delay was only marginally affected when controlling for between-country variation in the percentage of four year old children.

The rank-order correlation between country GINI index and prevalence of significant cognitive delay was +0.27 (95%CI -0.05 - +0.54) for all countries and +0.24 (95%CI -0.09 - +0.52) if Chad were excluded. Excluding Chad reduced the prevalence estimate for low income countries to 16.1% (15.4%-16.9%).

We applied pooled prevalence estimates to the estimated number of children under five living in upper middle, lower middle and low income countries,(33) applying the more conservative estimate for low income countries (by excluding Chad) and rounding results to the nearest 10,000 children. This exercise suggested that 54.4 million children under five living in low and middle income countries have significant cognitive delay. Of these, 4.66 million (9%) live in upper middle income countries, 33.40 million (61%) live in low middle income countries and 16.34 million (30%) live in low income countries.

[insert Table 2]

In Table 2 we present for upper middle, lower middle and low income countries the adjusted PAF of significant cognitive delay associated with five risk factors. We used the PAFs to provide global estimates of the number of children under five years of age in middle and low income countries for whom significant cognitive delay could potentially be eliminated if five specific goals were achieved: (1) relative household poverty was eliminated (4.4 million); (2) every mother had secondary level education (11.6 million); (3) child stunting was eliminated (4.6 million); (4) every household had access to improved water and sanitation (11.1 million); and (5) every child had an acceptable level of home stimulation (11.6 million). If all five goals were achieved, significant cognitive delay could potentially be eliminated for 43.3 million children, which is 80% of those estimated to have significant cognitive delay in the world's low and middle income countries. If the three most impactful goals were achieved (every mother had secondary level education, every household had access to improved water and sanitation, and every child had an acceptable level of home stimulation) significant cognitive delay could potentially be eliminated for 34.3 million (63%) children.

Analyses undertaken on participants in which we had complete ECDI data to determine significant cognitive delay classification reduced the estimated number of children with significant cognitive delay from 54.4 to 53.9 million and the total potential prevention percentage from 80% to 79%. Analyses undertaken using imputed ECDI data but including only the first enumerated child for each household reduced the estimated number of children with significant cognitive delay from 54.4 to 52.2 million and increased the total potential prevention percentage from 80% to 82%.

Discussion

Our analysis of 51 nationally representative surveys undertaken in low and middle income countries indicates that: (1) the prevalence of significant cognitive delay in young children is strongly inversely related to country economic wealth; and (2) the estimated global prevalence of significant cognitive delay in children under 5 living in low and middle income countries could be reduced by 80% if five separate goals were achieved, that is, every mother had secondary level education, every household had access to improved water and sanitation, every child had an acceptable level of home stimulation, household poverty were eliminated, and child stunting were eliminated.

Our study is, to our knowledge, the first to derive estimates from nationally representative data of the prevalence of significant cognitive delay among children in low and middle income countries and the first to estimate for low and middle income countries the potential impact of a range of preventative interventions. As such, it contributes to two of the key global research priorities identified by WHO in relation to significant cognitive delay (screening and early intervention),(38) and provides additional evidence in support of a range of specific preventative interventions in early childhood to reduce the loss of developmental potential among children in low and middle income countries.(1, 4-8, 17)

The primary limitations of our study lie in the unknown validity of our use of the five selected ECDI items as a screening measure of significant cognitive delay and the association between significant cognitive delay and later intellectual disability or borderline intellectual functioning. However, circumstantial evidence of the potential validity of the measure is provided by the strength and direction of association between significant cognitive delay and three well-established correlates of intellectual disability and/or borderline intellectual functioning~~significant cognitive delay~~; male gender; household poverty; and evidence of undernutrition.(1, 5, 7, 16) As has been argued previously by McCoy and colleagues, while use of the ECDI and similar instruments should be considered an asset in epidemiological research in low and middle income countries, future research is needed ‘to develop additional, more detailed, and age-specific measures of early childhood development that can more accurately capture children’s capacity across a wide range of cultures and local contexts’.(9)

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Table 1: Estimates of country-specific prevalence of risk of significant cognitive delay

Country	World Bank Region	Year of survey	Sample size	pcGNI (2015)	% with SCD	95% CIs
Upper Middle Income Countries			59,137			
Argentina*	Latin America & Caribbean	2011/12	3,625	12,430	0.8%	0.5-1.6
Panama	Latin America & Caribbean	2013	2,315	11,730	3.1%	2.2-4.3
Kazakhstan	Europe & Central Asia	2015	2,277	11,410	1.0%	0.7-1.7
Costa Rica*	Latin America & Caribbean	2011	906	10,570	0.1%	0.0-0.4
Mexico*	Latin America & Caribbean	2015	3,417	9,830	0.7%	0.5-1.1
Suriname*	Latin America & Caribbean	2011	1,285	8,830	1.5%	0.9-2.5
Saint Lucia	Latin America & Caribbean	2012	122	8,180	0.4%	0.1-2.9
Montenegro	Europe & Central Asia	2013	649	7,280	0.9%	0.3-2.3
Turkmenistan*	Europe & Central Asia	2015-16	1,518	7,120	2.1%	1.4-3.0
Belarus	Europe & Central Asia	2012	1,412	6,720	0.1%	0.0-0.6
Cuba	Latin America & Caribbean	2014	2,278	6,570	1.3%	0.6-3.1
Dominican Republic	Latin America & Caribbean	2014	8,039	6,240	1.6%	1.1-2.0
Iraq	Middle East & North Africa	2011	13,903	5,960	7.9%	7.2-8.7
Thailand	South Asia	2012/13	4,359	5,690	0.9%	0.5-1.3
Serbia	Europe & Central Asia	2014	1,211	5,540	0.2%	0.1-0.7
Macedonia	Europe & Central Asia	2011	558	5,100	0.8%	0.3-2.2
Bosnia	Europe & Central Asia	2011/12	1,031	5,050	0.2%	0.0-0.7
Algeria	Middle East & North Africa	2012/13	5,562	4,800	6.6%	5.8-7.6
Jamaica	Latin America & Caribbean	2011	671	4,730	0.6%	0.2-1.4
Belize	Latin America & Caribbean	2011	788	4,510	0.9%	0.4-2.0
Paraguay	Latin America & Caribbean	2016	1,861	4,210	2.4%	1.5-3.8
Guyana	Latin America & Caribbean	2014	1,350	4,060	1.7%	0.8-3.6
Lower Middle Income Countries				53,243		
Kosovo	Europe & Central Asia	2013/14	672	3,980	1.6%	0.8-3.1
Tunisia	Middle East & North Africa	2011/12	1,164	3,930	4.5%	3.3-6.3
Mongolia*	Europe & Central Asia	2013/14	2,373	3,850	1.3%	0.9-1.8
El Salvador	Latin America & Caribbean	2014	3,049	3,840	1.6%	1.2-2.2
Swaziland	Sub-Saharan Africa	2014	1,091	3,280	3.8%	2.7-5.1
Nigeria	Sub-Saharan Africa	2011	10,230	2,850	15.8%	14.6-17.1
Ukraine	Europe & Central Asia	2012	1,929	2,650	0.9%	0.5-1.5
Bhutan	South Asia	2010	2,422	2,340	4.4%	3.5-5.6
Moldova*	Europe & Central Asia	2012	733	2,230	0.2%	0.1-0.9
Lao PDR	South Asia	2011	4,476	2,000	5.2%	4.2-6.3
Vietnam	South Asia	2013/14	1,207	1,990	3.1%	2.2-4.3
Palestine	Middle East & North Africa	2014	3,280	1,875	4.8%	4.0-5.7
Sao Tome & Principe	Sub-Saharan Africa	2014	867	1,690	14.2%	11.8-17.1
Ghana	Sub-Saharan Africa	2011	3,069	1,470	7.8%	6.2-9.7
Cameroon	Sub-Saharan Africa	2014	2,846	1,470	13.9%	12.3-15.6
Mauritania	Sub-Saharan Africa	2011	3,718	1,230	7.2%	6.0-8.6
Bangladesh	South Asia	2012/13	8,801	1,190	7.5%	6.8-8.3
Kyrgyzstan*	Europe & Central Asia		1,816	1,180	4.2%	3.0-5.9

Table 1: Estimates of country-specific prevalence of risk of significant cognitive delay

Country	World Bank Region	Year of survey	Sample size	pcGNI (2015)	% with SCD	95% CIs
Low Income Countries			50,413			
Zimbabwe	Sub-Saharan Africa	2014	4,009	890	8.7%	7.6-9.8
Chad	Sub-Saharan Africa	2010	7,139	880	45.9%	43.6-48.2
Benin	Sub-Saharan Africa	2014	4,860	870	15.9%	14.4-17.5
Mali	Sub-Saharan Africa	2009/10	7,996	790	8.3%	7.4-9.3
Nepal	South Asia	2014	2,279	740	15.4%	12.5-18.8
Guinea-Bissau	Sub-Saharan Africa	2014	2,970	620	11.6%	10.0-13.3
Sierra Leone	Sub-Saharan Africa	2010	3,679	550	20.6%	18.8-22.5
Togo	Sub-Saharan Africa	2010	1,804	540	16.3%	14.3-18.5
Congo, DR	Sub-Saharan Africa	2010	4,047	430	23.3%	20.8-26.0
Central African Republic	Sub-Saharan Africa	2010	3,771	360	21.3%	19.3-23.4
Malawi	Sub-Saharan Africa	2013/14	7,839	340	14.7%	13.3-16.2

Notes: SCD = significant cognitive delay; CIs = Confidence intervals; * low internal consistency of ECDI items (alpha <0.5)

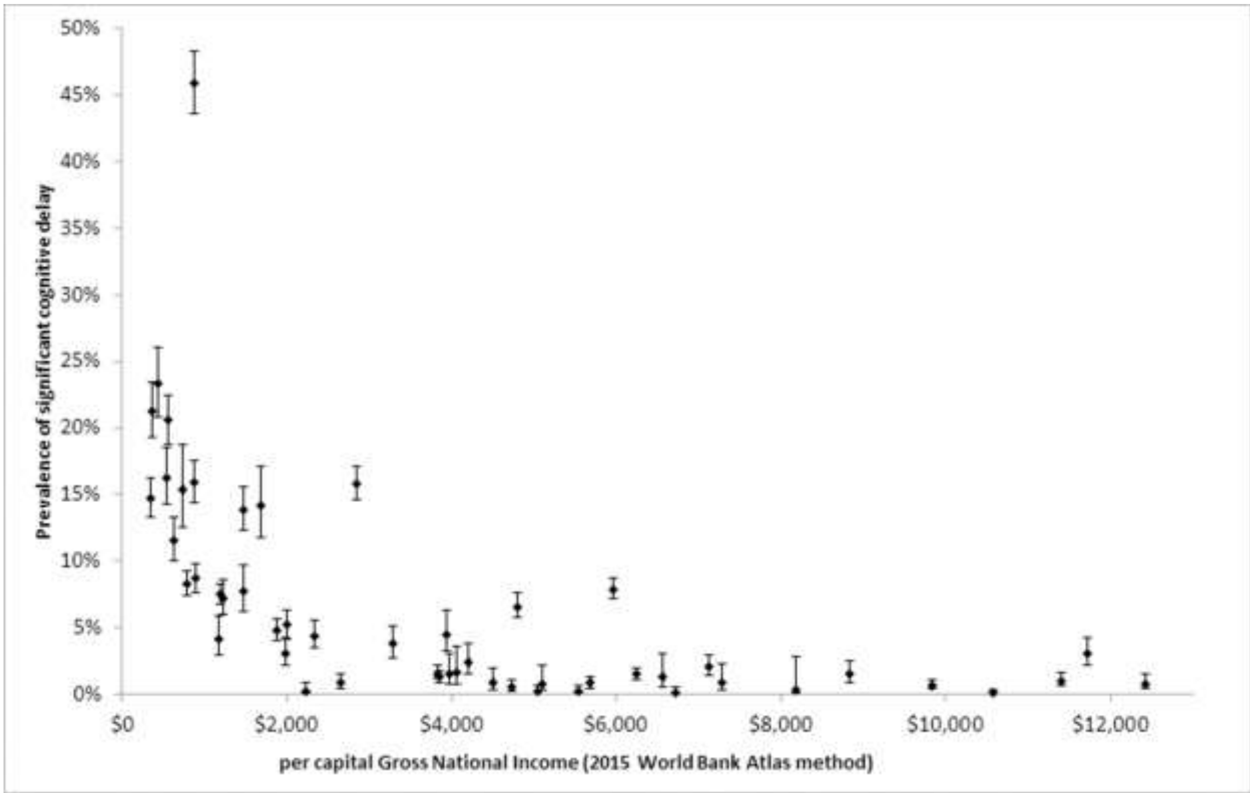
Table 2: Population Attributable Fractions for Risk Factors of Significant Cognitive Delay among 3-4 Year Old Children in Upper Middle Income, Lower Middle Income and Low Income Countries

Risk Factor	**World Bank Income Group Classification**		
	Upper Middle	**Lower Middle**	**Low**
% children exposed			
Relative household poverty	46.2%	45.2%	43.1%
	(44.2%-48.2%)	(43.6%-46.9%)	(41.9%-44.4%)
Mother has less than secondary education	31.8%	57.9%	81.4%
	(30.4%-33.4%)	(56.5%-59.3%)	(80.5%-82.2%)
Child stunting	12.4%	37.0%	38.7%
	(11.5%-13.4%)	(35.8%-38.2%)	(37.8%-39.6%)
Unimproved water or sanitation	47.1%	54.3%	80.2%
	(44.5%-49.6%)	(52.8%-55.8%)	(79.2%-81.3%)
Low level of home stimulation	34.3%	50.4%	63.4%
	(32.9%-35.8%)	(49.3%-51.5%)	(62.3%-64.5%)
Unadjusted prevalence rate ratio (with 95% CI) for risk of significant cognitive delay			
Relative household poverty	1.68	2.18	1.34
	(1.44-1.97)	(1.96-2.44)	(1.26-1.43)
Mother has less than secondary education	2.76	3.07	1.93
	(2.38-3.22)	(2.69-3.51)	(1.74-2.14)
Child stunting	1.77	1.80	1.30
	(1.47-2.14)	(1.63-1.98)	(1.23-1.38)
Unimproved water or sanitation	0.81	2.07	2.03
	(0.67-0.96)	(1.84-2.32)	(1.82-2.26)
Low level of home stimulation	6.20	2.90	1.39
	(5.29-7.27)	(2.56-3.29)	(1.28-1.50)
Adjusted prevalence rate ratio (with 95% CI) for risk of significant cognitive delay			
Relative household poverty	1.08	1.32	1.09
	(0.91-1.28)	(1.18-1.48)	(1.02-1.16)
Mother has less than secondary education	1.63	1.55	1.46
	(1.36-1.97)	(1.34-1.80)	(1.29-1.66)
Child stunting	1.42	1.40	1.16
	(1.17-1.42)	(1.27-1.54)	(1.10-1.23)
Unimproved water or sanitation	0.96	1.42	1.79
	(0.81-1.14)	(1.27-1.59)	(1.61-2.00)
Low level of home stimulation	5.09	1.95	1.26
	(4.18-6.19)	(1.72-2.21)	(1.17-1.37)
Population attributable fraction			
Relative household poverty	7.4%	12.1%	2.5%
Mother has less than secondary education	-3.6%	22.1%	33.9%
Child stunting	2.4%	10.6%	9.5%
Unimproved water or sanitation	8.7%	18.9%	42.7%
Low level of home stimulation	33.7%	25.1%	11.4%

Global estimate of number of children under 5 for who risk could potentially be eliminated if …			
Relative household poverty was eliminated	160,000	3,675,000	590,000
Every mother had secondary level education	575,000	6,850,000	4,185,000
Child stunting was eliminated	170,000	3,540,000	865,000
Every household had improved water or sanitation	0	5,380,000	5,785,000
Every child had an acceptable level of home stimulation	1,285,000	8,220,000	2,140,000

Figure Caption

Figure 1: The association between per capita Gross National Income and country-specific prevalence significant cognitive delay among three to four year old children (all countries)



Supplementary Table 1: Estimates of country-specific prevalence (% with 95% CIs) of risk of significant cognitive delay by age and gender

Country	Boys	Girls	children aged 36-47 months	Children aged 48-59 months
Upper Middle Income Countries				
Argentina*	1.0% (0.7%-1.6%)	0.5% (0.3%-1.0%)	0.9% (0.6%-1.5%)	0.7% (0.4%-1.2%)
Panama	2.3% (1.5%-3.4%)	4.1% (2.4%-6.7%	5.3% (3.6%-7.7%)	1.0% (0.6%-1.6%)
Kazakhstan	1.0% (0.8%-1.8%)	1.0% (0.6%-1.8%)	0.9% (0.5%-1.7%)	1.1% (0.6%-1.9%)
Costa Rica*	0.1% (0.0%-0.7%)	0.1% (0.0%-0.4%)	0.1% (0.0%-0.8%)	0.1% (0.0%-0.4%)
Mexico*	1.0% (0.6%-1.7%)	0.5% (0.3%-1.0%)	1.1% (0.7%-1.8%)	0.5% (0.3%-0.9%)
Suriname*	1.3% (0.7%-2.5%)	1.7% (0.8%-3.4%)	1.4% (0.7%-2.8%)	1.6% (0.7%-3.4%)
Saint Lucia	0.8% (0.1%-5.4%)	0.0% (0.0%-5.7%)	0.7% (0.1%-5.0%)	0.0% (0.0%-6.1%)
Montenegro	0.6% (0.2%-2.4%)	1.2% (0.3%-4.8%)	0.5% (0.1%-2.3%)	1.2% (0.3%-4.4%)
Turkmenistan*	2.4% (1.4%-4.0%)	1.7% (0.9%-3.3%)	4.0% (2.7%-5.9%)	0.2% (0.0%-1.6%)
Belarus	0.2% (0.0%-0.8%)	0.1% (0.0%-0.7%)	0.3% (0.1%-1.0%)	0.0% (0.0%-0.6%)
Cuba	2.0% (0.7%-5.1%)	0.5% (0.2%-1.2%)	1.5% (0.7%-3.0%)	1.1% (0.2%-5.9%)
Dominican Republic	1.3% (1.0%-1.7%)	1.9% (1.5%-2.4%)	2.4% (2.0%-3.0%)	0.9% (0.6%-1.2%)
Iraq	8.6% (7.7%-9.6%)	7.2% (6.4%-8.1%)	10.2% (9.3%-11.3%)	5.5% (4.8%-6.2%)
Thailand	0.7% (0.4%-1.3%)	1.0% (0.5%-1.8%)	1.6% (1.0%-2.6%)	0.2% (0.1%-0.5%)
Serbia	0.2% (0.1%-0.9%)	0.2% (0.1%-1.0%)	0.3% (0.1%-1.2%)	0.2% (0.0%-0.7%)
Macedonia	0.9% (0.2%-3.4%)	0.8% (0.2%-3.0%)	1.7% (0.6%-4.4%)	0.0% (0.0%-1.3%)
Bosnia	0.2% (0.0%-1.2%)	0.2% (0.0%-1.2%)	0.3% (0.1%-1.3%)	0.0% (0.0%-0.9%)
Algeria	7.1% (5.9%-8.6%)	6.1% (5.2%-7.2%)	9.2% (7.8%-10.8%)	4.0% (3.2%-5.0%)
Jamaica	0.5% (0.1%-1.9%)	0.7% (0.2%-2.4%)	1.3% (0.5%-3.4%)	0.0% (0.0%-1.0%)
Belize	0.9% (0.3%-2.7%)	1.0% (0.3%-2.9%)	0.9% (0.3%-2.7%)	1.0% (0.3%-2.9%)

Supplementary Table 1: Estimates of country-specific prevalence (% with 95% CIs) of risk of significant cognitive delay by age and gender

Country	Boys	Girls	children aged 36-47 months	Children aged 48-59 months
Paraguay	2.4%	2.4%	3.0%	1.8%
	(1.6%-3.6%)	(1.6%-3.6%)	(2.2%-4.6%)	(1.1%-2.9%)
Guyana	2.5%	0.9%	3.0%	0.5%
	(1.0%-6.2%)	(0.4%-1.9%)	(1.3%-6.7%)	(0.2%-1.3%)
Lower Middle Income Countries				
Kosovo	2.7%	0.4%	2.4%	0.9%
	(1.4%-5.4%)	(0.1%-2.7%)	(1.1%-5.35)	(0.3%-2.9%)
Tunisia	5.4%	3.7%	7.3%	1.5%
	(3.6%-7/8%)	(2.2%-6.0%)	(5.1%-10.3%)	(0.8%-2.6%)
Mongolia*	1.7%	1.0%	1.9%	0.8%
	(1.1%-2.6%)	(0.5%-1.7%)	(1.2%-2.9%)	(0.4%-1.5%)
El Salvador	1.8%	1.4%	1.8%	1.4%
	(1.2%-2.7%)	(0.8%-2.4%)	(1.2%-2.8%)	(0.8%-2.4%)
Swaziland	5.7%	1.9%	4.8%	2.8%
	(3.9%-8.1%)	(1.0%-3.5%)	(3.2%-7.0%)	(1.7%-4.7%)
Nigeria	16.5%	15.1%	19.4%	12.0%
	(15.0%-18.1%)	(13.7%-16.7%)	(17.7%-21.2%)	(10.7%-13.5%)
Ukraine	1.1%	0.7%	1.7%	0.1%
	(0.6%-1.9%)	(0.3%-1.4%)	(1.1%-2.8%)	(0.0%-0.5%)
Bhutan	4.9%	3.9%	6.2%	2.6%
	(3.7%-6.6%)	(2.8%-5.4%)	(4.8%-8.0%)	(1.7%-3.9%)
Moldova*	0.2%	0.3%	0.2%	0.2%
	(0.0%-1.3%)	(0.0%-1.9%)	(0.0%-1.6%)	(0.0%-1.5%)
Lao PDR	5.4%	4.9%	6.7%	3.5%
	(4.2%-6.8%)	(3.8%-6.3%)	(5.4%-8.3%)	(2.4%-4.9%)
Vietnam	3.1%	3.1%	4.0%	2.3%
	(1.8%-5.0%)	(1.9%-5.0%)	(2.6%-6.1%)	(1.3%-4.2%)
Palestine	5.3%	4.3%	5.6%	4.0%
	(4.3%-6.6%)	(3.3%-5.4%)	(4.5%-6.9%)	(3.1%-5.2%)
Sao Tome & Principe	15.6%	12.9%	18.4%	10.2%
	(12.2%-19.7%)	(9.8%-16.8%)	(15.0%-22.4%)	(7.1%-14.5%)
Ghana	7.4%	8.1%	9.9%	5.3%
	(5.7%-9.6%)	(6.0%-10.8%)	(7.7%-12.8%)	(3.9%-7.2%)
Cameroon	14.5%	13.2%	19.4%	7.8%
	(12.2%-17.1%)	(11.1%-15.7%)	(17.0%-22.1%)	(6.1%-10.0%)
Mauritania	7.6%	6.7%	8.2%	6.1%
	(6.2%-9.4%)	(5.3%-8.4%)	(6.8%-9.9%)	(4.7%-7.8%)
Bangladesh	7.6%	7.4%	9.6%	5.5%
	(6.7%-8.7%)	(6.4%-8.5%)	(8.5%-10.8%)	(4.7%-7.8%)
Kyrgyzstan*	5.4%	2.9%	5.9%	2.4%
	(3.5%-7.9%)	(1.7%-4.9%)	(4.2%-8.2%)	(1.3%-4.2%)

Supplementary Table 1: Estimates of country-specific prevalence (% with 95% CIs) of risk of significant cognitive delay by age and gender

Country	Boys	Girls	children aged 36-47 months	Children aged 48-59 months
Low Income Countries				
Zimbabwe	9.2%	8.1%	11.4%	5.6%
	(8.0%-10.6%)	(7.0%-9.4%)	(10.1%-12.9%)	(4.7%-6.8%)
Chad	45.9%	45.9%	50.9%	40.7%
	(43.1%-48.7%)	(43.1%-48.7%)	(48.2%-53.6%)	(38.1%-43.4%)
Benin	17.1%	14.7%	20.8%	11.0%
	(15.2%-19.1%)	(12.9%-16.8%)	(18.7%-23.1%)	(9.4%-12.8%)
Mali	8.7%	7.8%	11.5%	4.1%
	(7.6%-10.1%)	(6.8%-9.1%)	(10.1%-12.9%)	(3.3%-5.1%)
Nepal	15.5%	15.3%	19.1%	11.8%
	(12.4%-19.3%)	(11.7%-19.8%)	(15.2%-23.9%)	(8.7%-15.6%)
Guinea-Bissau	13.6%	9.6%	16.7%	6.4%
	(11.4%-16.1%)	(8.0%-11.5%)	(14.2%-19.4%)	(5.0%-8.2%)
Sierra Leone	18.7%	22.5%	23.1%	17.5%
	(16.5%-21.1%)	(20.0%-25.1%)	(20.7%-25.8%)	(15.4%-19.9%)
Togo	16.2%	16.4%	21.5%	10.1%
	(13.5%-19.3%)	(13.8%-19.3%)	(18.4%-25.0%)	(8.1%-12.4%)
Congo, DR	24.6%	22.0%	26.8%	18.7%
	(21.5%-27.9%)	(19.0%-25.4%)	(23.9%-30.0%)	(15.9%-21.8%)
Central African Republic	22.8%	19.9%	25.4%	16.3%
	(20.3%-25.5%)	(17.7%-22.3%)	(22.8%-28.1%)	(14.0%-19.0%)
Malawi	15.6%	13.8%	18.4%	10.8%
	(13.8%-17.5%)	(11.0%-15.9%)	(16.6%-20.4%)	(9.3%-12.5%)

Notes:
SCD = significant cognitive delay
CIs = Confidence intervals
* low internal consistency of ECDI items (alpha <0.5)