Society of Medical Education & Research

Infant and Early Childhood Adversity in Relation to Childhood Cognitive Development: Evidence from Four Developing Countries

María J. Navarro[1]*, Carlos R. Ibáñez[1]

[1]Department of Social Medicine, Faculty of Medicine, University of Zaragoza, Zaragoza, Spain.

*E-mail ✉ maria.navarro@outlook.com

Abstract

This research explored whether negative events experienced at age 1 (AE-1) influence both the levels and the trajectories of cognitive abilities throughout childhood, drawing on integrated datasets from four low- and middle-income nations. The sample comprised cohorts born around 2001–2002, who were tracked over time during 2006–2007 and 2009–2010 via the Young Lives project in Ethiopia, India, Peru, and Vietnam. Cognitive performance among children was assessed through the Peabody Picture Vocabulary Test (PPVT) when they were 5 years old (PPVT-5) and 8 years old (PPVT-8). Additionally, impacts on cognitive growth from ages 5 to 8 (PPVT-Change) were analyzed. The AE-1 index was derived from questionnaire responses collected at age 1. OLS regression models were applied for the analysis. Findings showed that youngsters facing greater hardship exposure in infancy displayed lower cognitive scores at both ages 5 and 8. Cognitive progression between these ages was typically reduced in cases of substantial early hardships. This detrimental link was most evident in India. The outcomes supply valuable insights for policymaking aimed at easing the harmful impacts of early-life hardships through prompt measures.

Keywords: Developing countries, Childhood, Adverse experiences, Infancy, Cognitive development, Peabody picture vocabulary test, Young lives study

Introduction

Globally, populations have endured extended periods of challenging circumstances that maintain high stress levels, leading scholars to primarily concentrate on the psychological effects of the COVID-19 crisis [1–3]. Children form an especially susceptible population to diverse hardships, owing to elements like their incomplete grasp of stressful situations, sudden disruption of schooling, peer interactions, and recreational pursuits, societal isolation and detachment from parents due to isolation protocols, rising household conflicts, shifts in nutritional habits, and various other factors [4–7]. Although immediate mental health repercussions of these challenging situations on youngsters have garnered broad discussion, their enduring effects will only emerge in the coming years. Experiences during the initial years of life—whether supportive or detrimental—form the groundwork for future health and welfare in adulthood, positioning early childhood as a key public health priority [8–11]. Young individuals encountering multiple hardships early on encounter elevated risks for numerous developmental challenges, such as slowed cognitive advancement [12] and compromised psychological health [13]. They additionally confront greater likelihoods of adult illnesses and premature death [14]. Youngsters facing hardships before age three show greater sensitivity to these impacts than those affected later [13].

Initiatives to avert and lessen the detrimental outcomes of early-life hardships represent a core societal duty across all communities, consistent with the United Nations Sustainable Development Goals [15, 16]. Such

initiatives must rely on robust empirical findings. Much prior scholarship has emphasized links between early hardships and adulthood results, while comparatively fewer investigations have probed associations with outcomes during childhood. From a policy standpoint, however, examining early hardship effects on child outcomes holds advantages over adult-focused analyses, as these manifest sooner and thus prove more responsive to interventional strategies [17]. Furthermore, substantial existing evidence on early hardship influences stems from high-income settings, with limited research available for low- and middle-income countries (LMICs) [14]. Contemporary events underscore why insights from wealthier nations may not extend to LMICs. Though many hardship types affecting children in affluent countries overlap with those in LMICs, the latter bear extra strains from financial disruptions—like household earnings loss and nutritional deficits from agricultural setbacks or livestock deaths—that rarely occur in higher-income contexts. Moreover, developmental issues in LMIC children receive diagnosis and management less frequently than in wealthier areas, allowing early stressor consequences on cognition to endure longer.

The present investigation, leveraging longitudinal multicountry data from four LMICs (Ethiopia, India, Peru, and Vietnam), assessed whether hardship encounters in the first year (age 1) relate to cognitive skills at early childhood (age 5) and middle childhood (age 8), evaluated via the Peabody Picture Vocabulary Test (PPVT). It further evaluated links between infancy hardships and cognitive shifts from age 5 to 8, gauged through residual PPVT score variations over that period. Comprehending such connections proves critical, given that cognitive advancement in childhood robustly forecasts adult cognitive capacity and overall productivity [8]. The hardship metric here is comprehensive, incorporating diverse negative experiences suited to LMIC settings, encompassing financial, ecological, psychological, and medical stressors. These results highlight a vital global health matter: the ways in which detrimental influences from early-life events linger and impede cognitive progress in youngsters from resource-constrained countries. The insights can support the creation of health strategies to diminish persistent dangers from ongoing challenges faced by many LMIC children, employing efficient and affordable approaches.

Materials and Methods

Data source and study sample

This investigation drew on information from the Young Lives (YL) project, a longitudinal study carried out in four low- and middle-income countries: Ethiopia, India, Peru, and Vietnam. The YL follows a multicountry panel, including around 2,000 children per nation from the younger cohort who were between 6 and 18 months old in 2002. Additionally, each country sampled approximately 1,000 older children aged 7–8 years in 2002, with subsequent data collections in 2006 (round 2) and 2009 (round 3). For the present analysis, we focused on data from nearly 8,000 participants in the younger cohort, who were about 1 year old during round 1, 5 years old in round 2, and 8 years old in round 3. The YL dataset provides comprehensive details on aspects such as health status, nutritional intake, household shocks, cognitive progress, educational attainment, and family socioeconomic and demographic characteristics. A key strength of the YL is its minimal loss to follow-up. Analyses relied on anonymized, openly accessible datasets obtained from the UK Data Archive [18].

Variables

Cognitive development in childhood: Cognitive abilities were evaluated using the Peabody Picture Vocabulary Test (PPVT), which was applied to the children at age 5 (round 2) and age 8 (round 3). The PPVT serves as a standardized instrument for assessing receptive vocabulary and overall verbal capability [19, 20]. Scores from the PPVT show strong positive correlations with established intelligence metrics, including the Wechsler and McCarthy Scales [21]. Initially created in English in 1959, the test has undergone multiple revisions and adaptations into numerous languages. The YL employed the third version of this assessment [19]. Administration occurred individually, through oral presentation, without time limits: examiners displayed pages containing four images each and asked the child to identify the one matching a spoken target word [22]. Tests were conducted in the child's most familiar language, and interviewers were directed to skip administration if no suitable version was available. In Peru, India, and Vietnam, the languages used were Spanish, Telugu, and Vietnamese, respectively; in Ethiopia, options included Amharic, Tigray, or Oromo. The YL team adjusted PPVT scores to ensure comparability across survey rounds and age groups [22], though scores from distinct language versions remained incomparable directly. To enable cross-country comparisons of adversity effects on

cognition—accounting for language differences—we transformed the PPVT scores into Z-scores standardized within each language group. This process also adjusted for variations in data handling across nations. The analysis incorporated three primary outcomes: Z-standardized PPVT at age 5 (PPVT-5), Z-standardized PPVT at age 8 (PPVT-8), and the residual-based change in PPVT from age 5 to age 8 (PPVT-Change). These standardized scores reflect receptive vocabulary relative to the mean for children tested in the same language.

To compute PPVT-Change: (1) a linear regression model was estimated with PPVT-8 as the outcome and PPVT-5 plus additional covariates as predictors; (2) predicted values for PPVT-8 were generated from this model; and (3) the standardized PPVT-Change was obtained by subtracting the predicted PPVT-8 from the observed PPVT-8 and dividing by the regression's standard error of the estimate. This approach yields a standardized indicator of cognitive level at age 8 relative to expectations based on age-5 performance, capturing residual (unpredicted) growth. Research has validated this regression-adjusted change score as a precise and dependable way to quantify typical developmental trajectories as well as clinically significant shifts [23, 24].

Adverse experiences at age 1 (AE-1): Infant exposure to hardships was gauged through parental or caregiver reports on various survey items concerning early-life conditions. From these, eight categories of adversity at age 1 were identified: suboptimal health (based on two items), parental separation or divorce (one item), household member imprisonment (one item), economic disruptions affecting the family (three items), natural or environmental hazards impacting the household (two items), criminal incidents involving the family (three items), and signs of parental neglect (one item). This inclusive set addresses diverse stressors relevant to child well-being in LMIC environments.

These individual items were aggregated into a composite infancy adversity index (AE-1 score). For binary-response questions, a value of "1" was assigned if exposure to the adverse condition was reported, and "0" otherwise. For the multi-level item on child weight status, scoring ranged from "0" (no underweight) to "1" (moderate underweight) to "2" (severe underweight). The total AE-1 score was the summation of these components, yielding a range of 0 to 18, where elevated values signify greater hardship severity. Subsequently, this continuous score was categorized into four levels of early adversity: None (AE-1 = 0), Mild (AE-1 = 1), Moderate (AE-1 = 2 or 3), and High (AE-1 ≥ 4). **Table 1** lists the specific survey items informing the AE-1 construction. Recognizing potential endogeneity bias from certain components in relating adversity to later outcomes, a sensitivity analysis employed an alternative AE-1 score built identically but omitting the potentially endogenous items flagged in **Table 1**.

Table 1. Survey items employed to construct the Adverse Experiences at age 1 (AE-1) index; early-life adversity and cognitive development in childhood across four low- and middle-income countries (Ethiopia, India, Peru, and Vietnam—2002–2009).

Category	Survey Item	Response Options	Assigned Score
1. Suboptimal child health (0–3)			
	Item 1: Child's weight-for-age category[a]	Not underweight	0
		Moderately underweight	1
		Severely underweight	2
	Item 2: Child experienced serious illness or injury	No	0
		Yes	1
2. Parental divorce or separation (0–1)			
	Item 1: Household shock—divorce or separation occurred[a]	No	0
		Yes	1
3. Household member incarceration (0–1)			

	Item 1: Any household member sent to prison[a]	No	0
		Yes	1
4. Financial disruptions (0–3)			
	Item 1: Shock—reduced food supply	No	0
		Yes	1
	Item 2: Shock—livestock died	No	0
		Yes	1
	Item 3: Loss of household income source	No	0
		Yes	1
5. Environmental and natural hazards (0–2)			
	Item 1: Shock—crop loss or failure	No	0
		Yes	1
	Item 2: Shock—natural calamity (e.g., flood, drought)	No	0
		Yes	1
6. Caregiving quality (0–1)			
	Item 1: Primary caregiver's relation to the study child[a]	Biological parent	0
		Other relative or non-relative	1
7. Criminal incidents (0–3)			
	Item 1: Theft of crops	No	0
		Yes	1
	Item 2: Theft of livestock	No	0
		Yes	1
	Item 3: Household affected by any crime	No	0
		Yes	1
8. Additional family disruptions (0–4)			
	Item 1: Serious illness or injury of a family member	No	0
		Yes	1
	Item 2: Birth was unplanned[a]	No	0
		Yes	1
	Item 3: Death of a family member	No	0
		Yes	1
	Item 4: Forced family relocation or migration	No	0
		Yes	1

[a] Items marked with this superscript were omitted when creating the alternative adversity index to address potential endogeneity concerns.

Covariates

In the regression analyses, we adjusted for potential confounders operating at the child, family, community, and broader societal levels that might affect cognitive development during childhood. These encompassed the child's age and sex, location of residence (rural versus urban), mother's educational attainment, religious affiliation, and household economic standing. The primary indicator of household socioeconomic position in the Young Lives study is the YL wealth index, which is derived from three sub-indices reflecting housing conditions, availability of basic services, and possession of consumer durables [25]. This composite index yields values ranging from 0 to 1, where higher figures denote greater affluence [25]. To account for fixed differences across settings, we incorporated dummy variables for each country and community, capturing unchanging features such as national or local economic conditions,

social structures, educational infrastructure, and other contextual factors specific to the sites selected for the YL study. All control variables in the main specification were taken from the initial survey round conducted in 2002, when the children were approximately 1 year old on average. Summary statistics for all variables included in the analysis are shown in **Table 2**.

Table 2. Descriptive characteristics of the children in the Young Lives study sample; early-life adversity and cognitive development in childhood across four low- and middle-income countries (Ethiopia, India, Peru, and Vietnam—2002–2009).

Variable	Ethiopia n = 1,999 % or mean (SD)	Total sample N = 8,062 % or mean (SD)	Peru n = 2,052 % or mean (SD)	Vietnam n = 2,000 % or mean (SD)	India n = 2,011 % or mean (SD)
A. Categorical Variables					
AE-1 Score Category					
None (0)	16.1	34.5	41.6	48.0	32.0
Mild (1)	14.7	25.6	36.1	28.0	23.1
Moderate (2–3)	31.5	25.3	20.8	21.1	28.1
High (4+)	37.7	14.7	1.6	3.0	16.8
Sex					
Male	52.5	52.0	50.1	51.4	53.8
Female	48.0	48.0	50.0	49.0	46.0
Mother's Education					
None	59.9	40.6	12.0	27.9	62.0
Primary	31.9	34.7	45.3	42.2	19.8
Secondary and above	8.0	25.0	42.7	30.0	18.0
Religion					
Non-Christian	17.2	54.0	5.7	97.8	95.1
Christian	83.0	46.0	94.0	2.0	5.0
Residence					
Urban	35.0	37.4	68.5	20.0	25.3
Rural	65.0	62.6	31.5	80.0	74.7
Wealth Quantiles					
Q1 (poorest)	25.0	25.0	25.1	25.1	25.0
Q2	25.2	25.0	25.0	25.0	25.0
Q3	24.8	25.0	25.1	26.3	25.0
Q4 (wealthiest)	24.9	25.0	24.9	23.7	25.0
B. Continuous Variables					
Age of the child (months)	11.7 (3.6)	11.7 (3.5)	11.5 (3.5)	11.6 (3.2)	11.8 (3.5)
Family size	5.7 (2.2)	5.4 (2.2)	5.7 (2.3)	4.9 (1.8)	5.4 (2.3)
PPVT-5 raw score	21.4 (12.4)	28.6 (18.5)	29.2 (17.8)	37.0 (18.2)	27.4 (21.1)
PPVT-8 raw score	79.2 (44.2)	72.6 (35.0)	58.9 (17.6)	94.0 (28.6)	58.5 (30.4)

Values represent percentages for categorical variables and means (standard deviations) for continuous variables. AE-1 denotes Adverse Experiences at age 1.

Analysis

Ordinary Least Squares (OLS) regression models were estimated to evaluate the relationship between the AE-1 score and the outcomes PPVT-5, PPVT-8, and PPVT-Change. To test whether the observed associations might be influenced by adversities occurring later in childhood—and thereby assess the robustness of the findings—a sensitivity analysis was performed by additionally controlling for adverse experiences at age 5 (AE-5) alongside AE-1.

The models followed this specification:

$$Y_{ijsc} = \beta_0 + \beta_1 AEI_{ijsc} + \beta_2 C_{ijsc} + \beta_3 H_{jsc} + \theta_{sc} + r_c + \mu_{ijsc} \qquad (1)$$

where each observation is for individual child *i* in household *j* in sentinel (community/cluster of villages) *s, and country c*. The dependent variable Y_{ijs} denotes the PPVT-5, PPVT-8, or PPVT-Change score, AEI_{ijsc} is a categorical variable ranging from 0 to 5, with higher values indicating more severe adversities. C_{ijsc} denotes child characteristics, H_{jsc} denotes household characteristics, θ_{sc} is sentinel/community fixed effects, r_c is a country fixed effect, and μ_{ijsc} are the idiosyncratic error terms. Standard errors were clustered at the child level to account for the fact that the same child was included in the model twice (at age 1 and at age 5 or 8). The primary analyses were first carried out on the combined dataset from all four countries, then replicated individually for each country to identify potential heterogeneity. For country-specific models, raw PPVT scores were employed, as standardization was unnecessary when examining scores within a single language and context. All data preparation and statistical analyses were performed using Stata version 15 [26].

Results and Discussion

The combined dataset across the four countries comprised 8,062 children, with roughly 2,000 participants per country. After excluding cases with missing values on any key explanatory variables, the final analytic sample for the pooled regressions included 7,327 children. More than one-third (34.5%) of the children recorded an AE-1 score of zero, while the remaining 65.5% experienced at least some adversity in infancy. The sample was nearly evenly split by sex, with 48.0% female and 52.0% male. Over 40% (40.6%) had mothers with no formal education, and close to two-thirds (62.6%) resided in rural settings.

Substantial cross-country differences emerged across most characteristics. Ethiopia and India showed lower rates of children with no adversity (16.1% and 32.0%, respectively) than Peru (41.6%) and Vietnam (48.0%). In contrast, high-severity adversity was far more prevalent in Ethiopia and India than in Peru and Vietnam. Raw PPVT scores also differed markedly, with PPVT-5 ranging from 21.4 in Ethiopia to 37.0 in Vietnam, and PPVT-8 from approximately 58–59 in India and Peru to 94 in Vietnam. As noted earlier in the variables description, the standardization procedure removes these baseline disparities and enables valid cross-country comparisons. Variations were likewise evident in socioeconomic indicators such as maternal schooling, urban/rural residence, and household wealth. Only minor differences appeared in average family size and child age **(Table 2)**.

Table 3 presents the estimated relationships between infancy adversities and cognitive outcomes in childhood. Children who faced adversities during infancy consistently displayed lower cognitive scores relative to those with no such experiences (the reference category), revealing a clear dose-response pattern. Relative to the no-adversity group, children with mild, moderate, and high AE-1 levels exhibited reduced PPVT-5 scores, with coefficients of −0.06, −0.09, and −0.09, respectively. The strongest negative associations appeared for the high-adversity category on PPVT-8 (−0.15) and PPVT-Change (−0.16). Results using the alternative AE-1 measure that excluded potentially endogenous items were very similar **(Table 3)**.

Table 3. Estimated relationships between early-life adversities at age 1 and cognitive outcomes in childhood for children in the Young Lives study; early-life adversity and cognitive development in childhood across four low- and middle-income countries (Ethiopia, India, Peru, and Vietnam—2002–2009).

Variable	Full adversity index[a]			Alternative adversity index (exogenous only)[b]		
	PPVT at age 5	PPVT at age 8	PPVT Change (5–8)	PPVT at age 5	PPVT at age 8	PPVT Change (5–8)
AE-1 Category						
None (reference)	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Mild (1)	−0.06** [−0.12, −0.00]	−0.01 [−0.07, 0.05]	−0.02 [−0.09, 0.05]	−0.04 [−0.10, 0.01]	−0.02 [−0.07, 0.04]	−0.04 [−0.10, 0.03]
Moderate (2–3)	−0.09*** [−0.15, −0.03]	0.01 [−0.05, 0.07]	0.02 [−0.05, 0.10]	−0.09*** [−0.15, −0.04]	−0.02 [−0.08, 0.04]	0.01 [−0.06, 0.09]
High (4+)	−0.09** [−0.17, −0.01]	−0.15*** [−0.23, −0.07]	−0.16*** [−0.25, −0.07]	−0.01 [−0.10, 0.08]	−0.12** [−0.22, −0.03]	−0.14** [−0.25, −0.03]
Child age (months)	0.05*** [0.04, 0.06]	0.04*** [0.04, 0.05]	0.01*** [0.00, 0.02]	0.05*** [0.04, 0.06]	0.04*** [0.04, 0.05]	0.01*** [0.00, 0.02]
Female	−0.06** [−0.10, −0.01]	−0.08*** [−0.12, −0.03]	0.00 [−0.06, 0.05]	−0.05** [−0.10, −0.01]	−0.07*** [−0.12, −0.03]	0.00 [−0.05, 0.05]
Family size	−0.01 [−0.02, 0.00]	−0.01 [−0.02, 0.00]	0.00 [−0.01, 0.01]	−0.01 [−0.02, 0.00]	−0.01* [−0.02, 0.00]	0.00 [−0.01, 0.01]
Mother's Education						
None (reference)	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Primary	0.17*** [0.11, 0.23]	0.17*** [0.11, 0.23]	0.03 [−0.04, 0.11]	0.17*** [0.11, 0.23]	0.17*** [0.11, 0.24]	0.04 [−0.04, 0.11]
Secondary+	0.54*** [0.46, 0.62]	0.48*** [0.40, 0.56]	0.01 [−0.09, 0.11]	0.54*** [0.46, 0.62]	0.48*** [0.40, 0.56]	0.01 [−0.08, 0.11]
Christian religion (vs. Non-Christian)	0.12** [0.02, 0.22]	−0.04 [−0.14, 0.06]	0.01 [−0.12, 0.13]	0.12** [0.02, 0.22]	−0.04 [−0.15, 0.06]	0.01 [−0.12, 0.13]
Rural residence (vs. Urban)	−0.28*** [−0.36, −0.20]	−0.19*** [−0.27, −0.11]	0.13*** [0.04, 0.22]	−0.28*** [−0.36, −0.21]	−0.20*** [−0.28, −0.12]	0.12** [0.03, 0.21]
Wealth Quantile						
Q1 (poorest, reference)	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Q2	0.09*** [0.03, 0.15]	0.22*** [0.16, 0.29]	0.17*** [0.09, 0.24]	0.09*** [0.03, 0.15]	0.23*** [0.16, 0.29]	0.17*** [0.10, 0.25]
Q3	0.19*** [0.12, 0.26]	0.42*** [0.34, 0.49]	0.24*** [0.15, 0.33]	0.20*** [0.12, 0.27]	0.42*** [0.35, 0.50]	0.24*** [0.15, 0.33]
Q4 (wealthiest)	0.57*** [0.48, 0.66]	0.62*** [0.53, 0.71]	0.23*** [0.13, 0.34]	0.58*** [0.48, 0.67]	0.62*** [0.53, 0.72]	0.24*** [0.13, 0.35]
Country (Ethiopia reference)						
India	0.08 [−0.03, 0.19]	−0.12** [−0.24, −0.01]	−0.07 [−0.20, 0.07]	0.08 [−0.03, 0.20]	−0.11* [−0.23, 0.00]	−0.05 [−0.19, 0.09]
Peru	−0.49*** [−0.37, −0.13]	−0.44*** [−0.52, −0.37]	−0.03 [−0.12, 0.06]	−0.48*** [−0.56, −0.40]	−0.42*** [−0.50, −0.35]	0.00 [−0.09, 0.08]
Vietnam	−0.25*** [−0.97, −0.58]	−0.40*** [−0.53, −0.27]	−0.14* [−0.29, 0.01]	−0.24*** [−0.36, −0.12]	−0.38*** [−0.51, −0.26]	−0.12 [−0.27, 0.04]
N	6,021	6,078	5,681	6,021	6,078	5,681

*** p < 0.001; ** p < 0.01; * p < 0.05. Values in brackets are 95% confidence intervals. AE-1 = Adverse Experiences at age 1; PPVT = Peabody Picture Vocabulary Test. [a] Composite adversity score constructed using all items listed in **Table 1**. [b] Composite adversity score constructed after removing potentially endogenous items from **Table 1**.

Findings from the sensitivity analysis that additionally adjusted for adverse experiences at age 5 (alongside those at age 1) are presented in **Table 4**. These results displayed a consistent pattern, indicating that greater adversity exposure during the first year of life was linked to reduced cognitive performance in childhood. Relative to children who experienced no infancy adversity, those classified as having mild, moderate, or high levels showed diminished PPVT-5 scores, corresponding to coefficients of −0.06, −0.08, and −0.08, respectively. The most pronounced negative associations for the high-adversity group emerged for PPVT-8 (−0.13) and PPVT-Change (−0.14). Once more, estimates derived from the alternative adversity index that omitted potentially endogenous items yielded very similar patterns **(Table 4).**

Table 4. Estimated relationships between early-life adversities at age 1 and cognitive outcomes in childhood—sensitivity analysis controlling for adversities at age 5; Early-life adversity and cognitive development in childhood across four low- and middle-income countries (Ethiopia, India, Peru, and Vietnam—2002–2009).

Variable	Full adversity index[a]			Alternative adversity index (exogenous only)[b]		
	PPVT at age 5	PPVT at age 8	PPVT Change (5–8)[c]	PPVT at age 5	PPVT at age 8	PPVT Change (5–8)[c]
AE-1 Category						
None (reference)	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Mild (1)	−0.06* [−0.11, 0.00]	0.00 [−0.06, 0.05]	−0.02 [−0.09, 0.05]	−0.04 [−0.10, 0.01]	−0.02 [−0.07, 0.04]	−0.03 [−0.10, 0.03]
Moderate (2–3)	−0.08*** [−0.15, −0.02]	0.02 [−0.04, 0.08]	0.03 [−0.04, 0.10]	−0.10*** [−0.15, −0.04]	−0.01 [−0.08, 0.05]	0.02 [−0.05, 0.09]
High (4+)	−0.08** [−0.16, −0.00]	−0.13*** [−0.21, −0.05]	−0.14*** [−0.24, −0.05]	−0.01 [−0.10, 0.08]	−0.11** [−0.21, −0.02]	−0.13** [−0.24, −0.02]
AE-5 Category						
None (reference)	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Mild (1)	−0.05* [−0.10, 0.01]	0.00 [−0.05, 0.06]	0.05* [−0.00, 0.10]	−0.05* [−0.10, 0.01]	0.00 [−0.05, 0.06]	0.02 [−0.03, 0.07]
Moderate (2–3)	−0.03 [−0.10, 0.04]	−0.04 [−0.11, 0.03]	−0.01 [−0.09, 0.06]	−0.03 [−0.10, 0.04]	−0.04 [−0.11, 0.03]	−0.11*** [−0.19, −0.03]
High (4+)	−0.07* [−0.14, 0.01]	−0.12*** [−0.20, −0.04]	0.00 [−0.08, 0.09]	−0.07* [−0.14, 0.01]	−0.12*** [−0.20, −0.04]	−0.29*** [−0.43, −0.15]
Child age (months)	0.05*** [0.04, 0.06]	0.04*** [0.04, 0.05]	0.01*** [0.00, 0.02]	0.05*** [0.04, 0.06]	0.04*** [0.04, 0.05]	0.01*** [0.00, 0.02]
Female	−0.06** [−0.10, −0.01]	−0.08*** [−0.12, −0.03]	0.00 [−0.06, 0.05]	−0.05** [−0.10, −0.01]	−0.08*** [−0.12, −0.03]	0.00 [−0.05, 0.05]
Family size	−0.01 [−0.02, 0.00]	−0.01 [−0.02, 0.00]	0.00 [−0.01, 0.01]	−0.01 [−0.02, 0.00]	−0.01 [−0.02, 0.00]	0.00 [−0.01, 0.01]
Mother's Education						
None (reference)	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Primary	0.17*** [0.11, 0.23]	0.17*** [0.11, 0.23]	0.03 [−0.04, 0.11]	0.17*** [0.11, 0.23]	0.17*** [0.11, 0.23]	0.04 [−0.04, 0.11]
Secondary+	0.54*** [0.46, 0.62]	0.48*** [0.40, 0.56]	0.01 [−0.09, 0.11]	0.54*** [0.46, 0.62]	0.48*** [0.40, 0.56]	0.01 [−0.08, 0.11]

Christian religion (vs. Non-Christian)	0.12** [0.02, 0.22]	−0.05 [−0.15, 0.05]	0.01 [−0.12, 0.13]	0.12** [0.02, 0.22]	−0.05 [−0.15, 0.05]	0.01 [−0.12, 0.13]
Rural residence (vs. Urban)	−0.28*** [−0.35, −0.20]	−0.18*** [−0.26, −0.10]	0.12*** [0.04, 0.22]	−0.29*** [−0.36, −0.21]	−0.19*** [−0.27, −0.11]	0.12** [0.03, 0.21]
Wealth Quantile						
Q1 (poorest, reference)	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Q2	0.09*** [0.03, 0.15]	0.22*** [0.15, 0.28]	0.17*** [0.09, 0.24]	0.09*** [0.03, 0.15]	0.23*** [0.16, 0.29]	0.17*** [0.10, 0.25]
Q3	0.19*** [0.11, 0.26]	0.41*** [0.33, 0.49]	0.23*** [0.14, 0.32]	0.20*** [0.12, 0.27]	0.42*** [0.34, 0.49]	0.24*** [0.15, 0.33]
Q4 (wealthiest)	0.56*** [0.47, 0.66]	0.61*** [0.52, 0.70]	0.23*** [0.13, 0.34]	0.58*** [0.49, 0.67]	0.62*** [0.53, 0.71]	0.24*** [0.13, 0.34]
Country (Ethiopia reference)						
India	0.08 [−0.04, 0.19]	−0.13*** [−0.25, −0.02]	−0.06 [−0.20, 0.08]	0.09 [−0.03, 0.20]	−0.12** [−0.24, −0.01]	−0.05 [−0.19, 0.09]
Peru	−0.50*** [−0.58, −0.42]	−0.46*** [−0.54, −0.38]	−0.02 [−0.11, 0.07]	−0.48*** [−0.56, −0.41]	−0.43*** [−0.51, −0.36]	0.00 [−0.09, 0.09]
Vietnam	−0.26*** [−0.38, −0.14]	−0.69*** [−0.88, −0.50]	−0.13* [−0.28, 0.02]	−0.23*** [−0.35, −0.11]	−0.39*** [−0.52, −0.27]	−0.11 [−0.26, 0.04]
N	6,021	6,078	5,681	6,021	6,078	5,681

*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$. Values in brackets are 95% confidence intervals. AE-1 = Adverse Experiences at age 1; AE-5 = Adverse Experiences at age 5; PPVT = Peabody Picture Vocabulary Test. [a] Composite adversity score constructed using all items listed in **Table 1**. [b] Composite adversity score constructed after removing potentially endogenous items from **Table 1**. [c] AE-5 categories are not included in the change score models because AE-5 is already accounted for in the preliminary regression used to derive the predicted PPVT-8 value.

The notable impacts of early-life adversities on cognitive development during childhood were similarly observed in the country-specific regressions for India and Vietnam, whereas no such patterns emerged for the remaining countries. In India, both PPVT-5 and PPVT-8 exhibited statistically significant negative relationships with infancy adversities. For Vietnam, infancy adversity showed a significant association solely with PPVT-5. Upon employing the alternative adversity index that excluded potentially endogenous elements, the estimates for Ethiopia at age 8 became statistically significant, while those for India lost significance. The relationships for Vietnam continued to show significance **(Table 5).**

Table 5. Estimated relationships between infancy adversities and cognitive outcomes in childhood, stratified by country, for participants in the Young Lives study; Early-life adversity and cognitive development in childhood across four low- and middle-income countries (Ethiopia, India, Peru, and Vietnam—2002–2009).

Country & Variable	Full adversity index[a]			Alternative adversity index (exogenous only)[b]		
	PPVT at age 5	PPVT at age 8	PPVT Change (5–8)	PPVT at age 5	PPVT at age 8	PPVT Change (5–8)
Ethiopia						

AE-1 Category[c]						
None (reference)	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Moderate (1)	−1.71 [−5.20, 1.78]	−5.20 [−13.97, 3.57]	−0.12 [−0.38, 0.13]	−0.15 [−2.65, 2.35]	−5.59 [−12.43, 1.24]	−0.16 [−0.36, 0.04]
High (2+)	−0.91 [−3.48, 1.67]	−5.56 [−12.91, 1.78]	−0.17 [−0.38, 0.05]	−0.15 [−2.01, 1.72]	−6.34* [−12.76, 0.07]	−0.20** [−0.39, −0.01]
India						
AE-1 Category						
None (reference)	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Moderate (1)	−1.55 [−3.88, 0.77]	0.01 [−3.54, 3.56]	0.02 [−0.12, 0.15]	−1.06 [−3.42, 1.30]	−1.17 [−4.60, 2.26]	0.00 [−0.13, 0.12]
High (2+)	−3.79*** [−5.92, −1.66]	−2.80* [−6.12, 0.52]	−0.07 [−0.19, 0.06]	−1.44 [−3.47, 0.59]	−0.99 [−4.41, 2.43]	−0.01 [−0.14, 0.12]
Peru						
AE-1 Category						
None (reference)	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Moderate (1)	−0.07 [−1.35, 1.20]	0.02 [−1.43, 1.48]	−0.01 [−0.12, 0.09]	0.21 [−1.00, 1.42]	0.27 [−1.13, 1.67]	0.00 [−0.10, 0.11]
High (2+)	0.01 [−1.51, 1.53]	0.03 [−1.74, 1.79]	0.00 [−0.14, 0.13]	0.17 [−1.65, 1.98]	1.41 [−0.60, 3.43]	0.10 [−0.05, 0.25]
Vietnam						
AE-1 Category						
None (reference)	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Moderate (1)	−1.93** [−3.50, −0.37]	0.09 [−2.44, 2.62]	0.01 [−0.09, 0.11]	−2.54*** [−4.08, −1.00]	−0.80 [−3.32, 1.73]	−0.04 [−0.14, 0.06]
High (2+)	−3.37*** [−5.09, −1.64]	−0.39 [−3.11, 2.34]	0.01 [−0.10, 0.11]	−2.52*** [−4.39, −0.65]	−1.19 [−4.33, 1.95]	−0.01 [−0.14, 0.11]

All models adjusted for child age, sex, family size, maternal education, urban/rural residence, religion, and household wealth. *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$. Values in brackets are 95% confidence intervals. AE-1 = Adverse Experiences at age 1; PPVT = Peabody Picture Vocabulary Test. [a] Composite adversity score constructed using all items listed in **Table 1**. [b] Composite adversity score constructed after removing potentially endogenous items from **Table 1**. [c] For Ethiopia, categories are None (0), Moderate (1), and High (2+) due to limited variation in higher adversity levels. For other countries, Moderate combines levels 1–2+ where appropriate, but high remains 2+.

This investigation explored the links between hardships encountered in early infancy and cognitive progress during childhood, utilizing integrated longitudinal data from multiple nations. The analysis revealed statistically significant relationships between adverse events at age 1 and cognitive performance levels at ages 5 and 8—assessed via standardized PPVT scores—as well as the trajectory of cognitive growth between these ages.

Youngsters exposed to infancy hardships exhibited reduced PPVT scores in childhood, with more severe hardships corresponding to greater deficits. High-severity adversity in infancy was further linked to diminished cognitive advancement from early to middle childhood. These patterns persisted even after adjusting for subsequent hardships, indicating that early stressors

exert enduring influences on cognitive development throughout childhood.

Of particular interest and relevance for policymaking is the connection between elevated AE-1 levels and residual (unpredicted) shifts in PPVT scores from age 5 to 8. This specification examines the influence of early hardships on later cognitive trajectories, independent of concurrent adversities. Children affected by infancy stressors may be more prone to recurring challenges later, potentially confounding the observed AE-1 effects. However, deriving the change score from residuals—after accounting for all age-5 information, including AE-5—eliminates this concern. Likewise, sensitivity analyses adjusting PPVT-5 and PPVT-8 for age-5 adversities further dispel such confounding. Another concern involves potential endogeneity arising from certain AE-1 components [27]. To address this, models were re-estimated with an alternative index omitting those elements, yielding consistent results that largely exclude meaningful bias.

Although the core results apply across the included nations, notable cross-country variations warrant attention. In Ethiopia, the relationships between AE-1 and PPVT outcomes were negative yet lacked statistical significance. India displayed strong negative and significant associations. Peru showed significance primarily for PPVT-8 and PPVT-Change, whereas Vietnam exhibited significance only for PPVT-5. Overall, the detrimental impacts of first-year hardships on childhood cognition appeared weakest in Ethiopia, most pronounced in India, intensifying over time in Peru, and attenuating over time in Vietnam. Such differences may stem from varying national contexts or policies addressing early childhood stressors. While the aggregated evidence supports the role of early-life hardships, individual countries should interpret these insights in light of their specific cultural and societal factors when designing targeted interventions [28]. One earlier investigation reported positive links between environmental disruptions and PPVT performance in Ethiopia and Peru, contrasting with null or opposing patterns in India and Vietnam [29].

Beyond the primary focus on AE-1, several socioeconomic and demographic influences on childhood cognition merit note. Girls achieved lower PPVT scores at both ages 5 and 8. Rural dwelling was consistently linked to poorer performance. Larger household sizes and lower maternal schooling were similarly associated with reduced cognitive test results.

These observations align closely with existing research, underscoring the need to incorporate these elements into strategies aimed at mitigating the harms of early adversities [30, 31].

The study has certain constraints. First, the AE-1 index relied on available survey items; although comprehensive—spanning health, economic hardship, neglect, environmental risks, and other age-relevant stressors—it is not exhaustive. Nonetheless, the broad scope offers substantial insight into infancy experiences. The PPVT primarily evaluates verbal abilities, thus not encompassing all facets of cognition. Yet, such skill-based assessments are often favored over schooling duration for predicting later-life outcomes, as cognitive capacities prove more predictive [32]. Despite controlling for numerous confounders, unobserved variables—such as hidden household traits, access to support during crises, location effects, or caregiver schooling—might still influence associations [33]. Additionally, Young Lives cohorts are not nationally representative, being drawn from selected communities; for instance, the Indian subsample, limited to 20 sites in Andhra Pradesh and Telangana, may not reflect statewide diversity [22]. Finally, while efforts were made to ensure cross-cultural validity, challenges remain regarding measure adaptation, translation, and equivalence across settings [20].

Notwithstanding these limitations, evidence from these four nations yields vital policy insights, particularly for resource-limited settings where infancy hardships are prevalent. Quantifying the cognitive costs of early stressors can guide the development of countermeasures to offset lasting damage. Given the relative scarcity of such research in LMICs, these results offer valuable contributions. They indicate that timely interventions enhancing early childhood environments could foster improved developmental trajectories, with downstream benefits extending into adulthood. Policymakers should prioritize parental education initiatives and compensatory programs to counteract the consequences of suboptimal infancy conditions.

Cognitive foundations laid in early life profoundly shape lifelong health and functioning. The present evidence underscores that societal progress hinges on robust efforts to alleviate infancy adversities.

References

1. Kumar A, Nayar KR. COVID 19 and its Mental Health Consequences. J Ment Health (2021) 30:1–2. 10.1080/09638237.2020.1757052

2. Ornell F, Schuch JB, Sordi AO, Kessler FHP. Pandemic Fear" and COVID-19: Mental Health burden and Strategies. Braz J Psychiatry (2020) 42:232–5. 10.1590/1516-4446-2020-0008

3. Cullen W, Gulati G, Kelly BD. Mental Health in the COVID-19 Pandemic. QJM Int J Med (2020) 113:311–2. 10.1093/qjmed/hcaa110

4. Imran N, Zeshan M, Pervaiz Z. Mental Health Considerations for Children & Adolescents in COVID-19 Pandemic. Pak J Med Sci (2020) 36:S67-S72. 10.12669/pjms.36.COVID19-S4.2759

5. Liu JJ, Bao Y, Huang X, Shi J, Lu L. Mental Health Considerations for Children Quarantined Because of COVID-19. Lancet Child Adolesc Health (2020) 4:347–9. 10.1016/S2352-4642(20)30096-1

6. Loades ME, Chatburn E, Higson-Sweeney N, Reynolds S, Shafran R, Brigden A, et al. Rapid Systematic Review: The Impact of Social Isolation and Loneliness on the Mental Health of Children and Adolescents in the Context of COVID-19. J Am Acad Child Adolesc Psychiatry (2020) 59:1218–39. 10.1016/j.jaac.2020.05.009

7. de Figueiredo CS, Sandre PC, Portugal LCL, Mázala-de-Oliveira T, da Silva Chagas L, et al. COVID-19 Pandemic Impact on Children and Adolescents' Mental Health: Biological, Environmental, and Social Factors. Prog Neuropsychopharmacol Biol Psychiatry (2021) 106:110171. 10.1016/j.pnpbp.2020.110171

8. Victora CG, Adair L, Fall C, Hallal PC, Martorell R, Richter L, et al. Maternal and Child Undernutrition: Consequences for Adult Health and Human Capital. Lancet (2008) 371:340–57. 10.1016/S0140-6736(07)61692-4

9. Lucas A. Programming by Early Nutrition in Man. Ciba Found Symp (1991) 156:38.

10. Gluckman PD, Hanson MA. Living with the Past: Evolution, Development, and Patterns of Disease. Science (2004) 305:1733–6. 10.1126/science.1095292

11. Bethell C, Jones J, Gombojav N, Linkenbach J, Sege R. Positive Childhood Experiences and Adult Mental and Relational Health in a Statewide Sample: Associations across Adverse Childhood Experiences Levels. JAMA Pediatr (2019) 173:e193007. 10.1001/jamapediatrics.2019.3007.

12. Bick J, Nelson CA. Early Adverse Experiences and the Developing Brain. Neuropsychopharmacology (2016) 41:177–96. 10.1038/npp.2015.252

13. Dunn EC, Soare TW, Zhu Y, Simpkin AJ, Suderman MJ, Klengel T, et al. Sensitive Periods for the Effect of Childhood Adversity on DNA Methylation: Results from a Prospective, Longitudinal Study. Biol Psychiatry (2019) 85:838–49. 10.1016/j.biopsych.2018.12.023

14. Hughes K, Bellis MA, Hardcastle KA, Sethi D, Butchart A, Mikton C, et al. The Effect of Multiple Adverse Childhood Experiences on Health: a Systematic Review and Meta-Analysis. Lancet Public Health (2017) 2:e356–66. 10.1016/S2468-2667(17)30118-4

15. Chamberlain C, Ralph N, Hokke S, Clark Y, Gee G, Stansfield C, et al. Healing the Past by Nurturing the Future: A Qualitative Systematic Review and Meta-Synthesis of Pregnancy, Birth and Early Postpartum Experiences and Views of Parents with a History of Childhood Maltreatment. PLoS One (2019) 14:e0225441. 10.1371/journal.pone.0225441

16. Hillis S, Mercy J, Amobi A, Kress H. Global Prevalence of Past-Year Violence against Children: A Systematic Review and Minimum Estimates. Pediatrics (2016) 137:e20154079. 10.1542/peds.2015-4079

17. Almond D, Currie J, Duque V. Childhood Circumstances and Adult Outcomes: Act II. J Econ Lit (2018) 56:1360–446. 10.1257/jel.20171164

18. Boyden J. Young Lives: An International Study of Childhood Poverty: Rounds 1-5 Constructed Files, 2002-2016. 3rd ed.. Oxford: UK Data Service; (2018). [data collection].

19. Dunn L, Dunn L. Examiner's Manual for the PPVT-III. Form IIIA and IIIB. Minnesota: AGS; (1997).

20. Dawes A. Measuring the Development of Cognitive Skills across Time and Context: Reflections from Young Lives 2020. Oxford: Oxford Department of International Development (ODID).

21. Campbell J. Book Review: Peabody Picture Vocabulary Test, Third Edition. J Psychoeduc

Assess (1998) 16:334–8. 10.1177/073428299801600405

22. Leon J, Singh A. The Peabody Picture of Vocabulary Test Equating Scores across Rounds and Cohorts for Ethiopia. India and Vietnam: (2017).

23. Sawrie SM, Marson DC, Boothe AL, Harrell LE. A Method for Assessing Clinically Relevant Individual Cognitive Change in Older Adult Populations. J Gerontol B Psychol Sci Soc Sci (1999) 54B:P116–24. 10.1093/geronb/54B.2.P116

24. Frerichs R, Tuokko H. A Comparison of Methods for Measuring Cognitive Change in Older Adults. Arch Clin Neuropsychol (2005) 20:321–33. 10.1016/j.acn.2004.08.002

25. Briones K. How many Rooms Are There in Your house?'Constructing the Young Lives Wealth index (2017).

26. StataCorp. Stata Statistical Software: Release, 15. College Station, TX: StataCorp LLC. (2017).

27. Rosales-Rueda M. The Impact of Early Life Shocks on Human Capital Formation: Evidence from El Niño Floods in Ecuador. J Health Econ (2018) 62:13–44. 10.1016/j.jhealeco.2018.07.003

28. Ungar M. Resilience, Trauma, Context, and Culture. Trauma Violence Abuse (2013) 14:255–66. 10.1177/1524838013487805

29. Zamand M, Hyder A. Impact of Climatic Shocks on Child Human Capital: Evidence from Young Lives Data. Environ Hazards (2016) 15:246–68. 10.1080/17477891.2016.1185003

30. Prime H, Pauker S, Plamondon A, Perlman M, Jenkins J. Sibship Size, Sibling Cognitive Sensitivity, and Children's Receptive Vocabulary. Pediatrics (2014) 133:e394–401. 10.1542/peds.2012-2874

31. Rice ML, Hoffman L. Predicting Vocabulary Growth in Children with and without Specific Language Impairment: A Longitudinal Study from 2;6 to 21 Years of Age. J Speech, Lang Hear Res (2015) 58:345–59. 10.1044/2015_JSLHR-L-14-0150

32. Hanushek EA, Woessmann L. The Role of Cognitive Skills in Economic Development. J Econ Lit (2008) 46:607–68. 10.1257/jel.46.3.607

33. Boo FL. Socio-economic Status and Early Childhood Cognitive Skills. Int J Behav Dev (2016) 40:500–8. 10.1177/0165025416644689