Early-life determinants of foundational cognitive skills: The roles of nutritional investments and pre-schooling

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What do we (need to) know?

- The long-term implications of early-life investments in human capital (including nutritional and educational investments), and conversely, negative shocks to these investments, on adult human capital and achievements are fairly well-established (Alderman et al., 2006; Hoddinott et al. 2008 and 2013; Behrman et al., 2009 and 2014; Maluccio et al., 2009; Hirvonen et al., 2017; Gertler et al., 2014; Walker et al., 2011; Engle et al., 2007 and 2011;; Heckman et al., 2010).

- The literature on human capital formation highlights the early childhood period (0-3 or 4-5 years) as a sensitive period for investing in skills.

  - importance of investing in pre-school education as a way to improve long-term outcomes of individuals that come from poor backgrounds (e.g., Barnett and Masse, 2007; Heckman et al., 2010).

- Over the last half-century increasing attention to a broad range of skills beyond literacy, numeracy (measured through standardised tools), including IQ, self-control, perseverance/grit, personality traits and socioemotional skills, such as self-esteem and self-efficacy (Kimball, 2015; Bowles et al., 2001; Duncan et al., 2007; Heckman, 2007).

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Gaps in the literature

- Widely claimed that unless undernutrition is addressed in the first 1,000 days, it has long-lasting and almost irreversible consequences. However, there is little population-based evidence about the mechanisms through which early-life undernutrition leads to poorer outcomes.

- Limited evidence about the impact of early investments in human capital from LMICs.
  - Lack of longitudinal data on LMICs

- Cognitive skills are usually approximate using domain specific cognitive-achievement test scores (e.g., in math, reading comprehension and vocabulary knowledge).
  - Differences in culture and language pose a challenge for comparability

- Even when comparability is feasible, differences in test scores cannot necessarily be attributed to underlying differences in cognitive skills.
  - Lack of non-domain specific cognitive skills; i.e. skills (and the tasks used to measure them) which does not required to have been exposed to any specific information.

- Difficult and expensive to measure cognitive skills and thought to be impracticable to include them in population studies.
  - Most evidence comes from experimental studies in HICs, small samples.

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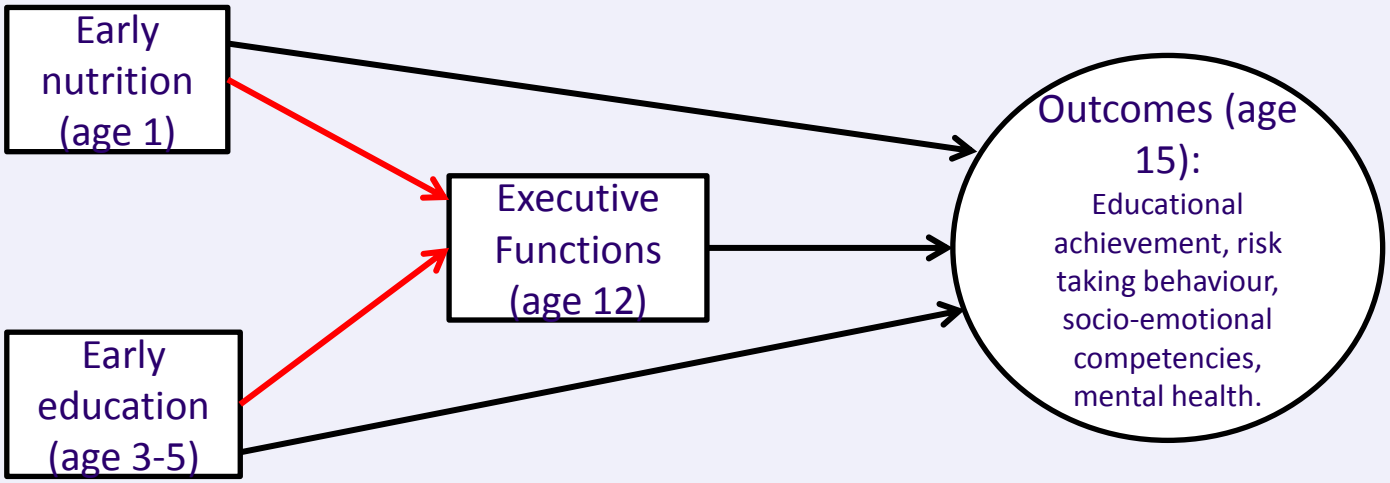
Research questions

- What is the impact of undernutrition and early investment in education on foundational cognitive skills (FCS)?
  - H1-1: improvements in early nutrition lead to improvements in FCS; H1-2: preschool education improves FCS; H1-3: the importance of early nutrition for FCS decreases as the child ages



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What is EF, what we know, why is important?

❑ Executive function (EF) is an umbrella term for a "set of inter-related high-order cognitive abilities that enable an individual to engage in independent, purposeful and, goal-oriented behaviour" (Lezak, 2004).

❑ FCS/EF is considered critical for a range of key outcomes:

- including school readiness, more so than is IQ or entry level reading or math skills (Blair and Razza, 2007; Blair, 2002), academic success (Mischel, 2014; Diamond, 2013;Duncan et al., 2007).
- Lower risk to engage in health-compromising behaviours related and crime (Cole et al., 1993; Speltz et al., 1999; McClelland et al., 2006).
- Higher productivity (earnings as young people) (Bassi and Urzua, 2010).

❑ EF is highly associated with early-life household socio-economic status (Noble et al., 2007; Klenberg et al., 20001; Ardila et al., 2005).

- Stressful, challenging, or deprived conditions may impede these skills' development and hasten their decay (McLaughlin and al. 2014; Sheridan, et al., 2012; Sheridan et al., 2013)
- EF can be "trained": increases in response to investments of time and effort by parents and teachers (Holmes et al., 2009; Diamond et al., 2007).

❑ EF begins to develop at infancy and continues through adolescence (Anderson, 2002) and is regulated in the prefrontal cortex (Siddiqui et al., 2008)

- It may, therefore, be one of the few mediums available for mitigating the adverse effects of early childhood undernutrition on cognitive skills and other outcomes among older children.

The Young Lives study

- Young Lives is an interdisciplinary, mixed methods, comparative, cohort-sequential study established in 2001 with a 15-years horizon.

- It follows 2 cohorts of children, about 12,000 children in 4 countries: Ethiopia; India (Andhra Pradesh & Telangana); Peru and Vietnam; over 5 rounds of data.

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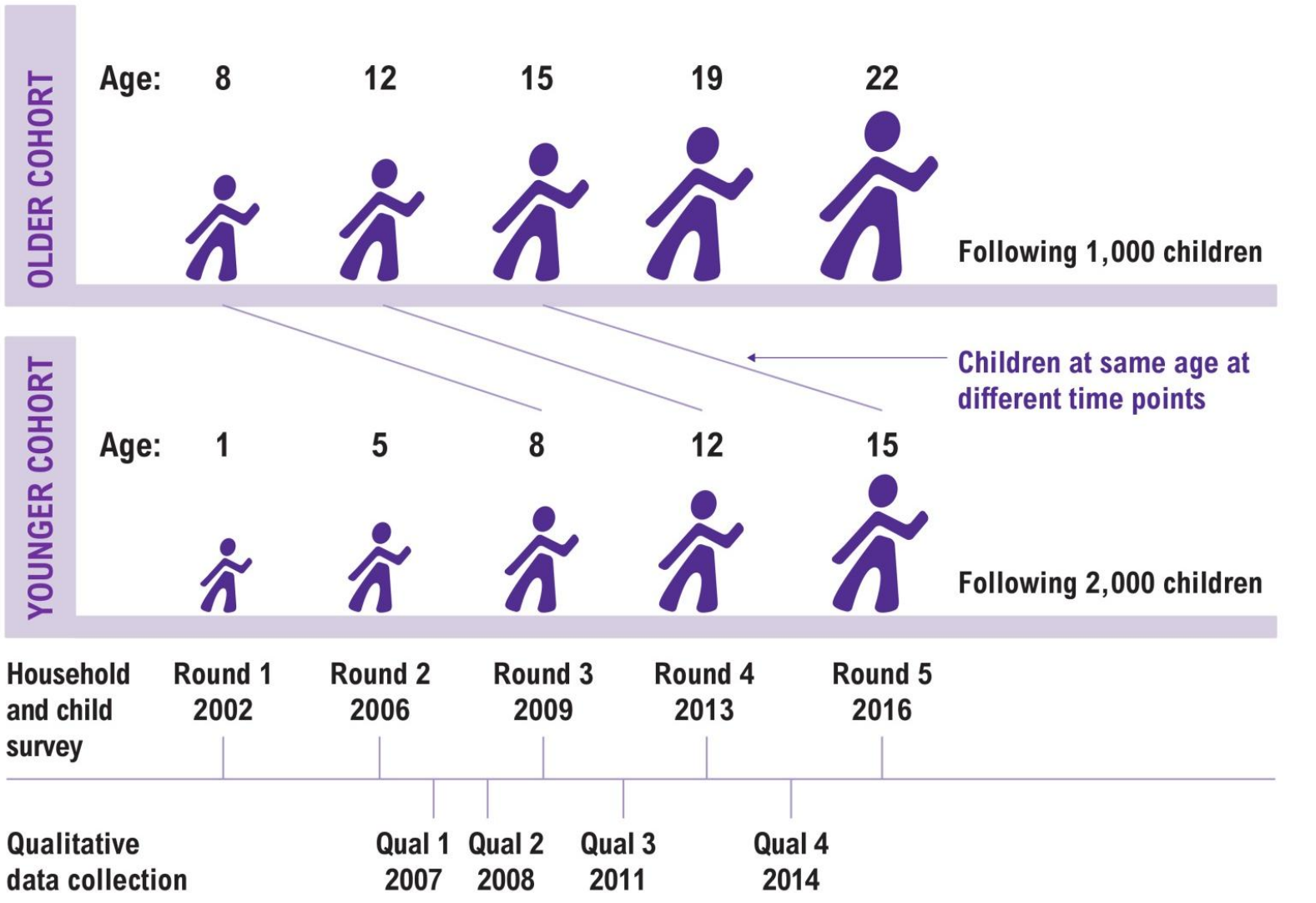
Young Lives household survey



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- It follows 2 cohorts of children, about 12,000 children in 4 countries: Ethiopia; India (Andhra Pradesh & Telangana); Peru and Vietnam; over 5 rounds of data.

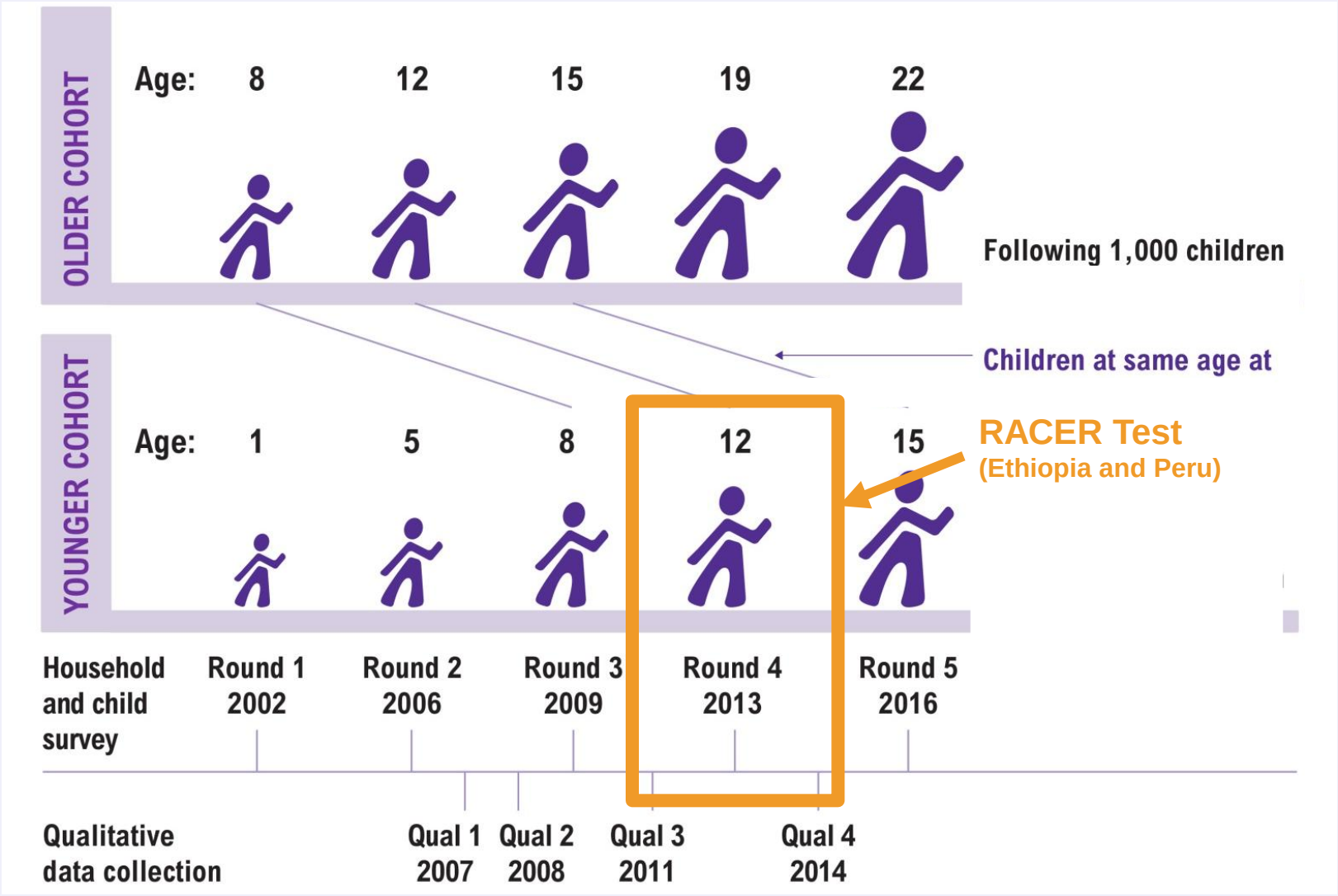
- Purposively over-sampled poor areas: 20 sites in each country, reflecting country diversity (rural-urban, diverse livelihoods, ethnicity).
  - Sampling design

- Very low attrition rates : 8% in Ethiopia; 9.8% in Peru (R1-R5)

- Child health, anthropometrics (from age 1), numeracy and literacy tests (from age 5), socio-emotional competencies (from age 8) and other individual characteristics data on caregiver background, livelihood, demographic characteristic of household members, socio-economic status (since round 1).

- Additional data were collected since round 3 (2009) on the sibling born immediately after the index child (younger sibling) or an older sibling if not available (in Ethiopia only).
  - Ethiopia (aged 3 to 8 and 8 to 17 years, respectively), in Peru (aged 2 to 8 years).. For the siblings sample.
  - anthropometric and vocabulary test data (since 2009) and socio-emotional indicators since 2013

Young Lives: RACER Administration



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The RACER

- The RACER (Rapid Assessment of Cognitive and Emotional Regulation) is a touch screen computer/table application used to measure foundational cognitive skills (FCS) of Younger Cohort (YC) and their siblings in the Round 4 (2013) survey in Ethiopia and Peru (designed by Margaret Sheridan and Amar Hamoudi).

- It contains 5 tasks to measure FCS which the child must answer in order.

- KEY FEATURES:
  1. No complex language or literacy requirement to perform.
  2. No additional skills or specialized knowledge requirement on part of the experimenter.
  3. Design of the test is intended to minimize the impact of culture and language on task performance and comprehension.
  4. Developed for touch-screen computers to maximize precision and data backup while not relying on any prior exposure to computers .

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RACER: Sample Sizes

	Sample size Round 4	PPVT response rate (%)	RACER response rate (%)	Age
ETHIOPIA				
Index children	1873	87.6	96.7	11-12
Sibling	1492	77.6	87.1	6-12 12-18
PERU				
Index children	1902	98.6	98.7	11-12
Sibling	784	97.6	98.7	6-12

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FCS: definition and examples

Cognitive Skill	Definition	Examples
Declarative Memory	the ability to encode and retain new knowledge.	Recollection of phone numbers
Inhibitory Control (EF)	the ability to stop oneself from exhibiting behaviours one does not want to exhibit.	Avoiding distractions and focus on a single task (checking phone or chatting when studying or working); Controlling or not dwelling on negative thoughts.
Working Memory (EF)	the ability to hold in mind and manipulate stimuli that are no longer present in the environment.	Recalling rules to a game; Taking down notes during a lecture.
Implicit Learning	the ability of the motor system to recognise and respond to regularities in the environment even when individuals are not aware of these regularities.	Riding a bike; Recalling the words to a song when someone sings the first few words

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The RACER: performance measures

Cognitive Skill	RACER Game	Performance Measure
Declarative Memory	Memory Game (Paired associate learning task)	Percentage of correct choices at first touch (↑)
Inhibitory Control	Sides Game (Simon Task)	Average time from appearance of dot until respondent touches it (↓)
Working Memory	Finding the Dots (Spatial delayed-match-to-sample task)	Average distance from centre of dot to respondent's touch (↓)
Implicit Learning	Catching Chickens (Adapted serial reaction time task)	Average time from appearance of dot until respondent touches it (↓)

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Cognitive skill indicators

Mean by nutritional status

	Not stunted		Moderately stunted		Severely stunted	
	Mean	SD	Mean	SD	Mean	SD
Peru						
Declarative memory	0.42	0.16	0.38***	0.15	0.39**	0.15
Inhibitory control	1.09	0.18	1.14***	0.19	1.18***	0.18
Working memory (LD)	4.34	0.28	4.44***	0.31	4.53***	0.33
Working memory(MD)	4.42	0.27	4.51***	0.3	4.59***	0.31
Implicit Learning	0.7	0.09	0.72***	0.09	0.72***	0.08
PPVT	0.26	0.94	-0.4***	0.9	-0.88***	0.85
Ethiopia						
Declarative memory	0.37	0.16	0.36	0.16	0.33***	0.12
Inhibitory control	1.16	0.16	1.19***	0.17	1.25***	0.18
Working memory (LD)	4.45	0.29	4.46	0.32	4.55***	0.41
Working memory(MD)	4.53	0.28	4.54	0.3	4.61**	0.39
Implicit Learning	0.72	0.08	0.72	0.08	0.74***	0.08
PPVT	0.1	0.97	-0.16***	1.02	-0.52***	0.98

Cognitive skill indicators

Mean by pre-school attendance

	No pre-school		With pre-school	
	Mean	SD	Mean	SD
Peru				
Declarative memory	0.36	0.14	0.41***	0.16
Inhibitory control	1.16	0.19	1.11***	0.19
Working memory (LD)	4.48	0.36	4.37***	0.29
Working memory(MD)	4.53	0.33	4.45***	0.29
Implicit Learning	0.72	0.08	0.71*	0.09
PPVT	-0.66	0.95	0.06***	0.98
Ethiopia				
Declarative memory	0.34	0.14	0.42***	0.18
Inhibitory control	1.19	0.16	1.13***	0.17
Working memory (LD)	4.48	0.32	4.42***	0.28
Working memory(MD)	4.55	0.31	4.5***	0.27
Implicit Learning	0.73	0.08	0.7***	0.08
PPVT	-0.3	0.96	0.78***	0.6

Empirical strategy (1)

$$\mathrm{FCS_{ij}} = \alpha_1 + \alpha_2 NUT_i + \gamma_1 FCSb_i + \gamma_2 FCSc_i + X_i\Gamma_1 + Z_{1.i}\Gamma_2 + \theta_c + \varepsilon_i$$

- NUT_i: child´s height-for-age z-score (HAZ) or being stunted;
- X_i: child´s age at the time FCS_{ij} was measured, sex, the native tongue of the mother;
- $Z_{1,i}$: maternal education, wealth index, area of location, household size (age 1);
- $FCSb_i$: child performance at the baseline task in the RACER application
- $FCSc_i$: n. practice tests (up to 3 attempts), administration week day and the time of the day;
- θ_c: cluster fixed effect

- More restrictive specification: more stringent (and likely endogenous) controls including household (monthly) education expenditure and non-food expenditure and the highest education grade completed (or currently studying) by age 12.

- Estimate the model for YC and siblings separately since the impact of NUT_i might differ (likely decline) as children age (YC:11-12; YS: 6-12)
- Household fixed effect estimates exploiting data for paired-siblings and deal with unobserved household heterogeneity

Empirical strategy (2)

$$FCS_{ij} = \alpha_1 + \alpha_2 NUT_i + \alpha_3 PREDU_i + \gamma_1 FCSb_i + \gamma_2 FCSc_i + X_i\Gamma_1 + Z_{1.i}\Gamma_2 + \theta_c + \varepsilon_i$$

- $PREDU_i$ is a dummy equal to 1 for children who attended pre-school and 0 otherwise.

- Household fixed effect to account for unobserved household heterogeneity.
- Empirical challenge: endogeneity of pre-school attendance; selection into pre-school not random;
  - IV model: district level pre-school supply in Peru in 2004-5, the years at which index children might have attended pre-school.

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Regression results (1)

	Declarative Memory	Inhibitory Control	Working Memory (LD)	Working Memory (MD)	Implicit Learning	PPVT
Ethiopia						
Stunted	-0.019**	0.011***	0.002	-0.009	-0.002	-0.106***
	(0.009)	(0.003)	(0.012)	(0.012)	(0.002)	(0.037)
With pre-school	0.029**	0.001	-0.028***	-0.012	-0.001	0.357***
	(0.013)	(0.008)	(0.009)	(0.017)	(0.004)	(0.075)
Peru						
Stunted	-0.010	-0.002	0.021**	0.024	-0.002	-0.197***
	(0.009)	(0.005)	(0.010)	(0.014)	(0.003)	(0.055)
With pre-school	0.031**	-0.013	-0.005	0.029	-0.008	0.220***
	(0.011)	(0.009)	(0.020)	(0.027)	(0.005)	(0.045)
EF baseline variables	x	x	x	x	x	x
HH controls	x	x	x	x	x	x
Expenditure						
# Grades completed						
Cluster fixed effect	x	x	x	x	x	x

OLS estimates with standard errors in parentheses clustered at cluster level. p<0.1, ** p<0.05, *** p<0.01
DM: % correct answer at first touch; IC: response time; WM: accuracy/distance; IL: response time .

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Regression results (2)

	Declarative Memory	Inhibitory Control	Working Memory (LD)	Working Memory (MD)	Implicit Learning	PPVT
Ethiopia						
Stunted	-0.011	0.009**	-0.003	-0.016	-0.003	-0.012
	(0.008)	(0.003)	(0.012)	(0.012)	(0.002)	(0.038)
With pre-school	0.028**	0.000	-0.029***	-0.011	-0.001	0.317***
	(0.011)	(0.008)	(0.009)	(0.016)	(0.004)	(0.081)
Peru						
Stunted	-0.008	-0.003	0.017*	0.021	-0.002	-0.157***
	(0.009)	(0.005)	(0.01)	(0.014)	(0.003)	(0.048)
With pre-school	0.026**	-0.012	0.004	0.042	-0.009*	0.158***
	(0.011)	(0.009)	(0.02)	(0.027)	(0.005)	(0.052)
EF baseline variables	x	x	x	x	x	x
HH controls	x	x	x	x	x	x
Expenditure	x	x	x	x	x	x
# Grades completed	x	x	x	x	x	x
Cluster fixed effect	x	x	x	x	x	x

OLS estimates with standard errors in parentheses clustered at cluster level. p<0.1, ** p<0.05, *** p<0.01
DM: % correct answer at first touch; IC: response time; WM: accuracy/distance; IL: response time .

Results summary

- Overall, well-nourished children and children who attended pre-primary school having better FCS than their peers once controlling for individual, household and community level characteristics as specified.
- The correlation between early nutrition and child's FCS seems to be stronger in ET than in PE and particularly among severely stunted children (more prevalent in ET).
- Declarative memory (or long term memory) and Inhibition (the ability to 'stop' ones self) (ET) and Working memory (the ability to hold information) (PE) are particularly sensitive to severe stunting in the first year of life.
- As predicted, we find no evidence of an association between early childhood stunting and subsequent implicit learning (an age-invariant skill).
- Pre-school attendance predicts declarative memory in both countries, working memory in Ethiopia only and Implicit learning in Peru.
- Declarative memory is particularly sensitive to socio-economic status; working memory to the number of years spent in schools by age 12, possibly indicating that school trains these abilities over time.

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Next steps

- Differences in timing of these impacts indicate when interventions might be most successful.
  - Is the importance of early nutritional status for FCS decreases as the child ages? Estimate the model separately for the index children (aged 11 to 12) and the younger siblings (aged 6 to 12).
  - Household fixed-effects estimates that deal with unobserved household heterogeneity.
  - Limitation: comparing the FCS of the index child and the sibling at two different ages (and different exposure to school, particularly for those cognitive functions that are malleable and can be trained; controlling for the number of years of school completed by age 12)
- IV model for pre-school attendance (likely for PE only).
- Broader research program : 1) the impacts of early undernutrition, pre-school education and exposure to shocks on the development of FCS, 2) the impacts of FCS on educational achievement, socio-emotional competencies and risky behaviors; and, 3) the factors associated with recovery and the remediation roles of social policy.

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Thanks! Find out more on YL/NdM

Child profiles and photos

Datasets (access via the **UK Data Service**)

Data visualization (via YL website)

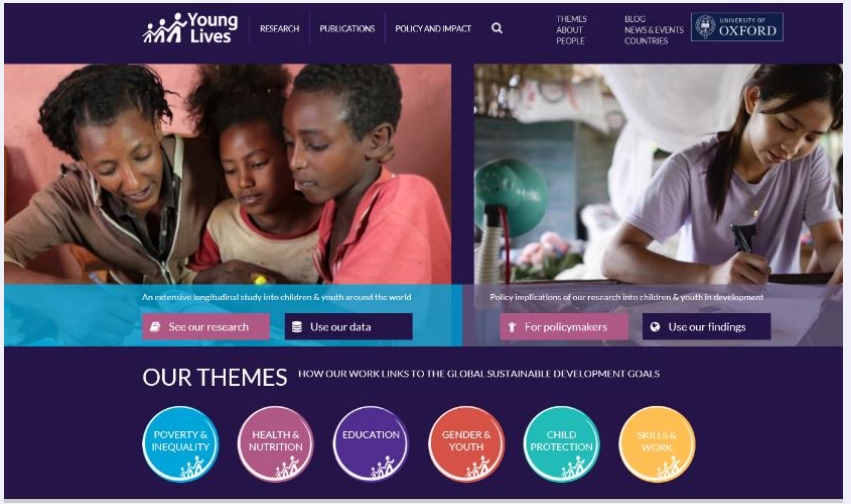
e-newsletter

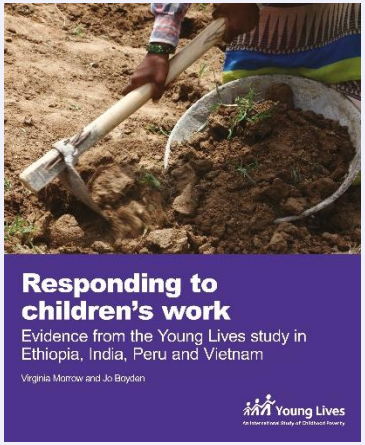
Impact case studies

Infographics

Methodology and research papers (including technical notes and survey documentation)

Publications (including summative reports)





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