Pre-analysis plan: the inter-generational impacts of subsidized secondary education in Ghana

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Starting in 2017, we began tracking children of the respondents involved in the Ghana Secondary Education study (Duflo, Dupas, Kremer 2021: "The Impact of Free Secondary Education: Experimental Evidence from Ghana") to assess the inter-generational impact of secondary education on cognitive development. This component is conducted in collaboration with Professor Elizabeth Spelke's Laboratory for Development Studies at Harvard University. The PIs on this project as Duflo, Dupas, Spelke and Mark Walsh.

1 Experimental design

In 2008, scholarships for secondary education were randomly allocated among qualified students who had financial difficulty enrolling. A first paper describes impacts on those students (Duflo, Dupas, Kremer 2021). For a separate paper, we are tracking children of the Ghana Secondary Education study respondents and administering an assessment of cognitive development, based on frontier research in cognitive science and developed for use in Ghana. We are administering assessments when a child reaches the following critical age windows: 14-22 months old, 30-36 months old, 3-4 years old, 5-6 years old, 7-8 years old. We designed the assessments after some children had already aged out of some of these so the final sample size for each assessment will vary.

1.1 Primary outcomes (explanation)

- Children's cognitive development: overall scores on the games measuring children's cognitive development at 14-22 months, 30-36 months, 3-4 years, 5-6 years and 7-8 years.

- Child survival: whether the child is still alive, whether the child survived for over 1 year and whether the child survived for over 3 years.

- Children's executive function: scores on child cognitive games involving working memory, object permanence, attention switching, and mental simulation/rotation when 14-22 months old, 30-36 months old or 3-4 years old, flanker tests when 5-6 years old or 7-8 years old, and impulsivity when 7-8 years old.

Children's language skills: caregiver-reported words and gestures of the child when 14-22 months old or 30-36 months old. Vocabulary assessment when 3-4 years old, 5-6 years old or 7-8 years old. Scores on child cognitive games involving identify letters and words and read sentences when 7-8 years old.

- Children's math & numeracy: scores on child cognitive games involving child's number sense at 14-22 months, 30-36 months old, 3-4 year olds and 5-6 years old, child's approximate number system aptitude at 30-36 months old, 3-4 year olds and 5-6 years old, child's ability to identify Arabic numbers and numbers of objects when 30-36 months old, 3-4 year olds, 5-6 years old or 7-8 years old, child's addition and subtraction skills when 3-4 years old, 5-6 years old or 7-8 years old.

- Children's social cognition: scores on child cognitive games involving ability to understand the mental states of others when 30-36 months old, 3-4 year olds, 5-6 year olds or 7-8 year olds, child's ability to identify emotions when 3-4 years old, 5-6 years old or 7-8 years old.

- Children's spatial reasoning: scores on child cognitive games involving ability to match shapes to holes when 30-36 months old, child's ability to reproduce block arrangements when 30-36 months old or 3-4 years old, child's ability to read maps and understanding of geometry when 3-4 years old, 5-6 years old or 7-8 years old.

1.2 Secondary outcomes (explanation)

- Child stunting: height and weight measurements of children at 14-22 months, 30-36 months, 3-4 years, 5-6 years and 7-8 years.

- Caregiver-child interactions: engagement of caregiver with their 14-22 months old, 30-36 months old, 3-4 year old, or 5-6 year old during video-taped book/toy play sessions. Adult word count, child vocalizations and conversational turns over the course of day-long recording when child is 14-22 months old or 30-36 months old.

-Child's socio-economic status: measure of child's household's socio-economic status based on caregiver-reports of number of bedrooms, food expenditures, occupation of family members and surveyor observation of building materials used in household's dwelling.

- Investment in children: measure of household investment in child's cognitive and physical development based on caregiver-reports of educational materials/toys in the house, child's food consumption, and treatment of health conditions.

Caregiver aspirations for child: caregiver's desired education level for the child.

-Child education: measures of child's formal education based on years in school, whether child attends public or private school, and school activities during COVID schooling closures.

-Child preventive health: measure of preventive health behaviors taken for the child including vaccinations, use of mosquito nets, doctor check-ups, treatment of drinking water, and toilet usage.

-Child health outcomes: measure of child health based on caregiver-reported child health, injuries to child that took more than a week to heal, and fevers in the past 3 months.

-Child engagement and stimulation: measure of child engagement based on caregiver-reports of cognitively-stimulating activities such as singing, reading, and telling stories performed with the child by adults and teenagers.

-Caregiver depression: measure of caregiver's self-reported symptoms of depression.

-Children's neighborhood quality: measure of quality of neighborhood of child when cognitive games administered based on average income and education of area in Ghanaian Census data.

2 Analysis Plan for Child Cognitive Development Outcomes

This section outlines the analysis plan for the child cognitive development-related outcomes. While outcomes collected prior to 2016[1] will be relevant to our analysis of child cognitive development, this analysis plan primarily focuses on how we will analyze the data collected through the child cognitive games and child caregiver surveys that began in 2017.

[1] The launch of this data collection was motivated by the strong evidence that scholarship winners had received more education as of 2016 along with the evidence that female scholarship winners had partnered with more educated individuals and delayed fertility.

2.1 Primary outcome: Child cognitive development

We will estimate each child's latent cognitive abilities at our target age ranges using item response theory (IRT). We will estimate a one-parameter logistic model on the relevant cognitive games trials[2]. The model will assign a difficulty level to each trial and then, a latent trait to each individual (for the remainder of this document, we will refer this latent trait as the child's IRT score) based on their answers to the trials adjusting for the trial's difficulty level. This model assumes that items share the same discrimination parameter. We will test our results robustness to relaxing this assumption by estimating a two-parameter logistic model when possible.

Non-responses will be dropped from our analysis since non-responses often indicate distractions arising in the field (i.e. other children distracting the child) or equipment failures. However, we will test our results robustness to scoring these trials as incorrect responses for all children or only for children who initiated the games.

For our measure of overall child cognitive development, we will estimate an IRT score for children at a given target age using all of the cognitive games trials administered at the target age. For our measures of domain-specific cognitive development (executive function, language skills, math & numeracy, social cognition, spatial reasoning), we will estimate an IRT score on the cognitive game trials relevant to that domain (refer to "Primary outcomes (explanation)" for the skills associated with each domain).

2.2 Primary outcome: Child survival

We will use three measures of child survival: child alive as of last survey, child survived for over 1 year and child survived for over 3 years.

2.3 Secondary outcomes

Child stunting: We will construct measures of child stunting by calculating weight-for-age Z-scores, height-for-age Z-scores, and body mass index-for-age Z-scores from the weight and height measures taken at the target age ranges.

Caregiver-child interaction: One measure of caregiver-child interaction will come from videos of caregivers interacting with their children with a book or a toy. Professor Elizabeth Spelke's lab will train surveyors who will code the quality of the caregiver's interactions with the child in these videos. For an alternative measure from a more naturalistic setting, we will attach the Language ENvironment Analysis (LENA) device to the 14-22 month old or 30-36 month old children for a day to capture an audio recording of the their speech and interactions. The LENA device automatically produces an adult word count, child vocalization count and conversational turn count. We will drop any recordings of under 8 hours. We will then adjust the counts for the length of the recording. These per minute counts will be used as additional measures of caregiver-child interaction.

Caregiver aspirations: We will measure the caregiver's educational aspirations for the child by asking "What is the highest level of education that you would like [child name] to complete?". We will convert these answers into years of education to create a measure of the caregiver's aspirations for the child

Other secondary outcomes: We will construct indices for the other secondary outcomes listed in "Secondary outcomes". To construct the indices, we will take the sum of the normalized variables that are relevant to the the given secondary outcome (refer to "Secondary outcomes (explanation)" to see the relevant variables for each index).

[2] Specifically, we will estimate the model on a set of binary variables indicating whether the child was correct or incorrect on a given trial.

2.4 Treatment effects

To measure the impact of the scholarship on our primary outcomes, we will run regressions of the following form:

$$Y_{ijte} = \beta_{0ijts} + \beta_1 T_i + \beta_2 ChildAge_{ijt} + \mu_t + \eta_s + \gamma \mathbf{X}_{ij} + \varepsilon_i \tag{1}$$

where Y_{ijt} is the outcome of interest for a given child j of the scholarship-eligible individual j at a given time t surveyed by enumerator s. $ChildAge$ is the child's age at the time the outcome was measured. μ_t are survey round fixed effects which accounts adjustments in the administration of the games made over the five years of surveying and η_s are enumerator fixed effects. $\mathbf{X}_i$ is a vector of child characteristics including scholarship-eligible parent's baseline region fixed effects, scholarship-eligible parent's Junior High School finishing exam score, and child's birth order. $\widehat{\beta_1}$ will estimate the difference between treatment and control observations. Since randomization was at the scholarship-eligible parent level, we will cluster errors at the scholarship-eligible parent level.

We will adjust for multiple hypothesis testing among our primary outcomes. Since our secondary outcomes are included to help us identify channels through which the treatment affected our primary outcomes, we will not include the secondary outcomes in the multiple hypothesis testing adjustment for the primary outcomes.

2.5 Heterogeneity analysis

To test for heterogenous effects by the gender of the scholarship recipient, we will run the following regression:

$$Y_{ijts} = \delta_{0ijts} + \delta_1 T_i + \delta_2 Female_i + \delta_3 Female * T_i + \delta_4 ChildAge_{ijt} + \mu_t + \eta_s + \gamma \mathbf{X}_i + \varepsilon_i \tag{2}$$

where $Female$ is 1 if the scholarship-eligible parent is female and 0 otherwise. $\widehat{\delta_2}$ will measure the treatment-control difference when the scholarship-eligible parent was male. $\widehat{\delta_2} + \widehat{\delta_3}$ will measure the treatment-control difference when the scholarship-eligible parent was female. $\widehat{\delta_3}$ will measure the difference in treatment effects between the genders. Our hypothesis is that there will be larger treatments effects on the children of female scholarship recipients since they are likely to be more involved in child-rearing activities.