Inequalities in adolescent learning: Does the timing and persistence of food insecurity at home matter?

Elisabetta Aurino , Jasmine Fledderjohann , Sukumar Vellakkal

PII: S0272-7757(18)30207-3
DOI: https://doi.org/10.1016/j.econedurev.2019.03.003
Reference: ECOEDU 1881

To appear in: *Economics of Education Review*

Received date: 14 April 2018
Revised date: 14 March 2019
Accepted date: 15 March 2019

Please cite this article as: Elisabetta Aurino , Jasmine Fledderjohann , Sukumar Vellakkal , Inequalities in adolescent learning: Does the timing and persistence of food insecurity at home matter?, *Economics of Education Review* (2019), doi: https://doi.org/10.1016/j.econedurev.2019.03.003

Highlights

- We investigated adolescent learning disparities by household food insecurity trajectories during childhood in a large emerging economy
- "Value-added" models of achievements included early-life cognition and extensive child and household controls
- Heterogeneity by timing of occurrence and persistence of food insecurity, and by skill, was present
- Chronic household food insecurity and early childhood food security at home followed by later food security were the largest predictors of impaired cognitive skills at 12 years
- Food security programmes may have important learning spillovers

Inequalities in adolescent learning: Does the timing and persistence of food insecurity at home matter?

Elisabetta Aurino[a, b]
[a] Department of Management & Centre for Health Economics and Policy Innovations, Imperial College London, UK
[b] Department of International Development, University of Oxford, UK

Jasmine Fledderjohann[c]
[c] Department of Sociology, Lancaster University, UK

Sukumar Vellakkal[d]
[d] Department of Economics, BITS Pilani Goa, India

Corresponding author:
Elisabetta Aurino, Department of Management and Centre for Health Economics and Health Policy, Department of Management, Imperial College Business School, South Kensington Campus, Ayrton Rd, Kensington, London SW7 2AZ, UK
Email: e.aurino@imperial.ac.uk; tel: +44 (0) 20 7589 5111

Abstract

We investigated inequalities in learning achievements at 12 years by household food insecurity trajectories at ages 5, 8 and 12 years in a longitudinal sample of 1,911 Indian children. Estimates included extensive child and household controls and lagged cognitive scores to address unobserved individual heterogeneity in ability and early investments. Overall, household food insecurity at any age predicted lower vocabulary, reading, maths and English scores in early adolescence. Adolescents from households that transitioned out from food insecurity at age 5 to later food security, and adolescents from chronically food insecure households had the lowest scores across all outcomes. There was heterogeneity in the relationship between temporal occurrence of food insecurity and cognitive skills, based on developmental and curriculum-specific timing of skill formation. Results were robust to additional explanations of the "household food insecurity gap", i.e. education and health investments, parental and child education aspirations, and child psychosocial skills.

Keywords: Cognitive skills; Learning; Adolescent; Food insecurity; India; Education inequality; Human capital; Longitudinal; Education; Lifecourse
JEL classification: I24; I29; I39; H52

1. Introduction

Following the large expansion in primary and secondary educational access called for in the Millennium Development Goals, equitable learning has become the new imperative in the Sustainable Development Goal education agenda (World Bank, 2018). Inequalities in child and adolescent learning achievements may have long-lasting effects on individual lifecourse income, productivity, health, and intergenerational transmission of poverty, undermining a country's overall economic and social development (Hanushek, 2013).

Policymakers in low- and middle-income countries (LMICs) are increasingly considering the role of household food security - a situation of unstable access to enough, safe and nutritious food - in children's accumulation of educational capital in order to devise multi-sectoral strategies for child learning, so that synergies with the social protection, health and food systems can be reaped (Bundy et al., 2017). Research on children's experiences of food insecurity at home in high-income countries—particularly the US—has suggested that household food insecurity has wide-ranging implications for child school participation, learning and broader development. The timing of food insecurity and its persistence during sensitive periods of childhood may also be associated with poorer educational outcomes (Alaimo, Olson, & Frongillo, 2001; Grineski, Morales, Collins, & Rubio, 2018; Howard, 2011; Jyoti, Frongillo, Jones, & Al, 2005). However, there is a serious dearth of research on the learning consequences of household food insecurity, particularly around its timing and persistence over childhood, in LMIC settings. In these contexts, the global burden of food insecurity is greatest and research on the linkages between food insecurity and early childhood undernutrition dominates much of the discourse (Chandrasekhar, Aguayo, Krishna, & Nair, 2017; Reis, 2012). Yet, returns from education, socio-demographic factors, and structure of the social protection, food and education systems—all of which have the potential to impact on household food insecurity, as well as to moderate the association between food insecurity and cognitive achievements— vary widely from higher-income contexts.

In this paper, we investigate inequalities in adolescent learning achievements by household food insecurity trajectories. We do this by relying on rich longitudinal data following children at early childhood, mid-childhood and adolescence in India, the second largest country in the world and a leading emerging economy. The country is currently home to a third of the global adolescent and youth population, and the Indian Government has recently identified inequalities in young people's human capital as a major challenge to reap the demographic dividend (Ministry of Statistics and Programme Implementation Government of India, 2017).

The need for robust evidence of inequalities in cognitive skills formation by household food insecurity trajectories is particularly pressing in India, which is in the midst of what has been defined as a "learning crisis" (World Bank, 2018). Since the 2000s, the country achieved impressive expansion in school participation but increases in learning levels have not followed: in rural India, only a quarter of Grade 3 students were at "grade-level" in

reading and in maths in 2016[1] (ASER Centre, 2017). While a large body of literature has decomposed learning disparities by gender, caste, household wealth, place of residence, and private schooling (Alcott & Rose, 2017; ASER Centre, 2017; Azam & Kingdon, 2013; Dercon & Singh, 2013; A. Singh, 2015), we are not aware of work focusing on household food insecurity. This is especially surprising in this context, as the country bears the largest burden of food insecurity and malnutrition globally (Aurino & Morrow, 2018; Headey, Hoddinott, & Park, 2016; Vellakkal et al., 2015) (also see Section 2.2).

Ending food insecurity is another global priority as testified by Sustainable Development Goal 2. Despite recent UNICEF estimates highlighted that at least 590 million children under age 15 live in moderately or severely food insecure households (Pereira, Handa, & Holmqvist, 2017), very few studies have addressed this topic in LMICs contexts, partially due to lack of data. Through this article, we aim at starting to fill this key evidence gap for policy-makers in those settings. The data we used are particularly suitable for examining this issue, as they simultaneously collected information on household food security and cognitive development during three critical periods of skills formation. Further, the longitudinal dimension allowed for the estimation of "value-added" models of adolescent learning by including measures of early childhood cognition that control for early-life heterogeneity in children's ability and household investments, thus increasing the robustness of our identification strategy (Andrabi, Das, Khwaja, & Zajonc, 2011; A. Singh, 2015; Todd & Wolpin, 2003). This way, we could investigate the extent to which the 'household food security gaps' in adolescent learning could be accounted for early-life differences in cognition and educational investments.

We hope to add to the literature in four main ways: first, we provide robust evidence on the relationship between the timing and duration of household food insecurity during childhood and learning outcomes at adolescence in a key emerging economy. Evidence from the US suggested that, as in the case of income poverty, household food security is more often a transient rather than a permanent condition, with the majority of households moving in and out of food insecurity over time (Burke et al., 2017; Grineski et al., 2018; Howard, 2011; Perez-Escamilla & Pinheiro de Toledo Vianna, 2012). Whether a similar dynamic pattern holds in India—where, proportionally speaking, the scale and depth of food insecurity is greater—and what the implications of this dynamics for adolescent learning are, has been, so far, unclear. Second, as adolescents were assessed in multiple learning domains, including child receptive vocabulary, reading in the local language, maths, and English, we were able to investigate skill-based heterogeneity in the predictive power of household food insecurity. This aspect has also been relatively under-researched so far, in both high-income and LMIC settings. We expect some degree of heterogeneity by cognitive achievement, due to variation in developmental periods in which different skills are usually acquired and curriculum-based variation in the age in which different skills are taught. Third, we hypothesise and test a number of potential explanations that could account for adolescent learning disparities instead of household food insecurity trajectories. Thanks to the richness of our data, we could

[1] In Andhra Pradesh and Telangana, the settings for our study, only 22% and 18% respectively of Grade 3 students were at the grade-level in reading, and 48% and 40% in Maths (ASER Centre, 2017).

consider a wider set of possible pathways than previous studies, including education investments, health and psychosocial skills. Fourth, we investigated gender inequalities in this relationship, as inequalities between boys and girls in human capital are pervasive in India.

The rest of the paper is organised as follows: Section 2 presents the background; Sections 3 and 4 present the methods and results, respectively. Finally, Section 5 discusses the results and concludes.

2. Background

2.1. Household food access and child education: theoretical pathways

Food insecurity is a multidimensional concept, ranging from the access to stable access to safe, nutritious and socially-acceptable food to individual nutritional outcomes (Burchi & De Muro, 2016). Arising from this complexity, the measurement of food insecurity includes assessing multiple dimensions. In this paper, we focus on a single domain: a household's capability to access adequate and nutritious food consistently over time, which, for simplicity, we refer to as "food security". Household food access is usually measured through experience-based access scales. These were first introduced in the US in the early 1990s and later validated for global comparisons (Ballard, Kepple, & Cafiero, 2013). Additional methodological details are presented in Section 3.2.

Due to the long-standing use of such scales in the US and Canada, most of the existing literature is set in those contexts (Gee, 2018; Howard, 2011; Johnson & Markowitz, 2017; Jyoti et al., 2005; Perez-Escamilla & Pinheiro de Toledo Vianna, 2012). Exceptions are studies set in China focusing on maths and language achievements (Hannum, Liu, & Frongillo, 2014) and in Ethiopia on enrolment and grade attainment (Belachew et al., 2011). While the literature differs widely in terms of measurement of household food insecurity, educational achievement metrics, periods of skills formation, and methodology, all studies consistently find negative associations between household food insecurity as measured by access scales and child learning.

There are multiple hypothesized mechanisms through which food insecurity at home may be associated with lower learning. First, faced with food insecurity, households may prioritise the purchase of basic foodstuffs as compared to non-food items, and consequently may invest less in educational inputs (e.g. school fees, private tuition, educational materials, uniforms). Second, children from food insecure families may be more likely to work within or outside the household as part of the family's responses to food insecurity, which may lead to increased absenteeism, less time to study, and earlier dropout (Aurino & Morrow, 2018; Belachew et al., 2011). A further channel is health-related: hunger and morning fasts have adverse effects on cognition, particularly through slower working memory, fatigue and distraction (Pollitt, Cueto, & Jacoby, 1998). Lower dietary quality and variety may also affect cognition via micronutrient deficiencies (Dave, Evans, Saunders, Watkins, & Pfeiffer, 2009). Undernutrition, particularly stunting, has long-term effects on educational outcomes (Alderman, Hoddinott, & Kinsey, 2006; Maluccio et al., 2009). Hunger and micronutrient deficiencies may impair cognition well before undernutrition is manifest (i.e. stunted growth),

highlighting the value added of focusing on household food insecurity rather than exclusively on nutritional outcomes. While the effects of malnutrition on cognition may be more pronounced in the first three years of life, when the brain structure is developing at a faster rate, research has shown that food insecurity in the preschool years (3 to 5 years) may undermine child behaviours and cognitive development in the same way as in the infancy period, thus interfering with a child's readiness to learn (Johnson & Markowitz, 2017). Fourth, household food insecurity may affect both children and parental psychosocial skills, through increased anxiety, irritability, and shame (Heflin, Siefert, & Williams, 2005; Howard, 2011; Johnson & Markowitz, 2017; Jyoti et al., 2005). Howard (2011) found that in the US, children who transitioned from food insecurity in first grade to food security in third grade had large impairments in non-cognitive skills that persisted through the fifth grade. Decreased child and parental psychosocial skills may in turn affect learning though lower-quality interactions with parents, teachers and peers, and distraught class-room behaviour.

There may be gender differences across all these pathways. At the individual level, boys and girls tend to react differently to acute stress (Hampel & Petermann, 2005; Jose & Ratcliffe, 2004). Also, in response to food insecurity, parents may reallocate the quantity and quality of human capital inputs in a gender-inequitable way (Björkman-Nyqvist, 2013). Previous research has shown that boys are more likely than girls to be buffered from the negative effects of food insecurity in Ethiopia (Hadley,Lindstrom, Tessema, & Belachew, 2008) and suggested that girls are more susceptible to the stress effects of food insecurity (Jyoti et al., 2005).Gender differences in the experience of household food insecurity and its repercussions on learning may be particularly pronounced in India, where a large literature has documented wide inequalities in education and nutrition investments by gender (Alcott & Rose, 2017; Aurino, 2016; Azam & Kingdon, 2013; Dercon & Singh, 2013).

Importantly, there may be variation in the relationship between household food insecurity and learning based on what specific skills are being developed. However, evidence documenting such heterogeneity has been modest at best. The formation of different learning competencies is not fixed across skills, and depends on a child's developmental stage, the organisation of the educational curriculum, and type of school. For instance, early childhood household food insecurity may be particularly detrimental for language development. This is a foundational ability for school readiness and the development of additional cognitive, academic and socio-emotional skills. Usually, language development is formed in early life at home and then is consolidated in the preschool years (3 to 6 years) (Jalongo & Sobolak, 2011). If household food insecurity is associated with lower quality of parent-child interactions and/or with decreased access to quality early education, developmental delays in this domain may have negative implications for the learning of other subjects through less motivation or increased difficulty to learn. By contrast, household food insecurity during mid-childhood or early adolescence may be more predictive of lower attainments in those skills that children start to learn only at later stages (e.g. foreign languages).

Adding further complexity, the dynamic aspect of household food insecurity constitutes a critical additional issue to consider. While some resilience may be possible in the short-term, long-term resilience to the negative effects of chronic food insecurity may be more elusive (Burke et al., 2017; Gennetian, Rodrigues, Hill, & Morris, 2018). Not only does long-term food insecurity increase the risk of food insecurity occurring during critical periods

for skills formation, but it may also erode the educational foundations that are fundamental for later learning. For example, a child who misses school occasionally due to short-term food insecurity may be able to make-up for missed lessons; a child with a long-term pattern of absenteeism may find it more difficult to catch-up on missed work, which will in turn make mastery of higher-order skills more difficult and increase the chances of falling behind or dropping-out. This issue may be particularly salient for maths, for which some degree of catch-up may be more challenging due to the cumulative nature of the curriculum. However, evidence on both the interactions between the timing of food insecurity and learning, and on the cumulative effects of chronic food insecurity have been relatively limited so far.

In summary, the relationship between food insecurity and child learning is complex and may vary based on the interaction between timing and persistence of food insecurity, as well as child-, household- and community-level factors. The latter relate, for instance, to the availability of learning support to children that are lagging behind, or accessibility and quality of educational and social protection services.

2.2. Food insecurity in India

The enduring food security challenge in India is a clear policy priority, as evidenced by the 2013 National Food Security Act and the 2018 National Nutritional Mission (Aurino & Morrow, 2018; Narayanan, 2015). The prioritisation of food security in the policy agenda is reflected in a number of food programmes, such as the Public Distribution Scheme, the Midday-Meal Scheme (the largest school feeding program in the world), and the Mahatma Gandhi National Rural Guarantee Act Scheme. The Indian food security problem does not arise from constrained food supply, but rather to its inequitable distribution, and the lack of an "enabling" environment apt to convert food into adequate nutrition and the capability to be food secure over time (Narayanan, 2015; Sen & Dreze, 1999). Despite decades of persistent economic growth and increases in food production, sustained access to adequate and diverse food continues to be a challenge for large shares of the Indian population. This "entitlement failure" is partly due to the shrinking of agrarian and informal sector incomes and structural patterns of inequalities, which were recently coupled by inflationary trends in food and non-food prices (Vellakkal et al., 2015). On the other hand, insufficiency of support-led measures (in terms of both policy framing and implementation) to combat the multiple dimensions of poverty (including income, education, water and sanitation, and so on) strengthened these trends leading to persistent malnutrition and food insecurity outcomes.

2.3. The educational landscape

Since the Independence in 1947, Indian education policies have focused primarily on expanding basic education, infrastructures and resources. Today, the country has dramatically increased access, with almost universal gross primary enrolment and about 80% gross secondary enrolment. However, learning levels have not followed these positive trends, with the country being at considerable disadvantage in international learning comparisons, including with other middle-income countries (Kingdon, 2007; R. Singh & Mukherjee, 2017).Following the 2009 Right to Education Act, education in India is mandatory between

ages 6 and 14 years, or up to Grade 8. Recently, there has been a substantial expansion in the enrolment of children in private schooling in Andhra Pradesh (where our study is based), with the risk of marginalising the poorest children or girls to government schools (Azam & Kingdon, 2013; R. Singh & Mukherjee, 2016). One of the appeals of private schools for Indian parents is the use of English as medium of instruction from preschool, which is considered as a considerable advantage in the labour market. By contrast, the local language is used in Government schools until about 8 or 9 years of age[2]. The quality of English teaching in the Government schools is variable, as the teachers who provide English instruction are mostly from Non-English disciplinary backgrounds.

A number of policies have been enacted to sustain equitable access and learning outcomes. One that received considerable attention is the national school feeding programme, also known as the Midday-Meal Scheme. The programme provides a free cooked meal to all children in compulsory education in government and aided schools. In Andhra Pradesh[3], coverage is almost universal. A midday-meal is also provided in preschool centres as part of early childhood support. Recent evidence has demonstrated the programme's positive impact on learning (Chakraborty & Jayaraman, 2016) and on mitigating the effects of early shocks on preschool nutritional status (A. Singh, Park, & Dercon, 2014). However, alone, it may not be sufficient to completely protect children's education from the negative effects of food insecurity such as being involved in work, lower dietary quality and intakes, and decreased psychosocial well-being.

3. Methods

3.1. Sample and Data

We draw on the Andhra Pradesh sample of Young Lives, a multi-country study of childhood poverty (Inka Barnett et al., 2013). The study recruited 2000 children aged ~1. Survey data were subsequently collected in 2006, 2009 and 2013[4]. In round 1, food insecurity data were not collected, therefore we use data from rounds 2, 3 and 4, where children were aged about five, eight and 12 years respectively.

The sampling approach was multistage and "pro-poor". First, 20 sentinel sites through oversampling more disadvantaged areas were selected. Later, 50 households were randomly selected. While the sample is not nationally representative, comparison in key child and household indicators with representative surveys show similar variation (Barnett et al., 2013). At 4.5%, attrition between Rounds 1 and 4 was extremely low for a study of this nature due to exceptional tracking efforts. We present findings from children that were present in all

[2] Since 2011, English started to be taught as a separate discipline from Grade 1 since 2011. However, this change did not affect our sample, as in 2011 children should have been in Grade 3 or 4.

[3] The State divided into Andhra Pradesh and Telangana in 2014. Together, the two States have a population of85 million people, making it the fourth largest State of India. We will refer to Andhra Pradesh throughout for simplicity, also in the light that the data we used were collected when the two States were still united.

4 An additional round of data was collected in 2016 but data are not publicly available.

three rounds of the data used here. Comparison of baseline characteristics between households that were successfully tracked and lost-to-follow-up showed that there were no differences in child and household covariates between these two groups, with the exception of a few instances (Appendix A): specifically, households that were lost to follow-up were more likely to be from other castes and less from backward castes, and had slightly higher wealth. The few covariates that predict attrition, together with the overall low prevalence of attrition rate, attenuates concerns for attrition bias.

3.2. Measurement of household food insecurity

Food insecurity access measures hinge on the notion that the experience of food insecurity is associated with behavioral responses that can be assessed and summarized through a scale (Coates, Swindale, & Bilinsky, 2007). Responses include: anxiety over the food supply, perceptions that food is of insufficient quantity and quality, reported reductions in food quantity and quality, skipping meals; and, in the most extreme cases, going all day and/or night without food. Experience-based scales differ from other metrics of food insecurity (e.g. anthropometrics or caloric availability) by directly measuring the prevalence and severity of households' failure to access food. In India, different scales have been used in various contexts (for a review, see: (Sethi, Maitra, Avula, Unisa, & Bhalla, 2017)).

In Round 2 (2006) household food security was assessed through an adaptation of the standard US measure (Bickel, Nord, Price, Hamilton, & Cook, 2000). This scale is based on a series of questions that ask respondents to indicate how often in the previous 12 months the household experienced food shortages; had been unable to eat preferred foods; had to limit portion sizes or skip meals; had to borrow money to eat; or had to forfeit meals to others. In Rounds 3 and 4, the Household Food Insecurity Access Scale (HFIAS) (Coates et al., 2007) was instead used. HFIAS is a validated measure of food access in LMICs. Many of the questions in the scale are similar to the US measure, but the HFIAS also asks about frequency of limiting variety of foods consumed and going to sleep hungry, while it does not ask about borrowing money for food. We report the questions included in each scale and related descriptive statistics in Appendix B.1.For each round, we coded a dichotomous indicator of food insecurity following the approach in Humphries et al. (2015). Households were coded as food insecure in Round 2 if they answered yes to any food insecurity question, except eating less-preferred foods. In Rounds 3 and 4, we coded households as food insecure if they were classified as moderately or severely food insecure by the HFIAS protocol.

We then generated a categorical variable aiming to reflect household food security trajectories. This variable assumed the following values: 0 if the child's household has never been food insecure across the three survey rounds; 1 if the household was food insecure when the child was 5 years old but then became food secure at 8 years or 12 years; 2 if the household became food insecure when the child was aged 8 years and remained so until the child was 12 years old; 3 if the household became food insecure when the child was aged 12 years; 4 for any other situation of household food insecurity, which we refer as to "transitory food insecurity"; and 5 if the household was food insecure in all the observations points (chronic household food insecurity). Table 1 summarises the values assumed by the variable based on household food insecurity status at each round.

As a robustness check, we created an alternative measure of household food insecurity restricted to only the common items between the scale used in 2006 and the one used in subsequent rounds. Excluding the question on eating less preferred foods, the common items were: limiting portion size; skip meal and skip eating for a whole day and going to bed hungry. The alternative measure ranges from 0-3; we coded households as food insecure if they responded yes to at least one of these indicators. We then constructed the food security trajectories as in the case of our standard measure (food insecure at age 5, 8, 12, chronic food insecurity, transitory food insecurity, never food insecure).

[Table 1 about here]

3.3. Measures of adolescent learning

Adolescent learning at 12 years was assessed through a number of tests, which were designed by education experts and adapted to the formal curriculum of Andhra Pradesh. Tests included: (i) a version of the Peabody Picture Vocabulary Test (PPVT), a measure of vocabulary development; (ii) a reading test in the local language (Telugu); (iii) a maths assessment; and (iv) a English test. We also employed two measures of cognitive development at 5 years: the PPVT score and a Cognitive Development Assessment (CDA), a measure of children's grasp of basic numeracy concepts. All cognitive scores were collected at home in order to include out-of-school children. They were standardised to have a mean of zero and a standard deviation of one.

3.4. Empirical strategy

There are three potential sources of bias in the estimation of the OLS parameters in the relation between household food insecurity and learning. First, unobserved child and parental heterogeneity may drive "selection" into food insecurity: as these characteristics may be also associated with child learning achievements, endogeneity bias due to those omitted variables may be present. Second, potential mis-measurement of test scores may lead to measurement bias in the estimates[5]. We tackle both issues through the adoption of "value-added models of achievement" (Andrabi et al., 2011; Todd & Wolpin, 2003). These models include prior cognitive scores as a summary statistics of the history of household and school inputs for learning, as well as of individual variation in ability (Koedel, Mihaly, & Rockoff, 2015). Although it is arguable that there may be still some degree of unobserved individual heterogeneity and measurement error, estimates from these models have shown to be unbiased when compared with experimental estimates (Angrist, Pathak, & Walters, 2013; A. Singh, 2015). For this reason, value-added models are commonly considered as the most

[5] A related issue is the mismeasurement of household food security. Gundersen and Ribar (2011), for instance, reported that a large share of food insecurity is underreported in the US, particularly among households at the lower end of the consumption distribution. This may bias downwards the coefficient related to household food insecurity: when this bias is taken into account, the effect of food security on child outcomes is even larger than previously thought (Gundersen & Kreider, 2009).

robust approach in face of potential biases stemming from missing data on endowments and educational inputs in observational data.

Omitted variable bias may also arise from unobserved characteristics of the local food, health and educational environments (e.g. availability and quality of social protection and other services, school infrastructure and quality of education, local prices and wages) that may be correlated with both a household food security status and with children's learning (Howard 2011). We address this further concern by relying on a community-fixed effect approach, which sweeps out those characteristics that are common to all children living in the same community.

Third, selection bias based on school attendance may arise if adolescents were tested at school. We rule out this possibility as the learning assessments were conducted at home, thereby including all adolescents, independently of their school enrolment status[6].

Despite our focus on addressing these potential sources of bias in our identification, we cannot claim causality. However, we are confident that the combination of value-added estimation with a rich set of child and household covariates should provide robust estimates of the predictive role of household food insecurity dynamics on adolescent learning outcomes. In econometric terms, the "value-added" model is represented in Equation 1:

$$y_{ij,t} = \beta_0 + \beta_1 FI_{i\,j,t} + \beta_2 X_{ij,t} + \beta_3 \varphi_{ij,\tau} + \gamma_j + \varepsilon_{ij,t} \qquad (1)$$

Where $y_{ij,t}$ relates to the test score for child *i* at t=12 years old living in community *j;* $X_{ij,t}$ is a vector of contemporaneous child, caregiver and household controls; $\varphi_{ij,\tau}$ is a vector of cognitive achievements at age τ = 5 years; γ_j are community characteristics[7] and $\varepsilon_{ij,t}$ is the error term. The term $FI_{ij,t}$ represents a categorical variable related to the adolescent's household food insecurity trajectory from preschool until age 12 years. As described in Section 3.2, such variable provides a summary at time t=12 years of the household food insecurity situation when the adolescent was aged 5, 8, and 12 years old. The basic vector of controls included: child age in months, gender, caste, child is first born, caregiver's age, caregiver's education, household size, number of boys aged 0-12 years, number of girls aged 0-12 years, number of boys aged 13-17 years, number of girls aged 13-17 years, female head

[6] We also note that at age 8 years almost all sample (99%) was in school, with only 19 children being out of school. At round 4, only 54 adolescents were not in school, with the remaining 97.2% still enrolled in school. These very low proportions of school drop-out, and together with the fact that children were assessed at home, suggest that our models are robust to proportion of children out of school.

[7] We run the community fixed effects based on the community in which the adolescent was located in the first survey round. This is because for children and households that migrated (around 10% across the four rounds), there is no information on the community of destination, except of whether this community is rural and urban. All migrating households are located in a single fictional community, for which it would not be possible to run the community fixed effect estimates. We controlled further for migration by adding covariates that state whether and when the household has changed community.

of the household, wealth index, household is urban at Round 4, and three dichotomous dummies related to change of community between rounds.

We then extend the value-added model to obtain Equations 2-4 through the inclusion of three sets of contemporaneous groups of variables that may contribute to explain (alone and in combination) the food insecurity gaps in adolescent learning, as per our conceptual framework. Specifically, we include groups of variables capturing: (i) investments in adolescent education; (ii) investments in adolescent health: (iii) caregiver and adolescent psychosocial outcomes.

$$y_{ij,t} = \beta_0 + \beta_1 FI_{i\,j,t} + \beta_2 X_{ij,t} + \beta_3 \varphi_{ij,\tau} + \gamma_j + \varepsilon_{ij,t} \quad (1)$$

$$+\beta_4 Educational\ Inputs_{ij,t} \quad (2)$$

$$+\beta_5 Health\ Inputs_{ij,t} \quad (3)$$

$$+\beta_6 Psychosocials_{ij,t} \quad (4)$$

Where the vector $Educational\ Inputs_{ij,t}$ includes: (i) a dichotomous variable of whether or not the adolescent was enrolled in school, and (ii) a binary variable related to private school (where Government school is the baseline)[8]. $Health\ Inputs_{ij,t}$ are summarised by contemporaneous height-for-age z-scores (HAZ), which proxy all the health investments up to 12 years. $Psychosocials_{\mathrm{ij,t}}$ is a vector of caregiver's and adolescent psychosocial skills. The vector included the following: (i) a dichotomous variable of whether the caregiver aspired for the adolescent to attain at least secondary schooling (Grade 12); (ii) a dichotomous variable of whether the adolescent aspired to attain at least Grade 12; (iii) adolescent's self-efficacy; and, (iv) adolescent self-esteem. Educational aspirations and psychosocial traits like self-efficacy (a person's belief about one's own ability) and self-esteem (one's own assessment of self-worth) interact with previous cognition in the formation of human capital and influence schooling decisions (Cunha, Heckman, & Schennach, 2010). Self-esteem and self-efficacy were measured through questions (six and five items respectively) capturing the adolescent degree of agreement/disagreement with statements related to her sense of pride and shame, and of agency respectively[9]. Both scores where standardized in order to have mean of 0 and standard deviation of 1 (see Dercon & Sánchez 2013 for details). Descriptive statistics of all controls are presented in Appendix C.

4. Results

4.1. Descriptive statistics

[8] Although the data allowed for the inclusion of additional educational variables such as school attendance, time in school/study or household educational expenditures, we opted for a succinct vector of educational inputs. This was because, although endogeneity may be present across all intermediate outcome considered in the extended models, this problem may be particularly salient in the case of the educational inputs.

[9] Both scales have a Chronbach's Alpha of 0.7, which is commonly considered as an acceptable score for supporting the notion that there is a common underlying factor behind answers to different items (Dercon and Sanchez 2013).

Household food insecurity was largely a dynamic phenomenon (Figure 1): only 2% of the full sample households were classified as food insecure in all the three rounds of data collection, while only a little over half (53%) were always food secure. The remaining households, about 45% of the sample, were characterized by variation in the timing in which they first became food insecure, as well as in the length of their food insecurity experience. The stratification of household food insecurity trajectories by wealth quartiles (a commonly used indicator of socioeconomic status) pointed to a partial overlap between household food insecurity and wealth, with only 34% of households from the lowest wealth quartile always food secure as compared to 83% of households in the top wealth quartile. Further, while 5% of the households in the lowest quartile were chronically food insecure, virtually no household from the top quartile was food insecure at all rounds. Wealthier households, however, also experienced transitory episodes of food insecurity in some instances.

[Figure 1 about here]

Figure 2 provides the standardized learning scores for adolescents at age 12 based on their households' food insecurity trajectories across the four tests. Children in households that were never food insecure perform approximately 0.2 standard deviations above the sample mean across all metrics. Children experiencing transitory household food insecurity were near the mean on PPVT and reading scores, though somewhat further below the mean on maths and English. The descriptive data suggest a general gradient in educational achievement by household food insecurity trajectories, with adolescents who experienced chronic food insecurity being most disadvantaged, and that the earlier the experience of food insecurity at home, the lower an adolescent's standardized test scores.

There were a few exceptions to this overall trend: adolescents living in food insecure households at 12 years performed worse on reading and maths compared to adolescents who became food insecure at age 8. Moreover, adolescents who became food insecure at age 8 scored roughly equivalently to those who were food insecure at age 5 in English. This variation may be linked both to critical learning periods for subject-specific skills, and to the timing of curriculum. For instance, at the time the survey was conducted, the teaching of English generally started around Grade 4 (at around age 8/9 years) in Government schools, making mid-childhood episodes of food insecurity more salient for achievements in this domain.

[Figure 2 about here]

Supplementary figure 1 disaggregates these bivariate associations further by adolescent gender. For girls, being in a chronically food insecure household is associated with larger losses across all cognitive abilities than for boys. For boys, being food insecure at age 5 is associated with larger gaps in adolescent learning outcomes than for girls. In the case of English, boys who experienced food insecurity in mid-childhood (8 years old), have English scores that are two times lower than for girls. Although these are only descriptive statistics, and the sample sizes split by gender are more limited (particularly in the case of

chronic food insecurity), these results are suggestive of gender differences in adolescent learning by household food security trajectories.

Before moving to the discussion of the main results, we also present the descriptive statistics of the intermediate outcomes that may contribute to explain (alone and in combination) the food insecurity gaps in early adolescent learning outcomes. Table 2 presents differences in means of the variables introduced in Section 3.4 by household food insecurity trajectory. Consistent with the descriptive patterns on learning, adolescents who were never food insecure tended to fare better across all intermediate outcomes. Within adolescents that had ever experienced food insecurity, those who experienced later or transitory food insecurity tended to have better outcomes in all dimensions than adolescents who were in food insecure households at age 5 or in chronically food insecure households. Moreover, the later food insecurity occurred, the better the intermediate outcomes tended to be. There were two exceptions to this general trend: on the one hand, children who became food insecure at age 8 had the lowest enrolment in private school (13%) across categories of food insecurity, with even lower enrolment than children whose household was food insecure at age 5 or children living in chronically food insecure households. There was also a large, clear gap between children who became food insecure at age 8 versus age 12 for some outcomes, highlighting the vital role of the timing of food insecurity across these intermediate outcomes. Specifically, for children who became food insecure at age 8, the proportion enrolled in private school and their caregiver's aspirations for their educational attainment were closer to that of children who became food insecure at age 5 than for those children whose household became food insecure at age 12. On the other hand, while children's self-efficacy scores were below the sample mean for this group, their self-esteem scores were actually well above the mean. In fact, children who were food insecure at age 5 had the highest self-esteem scores across all the remaining categories of food insecurity. A strikingly similar pattern can be observed for children experiencing chronic food insecurity, with both their self-efficacy and self-esteem scores being slightly above the mean.

[Table 2 about here]

4.2. Main results

Table 3 presents the results from the value-added models estimating the relationship between household food insecurity trajectories and adolescent test scores. We only report the coefficients associated with household food insecurity trajectories and age 5 cognition. Results for the full model are presented and discussed in Appendix D. We focus on five key findings. First, transitioning from a situation of household food insecurity during early childhood (at age 5) to later food security consistently predicted lower vocabulary, reading, and maths test scores. Results for English scores were negative, but non-significant.

Second, starting from a situation of household food security at 5 years and becoming food insecure at home in mid- to late-childhood—that is, at age 8 or 12 years —was not significantly associated with performance on vocabulary and reading tests compared to children who were always food secure. There was, however, a significant, strong, and

negative association between becoming food insecure at age 8 and both maths and English scores. The pattern for children who became food insecure at age 12 was quite similar, with significant, negative associations between food insecurity and both maths and English scores. Similarly, transitory household food insecurity was significantly, negatively associated with maths and English scores. However, neither mid- to late-childhood nor transitory food insecurity were significantly associated with vocabulary nor reading scores.

A third pattern was observable for children who experienced household food insecurity at all ages: although these were only 2% of the sample, the negative association between chronic household food insecurity and both PPVT and English scores was strong and significant. Albeit negative, there was no significant association with reading and maths scores, perhaps due to limited statistical power arising from few households being food insecure at all rounds. These were the highest magnitude coefficients across categories of food insecurity for the respective academic performance tests. Nevertheless, comparing coefficients across categories of food insecurity, the direction and magnitude of the coefficients for reading and maths for children experiencing chronic food insecurity were roughly on par with those for children who were food insecure at age 5 and then transitioned to food security. This is logically consistent with expectations, as children in the chronically food insecure category experienced early life food insecurity as well, but also continued to do so through all observed time points.

Fourth, as expected, cognitive outcomes at age 5 predicted between 0.1 and 0.2 of a standard deviation across all scores. Notably, however, many coefficients related to household food insecurity were often stronger predictors of adolescent learning than early cognition measures.

Finally, as shown in Appendix Table D.1, being a boy was associated with higher receptive vocabulary scores, while being a girl was predictive of higher reading scores. Consistent with the conceptual framework, we investigate whether there is heterogeneity in the relationship between food insecurity trajectories and learning outcomes by adolescent gender. We test this hypothesis by interacting the categories included in the household food insecurity variable with adolescent gender. Figure 3 presents the predicted values of such interactions and their confidence intervals for the four learning outcomes. Once we control for previous cognitive scores and all the other adolescent and household controls, we do not find statistically significant differences by gender in the association between food insecurity and adolescent learning outcomes (full results with interactions are available upon request).

[Figure 3 about here]

4.3. Extended models

We then estimate the extended models that include potential explanations for the food insecurity gap in adolescent learning achievements. We augment the basic model by including contemporaneous: (i) educational inputs; (ii) health inputs; and, (iii) psychosocial skills. As discussed in Section 2.1, these factors may vary between children based on the

timing and duration of household food insecurity. Accordingly, once these potential explanations are included, the food insecurity gaps in learning may diminish substantially or disappear altogether.

Table 4, Panels A-D present the results for the value-added models for each of the outcomes with the additional covariates. The latter were included gradually in order to investigate whether, alone or in combination, they could explain household food insecurity gaps. Estimates reporting the coefficients for the additional covariates are available upon request. An F-test of joint significance rejected the hypothesis that the estimated coefficients were jointly equal to 0 (available upon request).

The inclusion of these potential explanations was able to explain about a third of the variation in the early childhood (age 5) household food insecurity associations for vocabulary, reading and maths and between chronic food insecurity and vocabulary and English. However, the inclusion of potential sources of disparities in adolescent learning outcomes by household food insecurity dynamics did not affect the main results presented in Table 3.

Further, given the relatively low sample sizes in both the early childhood and chronic food insecurity groups, it is quite remarkable that after the introduction of the additional controls, disparities in adolescent learning by these household food insecurity remained significant and strong in most specifications. In the full model specification for vocabulary and maths, the coefficients related to early childhood food insecurity were about three times the size of the coefficients related to HAZ, and about twice as large as the estimates for lagged vocabulary scores. In the case of chronic food insecurity, coefficients for vocabulary and English were about the same size as parental aspirations for child education, which has been previously documented as a driver of learning achievements (Dercon & Singh, 2013). For maths, contemporaneous household food insecurity shocks negatively explained about a quarter of a standard deviation in test scores in the most conservative specification with all the factors jointly included. Educational investments appeared to account for a large variation in the relation between household food insecurity and English achievements[10].

[Table 4 about here]

4.4. Robustness checks

We ran a series of robustness checks. First, we investigated the extent to which our results were driven by the noted change in the household food insecurity measure between Rounds 2 (age 5) and 3 (age 8) (see Section 3.2). So far, following our conceptual framework, we have

[10] We tested further the robustness of the model related to the private schooling with interactions testing the relation between wealth terciles and private enrolment – as wealthier children are more likely to enroll in those schools. However, we did not find substantial differences in our findings and the interactions were never significant (results available upon request).

attributed the differential associations between learning outcomes and food insecurity at age 5 compared to ages 8 and 12 to the particularly sensitive period of early childhood in the formation of skills like vocabulary, reading and maths. However, it may be possible that our findings are only an artefact of the change in food insecurity metrics between early- and mid-childhood. We checked for this possibility by relying on a new measure of household food insecurity based only on items that are common across rounds (see Section 3.2). Appendix E, Table E.1 presents results from the value-added models using this "robustness measure". There were a few minor differences between the measures, to be expected, but in general the direction, strength, and significance of the coefficients were similar across specifications, and larger differences seemed primarily to result from smaller cell sizes in some categories. For example, for transitory (any other) food insecurity, the relationship between food insecurity and vocabulary scores was stronger for the robustness versus the standard measure, but the standard measure was statistically significant while the robustness measure was not. Also, early childhood food insecurity was significant for English using the robustness measure, whereas it had not been significant using the standard measure. On the whole, however, these results provide evidence that the timing effects we have identified above in terms of early versus later childhood food insecurity were not the result of changes in the food insecurity measure over time.

Another limitation relates to the lack of assessment of household food insecurity in 2002, when the adolescent would have been aged about one year. Household food insecurity is a key driver of illness and malnutrition in infancy, which may lead to impaired cognition later in life(Alderman et al., 2006; Maluccio et al., 2009). Although we believe the lifecourse effects of early health investments should already be captured by age-5 cognitive achievements, we ran an additional model including infancy HAZ (HAZ1) and weight-for-height z-scores (BAZ1). HAZ1 provides a synthetic measure of chronic food insecurity the adolescent may have faced *in utero* and in the first year, while BAZ1 assesses concurrent nutritional status, which is likely to be directly influenced by sudden shocks in household food security. Results are presented in Table E.2. Consistent with the literature (e.g. (Schott, Crookston, Lundeen, Stein, & Behrman, 2013)) HAZ1 scores were predictive of between 0.02-0.07 standard deviations across all domains, and BAZ1 scores were predictive of about 0.05 of a standard deviation in vocabulary scores, indicating the early-life origins of vocabulary development. However, the inclusion of indicators of early nutrition in the value-added model did not change our main results, suggesting that household food insecurity at later stages of the lifecourse acts as a strong and independent channel on adolescent learning, over and above early-life exposure to food insecurity.

With regards to the pathways, there may be concerns that the inclusion of contemporaneous measures of educational and psychosocial inputs may not necessarily reflect the same inputs at younger ages. Indeed, age-12 school enrolment and psychosocial outcomes are likely to be influenced by cognitive skills observed at younger ages and hence may not be good measures of the potential pathways by which food insecurity at younger ages is associated with learning at older ages. On the one hand, following from common practice in the cognitive development literature, the inclusion of cognition at age 5 years addresses this issue by controlling for the extent to which food insecurity gaps in learning at adolescence may be accounted for inequalities that were already evident at preschool age (A.

Singh, 2015; Todd & Wolpin, 2003). On the other hand, to check for this issue further, we ran additional estimates by controlling for private schooling and adolescent self-efficacy and self-esteem, as measured in mid-childhood (age 8)[11]. We do not find any qualitative change in our results (available upon request), which provides further support for the robustness of our estimation strategy and findings.

5. Discussion and Conclusions

As far as we are aware, this is the first paper examining adolescent learning disparities by household food insecurity trajectories during early childhood, mid-childhood and adolescence in India. Even in the most conservative value-added estimates, household food insecurity was a significant predictor of lower learning achievements. Consistent with our expectations, we found considerable heterogeneity based on the interaction between timing and persistency of food insecurity, and different learning domains. Early childhood and chronic household food insecurity were the most consistent predictor of impaired cognitive skills at 12 years, but with a larger effect on vocabulary development and reading. The magnitude of the coefficient related to transitions from household food insecurity at age 5 to later food security was much larger than the one related to concurrent food insecurity, suggesting that early-childhood experiences of food insecurity have mid-term associations with learning. Strikingly, the same pattern was documented in a previous study focusing on food insecurity transitions among US fifth-graders (Howard, 2011). Food insecurity in mid-childhood and early adolescence were also predictive of impaired maths and English scores. The inclusion of additional variables related to education, health and psychosocial skills was able to explain part of the variation in achievement scores, but household food insecurity remained an important predictor.

Consistent with our initial hypotheses, children in households experiencing only a transitory episode of food insecurity exhibited a lower degree of disadvantage in terms of vocabulary and reading as compared to peers that experienced longer spells of food insecurity. This, however, was not the case for maths and English. We interpret this result as arising from differences in sensitive periods of skills formation across the learning domains considered. Once a child has some foundational vocabulary and literacy skills, a certain amount of catching up may be possible in terms in these domains, and children may be resilient to temporary food insecurity shocks. However, resilience may be more difficult for skills such as maths. In this case, learning at one level is directly built on the previous level and it may be more difficult to fill basic gaps while the school curriculum moves forward, increasing the risk for the child to be left behind. By the same token, mid-childhood and early adolescence food insecurity at home may be comparatively more detrimental for English, as households may decrease the educational inputs invested in the adolescent, and with those enrolment in private schools or after-school tuition.

[11] We focus on these specific intermediate inputs because, in the case of enrolment, we do not have variation in this indicator at age 8 years, as all children are in school (as noted in footnote 7). We do not have age 8 data on school aspirations of caregivers and children.

Compared to most previous literature, a considerable advantage of our identification strategy relates to the use of value-added models: across all the domains of learning, the lagged vocabulary and CDA scores were strong and significant predictors of adolescent achievements, which highlights the importance of early investments for learning trajectories. Lagged cognitive scores did not only capture underlying variation in ability, but also the cumulative lifetime effects of exposures to adverse conditions, particularly during the critical "first 1000 days" (e.g. maternal nutrition during pregnancy, early life investments in nutrition and cognitive stimulation, and all other household and community influences that affect children's early life cognition and development). As these factors are key drivers of later-life learning disparities (Cunha, Heckman, & Schennach, 2010; Heckman & Mosso, 2014), their inclusion in the econometric models strengthen the robustness of the findings related to household food security as a source of divergence in adolescent learning.

This study has some limitations: first, food security was measured at the household level rather than at the child level. This may result in failure to capture intra-household effects, based, for instance, on gender and age (Aurino, 2016; Aurino & Morrow, 2018). Secondly, in contrast to Howard (2011), we did not consider the intensity of the household food insecurity experience, as the change in the scales renders this assessment particularly problematic. Also, issues related to quantity and quality of food access were not directly included. Future study may consider these nutritional aspects, and also incorporate coping strategies (e.g. as substitution of more expensive/nutritious food with cheaper food to ensure the necessary caloric intakes), and their effect on educational attainments. Also, we did not directly address the role of social protection programmes such as the public distribution system and the midday-meal scheme; this important question will require ad-hoc future studies that include evaluation methods. Also, although we use community fixed effects to sweep out school quality characteristics that are common for all children in the same community, and we control for private schooling in the extension analysis, we cannot fully account for other potentially important school quality characteristics. Other community and school factors may also matter, and future work should consider whether or how community context may matter for these associations.

Finally, additional research is needed to investigate the descriptive finding related to the positive relationship between food insecurity and self-esteem. We hypothesize that this finding had to do with the relative impacts of food insecurity, both over time and within our communities. It is possible that children who were food insecure from a very young age, and those who regularly experienced food insecurity, experienced food insecurity as a state of normalcy. So, to the extent that food insecurity is associated negatively with correlates of self-esteem such as formation of friendships, experiences of bullying, and so forth, it may be more detrimental to *lose* friends or begin experiencing bullying in mid-childhood and early adolescence than to experience this as the norm from the outset. This would explain why we observe lower self-esteem scores when children transition into food insecurity later in childhood, but we observe the inverse for early and chronic food insecurity.

Importantly, the fact that household food insecurity dynamics was a strong predictor of achievements, controlling for early-childhood cognition and key sources of learning inequalities (e.g. gender, caste, wealth, etc.), suggests an independent role for household food insecurity in the formation of adolescent learning disparities. Also, our results highlight the

importance of considering not only whether or not children have ever experienced food insecurity at home, but also when, for how long, and in relation to which specific skills. These considerations have important implications for the design (particularly around the timing), targeting, and delivery of interventions directed at children from food insecure households at critical life stages both at home and at school. From an educational perspective, these results can inform educational programmes targeting children at higher risk of food insecurity (e.g. tribal areas, urban slums, remote areas) and providing them with extra educational support. Also, the focus of those programmes may be tailored based on the period on which each specific skill may be more likely to be impaired from household food insecurity episodes. This could be achieved through programmes focusing on foundational skills such as vocabulary in the preschool and early primary school years (Jalongo & Sobolak, 2011) and/or through remedial education through primary in basic literacy and numeracy skills (Banerjee, Cole, Duflo, & Linden, 2007).

On the other hand, our findings can be used by policy-makers working in food programmes and other social protection to devise potential ways in which those schemes can enhance their "educational-sensitiveness". For instance, based on the robust and detrimental associations between household food insecurity at age 5 and adolescent outcomes, there may be scope for strengthening food-for-education preschool programmes (e.g. by including breakfast or take-home rations in areas where food insecurity is particularly widespread, such as in remote tribal communities); to improve the nutritional content of the food received through the public distribution systems for households with preschoolers; and to strengthen the overall quality of early education. Also, if the potential educational spillovers of such programmes are taken into account, the potential benefits of social protection spending could be larger than previously estimated.

Taken together, our results demonstrated that household food insecurity poses a considerable risk for adolescent learning. Also, they highlighted the importance of considering the timing and chronicity of food insecurity to understand this association from a lifecourse perspective. As articulated in the Sustainable Development Agenda, investment in ending food insecurity and in adolescents' education is key to achieve equitable, sustainable development. Our findings suggest that a tailored approach to mitigating the effects of household food insecurity, with particular attention to the timing and chronicity of the experience of food insecurity, may be critically important for improving adolescent learning outcomes in India.

Acknowledgements

EA gratefully acknowledges the "*Guido Cazzavillan Research Fellowship*" and the Cazzavillan family, and the "*Imperial College Research Fellowship*". She also wishes to thank Monica Bilio, Geraldine Ludbrook and Ignazio Musu for their fantastic support during the Cazzavillan fellowship. We also warmly thank Marisa Miraldo, Chris Millet, and Jere Behrman for their invaluable and continuous support, as well as for discussions and comments on earlier drafts of this manuscript. We acknowledge seminar participants at Indira Gandhi Institute for Development Research and BITS Pilani Goa. We are grateful to Young Lives and the children and families participating to the study. All remaining errors are ours.

Authors' contributions

EA and JF designed the research questions. EA conducted the data analysis. EA and JF drafted the manuscript. All authors discussed the results and contributed to the final manuscript.

References

Alaimo, K., Olson, C. M., & Frongillo, E. A. (2001). Food insufficiency and American school-aged children's cognitive, academic, and psychosocial development. *Pediatrics*, *108*(1), 44–53. https://doi.org/10.1542/peds.108.3.e44

Alcott, B., & Rose, P. (2017). Learning in India's primary schools: How do disparities widen across the grades? *International Journal of Educational Development*, *56*, 42–51. https://doi.org/10.1016/j.ijedudev.2017.05.002

Alderman, H., Hoddinott, J., & Kinsey, B. (2006). Long term consequences of early childhood malnutrition. *Oxford Economic Papers*, *58*(3), 450–474. https://doi.org/10.1093/oep/gpl008

Andrabi, T., Das, J., Khwaja, A. I., & Zajonc, T. (2011). Do value-added estimates add value? Accounting for learning dynamics. *American Economic Journal: Applied Economics*, *3*(3), 29–54. https://doi.org/10.1257/app.3.3.29

Angrist, J. D., Pathak, P. A., & Walters, C. R. (2013). Explaining charter school effectiveness. *American Economic Journal: Applied Economics*, *5*(4), 1–27. https://doi.org/10.1257/app.5.4.1

ASER Centre. (2017). *Annual Status of Education Report 2016*. Ne Delhi.

Aurino, E. (2016). Do boys eat better than girls in India? Longitudinal evidence on dietary diversity and food consumption disparities among children and adolescents. *Economics and Human Biology*. https://doi.org/10.1016/j.ehb.2016.10.007

Aurino, E., & Morrow, V. (2018). "Food prices were high, and the dal became watery". Mixed-method evidence on household food insecurity and children's diets in India. *World Development*, *111*, 211–224. https://doi.org/10.1016/j.worlddev.2018.07.009

Azam, M., & Kingdon, G. G. (2013). Are Girls the Fairer Sex in India? Revisiting Intra-Household Allocation of Education Expenditure. *World Development*, *42*(1), 143–164. https://doi.org/10.1016/j.worlddev.2012.09.003

Ballard, T. J., Kepple, A. W., & Cafiero, C. (2013). *The Food Insecurity Experience Scale Development of a Global Standard for Monitoring Hunger Worldwide*. Rome.

Banerjee, A. V., Cole, S., Duflo, E., & Linden, L. (2007). Remedying Education : Evidence from Two Randomized Experiments in India. *Quarterly Journal of Economics*, *122*(3), 1235–1264. https://doi.org/10.1162/qjec.122.3.1235

Barnett, I., Ariana, P., Petrou, S., Penny, M. E., Duc, L. T., Galab, S., … Boyden, J. (2013). Cohort profile: The young lives study. *International Journal of Epidemiology*, *42*(3), 701–708. https://doi.org/10.1093/ije/dys082

Barnett, I., Ariana, P., Petrou, S., Penny, M. E., Duc, L. T., Galab, S., … Boyden, J. (2013). Cohort Profile: The Young Lives Study. *International Journal of Epidemiology*, *42*(3), 701–708. https://doi.org/10.1093/ije/dys082

Belachew, T., Hadley, C., Lindstrom, D., Gebremariam, A., Lachat, C., Kolsteren, P., … Hassan, I. (2011). Food insecurity, school absenteeism and educational attainment of adolescents in Jimma Zone Southwest Ethiopia: a longitudinal study. *Nutrition Journal*, *10*(1), 29. https://doi.org/10.1186/1475-2891-10-29

Bickel, G., Nord, M., Price, C., Hamilton, W., & Cook, J. Guide to Measuring Household

Food Security Revised 2000, Agriculture § (2000). Alexandria (VA).
Björkman-Nyqvist, M. (2013). Income shocks and gender gaps in education: Evidence from Uganda. *Journal of Development Economics*, *105*, 237–253. https://doi.org/10.1016/j.jdeveco.2013.07.013
Bundy, D. A. P., Silva, N. de, Horton, S., Patton, G. C., Schultz, L., Jamison, D. T., … Al., E. (2017). Investment in child and adolescent health and development: key messages from Disease Control Priorities, 3rd Edition. *The Lancet*, 2423–2478. https://doi.org/10.1016/S0140-6736(17)32417-0
Burchi, F., & De Muro, P. (2016). From food availability to nutritional capabilities: Advancing food security analysis. *Food Policy*, *60*, 10–19. https://doi.org/10.1016/j.foodpol.2015.03.008
Burke, M. P., Martini, L. H., Blake, C. E., Younginer, N. A., Draper, C. L., Bell, B. A., … Jones, S. J. (2017). Stretching Food and Being Creative: Caregiver Responses to Child Food Insecurity. *Journal of Nutrition Education and Behavior*, *49*(4), 296–303.e1. https://doi.org/10.1016/J.JNEB.2016.11.010
Chakraborty, T., & Jayaraman, R. (2016). *School Feeding and Learning Achievement: Evidence from India's Midday Meal Program* (CESifo Working Papers No. 5994). Munich.
Chandrasekhar, S., Aguayo, V. M., Krishna, V., & Nair, R. (2017). Household food insecurity and children's dietary diversity and nutrition in India. Evidence from the comprehensive nutrition survey in Maharashtra. *Maternal and Child Nutrition*, *13*, e12447. https://doi.org/10.1111/mcn.12447
Coates, J., Swindale, A., & Bilinsky, P. (2007). *Food and Nutrition Technical Assistance Project (FANTA) Academy for Educational Household Food Insecurity Access Scale (HFIAS) for Measurement of Food Access: Indicator Guide VERSION 3*. Washington (D.C.).
Cunha, F., Heckman, J. J., & Schennach, S. M. (2010). Estimating the Technology of Cognitive and Noncognitive Skill Formation. *Econometrica*, *78*(3), 883–931. https://doi.org/10.3982/ECTA6551
Dave, J. M., Evans, A. E., Saunders, R. P., Watkins, K. W., & Pfeiffer, K. A. (2009). Associations among Food Insecurity, Acculturation, Demographic Factors, and Fruit and Vegetable Intake at Home in Hispanic Children. *Journal of the American Dietetic Association*, *109*(4), 697–701. https://doi.org/10.1016/j.jada.2008.12.017
Dercon, S., & Sánchez, A. (2013). Height in mid childhood and psychosocial competencies in late childhood: Evidence from four developing countries. *Economics & Human Biology*, *11*(4), 426–432. https://doi.org/10.1016/j.ehb.2013.04.001
Dercon, S., & Singh, A. (2013). From Nutrition to Aspirations and Self-Efficacy: Gender Bias over Time among Children in Four Countries. *World Development*, *45*, 31–50. https://doi.org/10.1016/j.worlddev.2012.12.001
Gee, K. A. (2018). Growing Up With A Food Insecure Adult: The Cognitive Consequences of Recurrent Versus Transitory Food Insecurity Across the Early Elementary Years. *Journal of Family Issues*, 0192513X1875519. https://doi.org/10.1177/0192513X18755199
Gennetian, L. A., Rodrigues, C., Hill, H. D., & Morris, P. A. (2018). Stability of income and school attendance among NYC students of low-income families. *Economics of Education Review*, *63*, 20–30. https://doi.org/10.1016/j.econedurev.2018.01.003
Grineski, S. E., Morales, D. X., Collins, T. W., & Rubio, R. (2018). Transitional Dynamics of Household Food Insecurity Impact Children's Developmental Outcomes. *Journal of Developmental and Behavioral Pediatrics : JDBP*. https://doi.org/10.1097/DBP.0000000000000598

Gundersen, C., & Kreider, B. (2009). Bounding the effects of food insecurity on children's health outcomes. *Journal of Health Economics*, *28*, 971–983. https://doi.org/10.1016/j.jhealeco.2009.06.012

Gundersen, C., & Ribar, D. (2011). Food insecurity and insufficiency at low levels of food expenditures. *Review of Income and Wealth*, *57*(4), 704–726. https://doi.org/10.1111/j.1475-4991.2011.00471.x

Hampel, P., & Petermann, F. (2005). Age and Gender Effects on Coping in Children and Adolescents. *Journal of Youth and Adolescence*, *34*(2), 73–83. https://doi.org/10.1007/s10964-005-3207-9

Hannum, E., Liu, J., & Frongillo, E. A. (2014). Poverty, food insecurity and nutritional deprivation in rural China: Implications for children's literacy achievement. *International Journal of Educational Development*, *34*(1), 90–97. https://doi.org/10.1016/j.ijedudev.2012.07.003

Hanushek, E. A. (2013). Economic growth in developing countries: The role of human capital. https://doi.org/10.1016/j.econedurev.2013.04.005

Headey, D., Hoddinott, J., & Park, S. (2016). Drivers of nutritional change in four South Asian countries: a dynamic observational analysis. *Maternal & Child Nutrition*, *12*(S1), 210–218. https://doi.org/10.1111/mcn.12274

Heckman, J. J., & Mosso, S. (2014). The Economics of Human Development and Social Mobility. *Annual Review of Economics*, *6*(1), 689–733. https://doi.org/10.1146/annurev-economics-080213-040753

Heflin, C. M., Siefert, K., & Williams, D. R. (2005). Food insufficiency and women's mental health: Findings from a 3-year panel of welfare recipients. *Social Science and Medicine*, *61*(9), 1971–1982. https://doi.org/10.1016/j.socscimed.2005.04.014

Howard, L. L. (2011). Does food insecurity at home affect non-cognitive performance at school? A longitudinal analysis of elementary student classroom behavior. *Economics of Education Review*, *30*(1), 157–176. https://doi.org/10.1016/j.econedurev.2010.08.003

Jalongo, M. R., & Sobolak, M. J. (2011). Supporting Young Children's Vocabulary Growth: The Challenges, the Benefits, and Evidence-Based Strategies. *Early Childhood Education Journal*, *38*(6), 421–429. https://doi.org/10.1007/s10643-010-0433-x

Johnson, A. D., & Markowitz, A. J. (2017, March). Associations Between Household Food Insecurity in Early Childhood and Children's Kindergarten Skills. *Child Development*. https://doi.org/10.1111/cdev.12764

Jose, P. E., & Ratcliffe, V. (2004). Stressor frequency and perceived intensity as predictors of internalizing symptoms: Gender and age differences in adolescence. *New Zealand Journal of Psychology*.

Jyoti, D. F., Frongillo, E. A., Jones, S. J., & Al, J. E. T. (2005). Food insecurity affects school children's academic performance, weight gain, and social skills. *The Journal of Nutrition*, *135*(12), 2831–2839. https://doi.org/135/12/2831 [pii]

Kingdon, G. (2007). The progress of school education in India. *Oxford Review of Economic Policy*, *23*(2), 168–195. https://doi.org/10.1093/icb/grm015

Koedel, C., Mihaly, K., & Rockoff, J. E. (2015). Value-added modeling: A review. *Economics of Education Review*, *47*, 180–195. https://doi.org/10.1016/J.ECONEDUREV.2015.01.006

Maluccio, J. A., Hoddinott, J., Behrman, J. R., Martorell, R., Quisumbing, A. R., & Stein, A. D. (2009). The Impact of Improving Nutrition During Early Childhood on Education among Guatemalan Adults. *The Economic Journal*, *119*(537), 734–763. https://doi.org/10.1111/j.1468-0297.2009.02220.x

Ministry of Statistics and Programme Implementation Government of India. (2017). *Youth in india 2017*.

Narayanan, S. (2015). Food security in India: The imperative and its challenges. *Asia and the Pacific Policy Studies*, *2*(1), 197–209. https://doi.org/10.1002/app5.62

Pereira, A. L., Handa, S., & Holmqvist, G. (2017). *Prevalence and Correlates of Food Insecurity among Children across the Globe*.

Perez-Escamilla, R., & Pinheiro de Toledo Vianna, R. (2012). Food insecurity and the behavioral and intellectual development of children: a review of the evidence. *Journal of Applied Research on Children: Informing Policy for Children at Risk*, *3*(1), 9.

Pollitt, E., Cueto, S., & Jacoby, E. R. (1998). Fasting and cognition in well- and undernourished schoolchildren: a review of three experimental studies. *The American Journal of Clinical Nutrition*, *67*(4), 779S–784S.

Reis, M. (2012). Food insecurity and the relationship between household income and children's health and nutrition in Brazil. *Health Economics*, *21*(4), 405–427. https://doi.org/10.1002/hec.1722

Schott, W. B., Crookston, B. T., Lundeen, E. A., Stein, A. D., & Behrman, J. R. (2013). Periods of child growth up to age 8 years in Ethiopia, India, Peru and Vietnam: Key distal household and community factors. *Social Science and Medicine*, *97*, 278–287. https://doi.org/10.1016/j.socscimed.2013.05.016

Sen, A., & Dreze, J. (1999). The Amartya Sen and Jean Drèze Omnibus:(comprising) Poverty and Famines; Hunger and Public Action; and India: Economic Development and Social Opportunity. *OUP Catalogue*.

Sethi, V., Maitra, C., Avula, R., Unisa, S., & Bhalla, S. (2017). Internal validity and reliability of experience-based household food insecurity scales in Indian settings. *Agriculture and Food Security*, *6*(1). https://doi.org/10.1186/s40066-017-0099-3

Singh, A. (2015). Private school effects in urban and rural India: Panel estimates at primary and secondary school ages. *Journal of Development Economics*, *113*, 16–32. https://doi.org/10.1016/j.jdeveco.2014.10.004

Singh, A., Park, A., & Dercon, S. (2014). School Meals as a Safety Net: An evaluation of the Midday Meal Scheme in India. *Economic Development and Cultural Change*, *62*(2), 275–306. https://doi.org/10.1086/674097

Singh, R., & Mukherjee, P. (2016). *Education Trajectories: From Early Childhood to Early Adulthood in India* (Young Lives Policy Report). Oxford.

Singh, R., & Mukherjee, P. (2017). *Comparison of the Effects of Government and Private Preschool Education on the Developmental Outcomes of Children :* (Young Lives Working Paper No. 167). Oxford.

Todd, P. E., & Wolpin, K. I. (2003). On the specification and estimation of the production function for cognitive achievement. *Economic Journal*, *113*(485). https://doi.org/10.1111/1468-0297.00097

Vellakkal, S., Fledderjohann, J., Basu, S., Agrawal, S., Ebrahim, S., Campbell, O., … Stuckler, D. (2015). Food Price Spikes Are Associated with Increased Malnutrition among Children in Andhra Pradesh, India. *The Journal of Nutrition*, *145*(8), 1942–1949. https://doi.org/10.3945/jn.115.211250

World Bank. (2018). *World Development Report 2018: Learning to realize education's promise*. Washington, D.C. https://doi.org/10.1596/978-1-4648-1096-1

Table 1. Coding of household food insecurity trajectory variable by survey round

	Whether Household Food Insecure		
	Round 2 (~Age 5, 2006)	**Round 3** (~Age 8, 2009)	**Round 4** (~Age 12, 2013)
Household never food insecure (=0)	No	No	No
Household food insecure when child aged 5 years and later became food secure (=1)	Yes	No	No
	Yes	Yes	No
Household became food insecure when child aged 8 years (=2)	No	Yes	Yes
Household became food insecure when child aged 12 years (=3)	No	No	Yes
Any other transitory household food insecurity (=4)	No	Yes	No
	Yes	No	Yes
Chronic household food insecurity (=5)	Yes	Yes	Yes

Table 2. Difference in means of intermediate outcomes at 12 years old by household food insecurity trajectories

	% Enrolled	% Enrolled in private school	Height-for-age z-scores	% Parents would like adolescent to finish Grade 12	% adolescents that would like to finish Grade 12	Child self-efficacy z-scores	Child self-esteem z-scores
Household never food insecure	99	55	-1.29	92	93	0.07	0.07
Food insecure when child was aged 5 years	93	17	-1.88	71	76	-0.18	0.12
Became food insecure when child was aged 8 years	96	13	-1.52	72	78	-0.07	-0.19
Became food insecure when child was aged 12 years	97	26	-1.61	80	83	-0.09	-0.12
Any other food insecurity	95	25	-1.55	84	87	-0.05	-0.06
Chronic food insecurity	92	18	-1.94	68	68	0.03	0.03
Overall	97	40	-1.44	86	88	0	0
Probability Pearson Chi Squared	0	0	0.998	0	0	0.001	0.055

Notes: This table presents difference in mean intermediate outcomes by household food insecurity trajectories.

Table 3. Household food insecurity trajectories and adolescent learning achievements, OLS estimates

	(1)	(2)	(3)	(4)
	Vocabulary	**Reading**	**Maths**	**English**
Household food insecure when child was aged 5 years	-0.225**	-0.252**	-0.332**	-0.147
	(0.089)	(0.111)	(0.118)	(0.122)
Household became food insecure when child was aged 8 years	-0.126	0.006	-0.198**	-0.274**
	(0.100)	(0.075)	(0.076)	(0.102)
Household became food insecure when child was aged 12 years	-0.075	-0.108	-0.319***	-0.160**
	(0.100)	(0.091)	(0.069)	(0.064)
Transitory household food insecurity	-0.038	-0.078	-0.133**	-0.157***
	(0.053)	(0.065)	(0.054)	(0.052)
Chronic food insecurity	-0.343*	-0.214	-0.289	-0.406**
	(0.170)	(0.209)	(0.176)	(0.150)
Lagged PPVT score	0.118***	0.131***	0.134***	0.119***
	(0.035)	(0.027)	(0.031)	(0.021)
Lagged CDA score	0.205***	0.199***	0.187***	0.122***
	(0.029)	(0.027)	(0.025)	(0.028)
Constant	-0.011	0.439	0.680	0.023
	(0.850)	(1.003)	(0.774)	(0.763)
Observations	1,773	1,730	1,733	1,739
R-squared	0.179	0.180	0.241	0.272

**** p<0.01, ** p<0.05, * p<0.1*

Notes: Standard errors clustered at the community level in parentheses, community fixed effects. Data from the Indian sample of Young Lives were used for the estimations. All models control for: adolescent age in months, gender, caste, child is first born; caregiver's age and education (in years of completed schooling); household size, number of boys aged 0-12 years (excluding the index adolescent), number of girls aged 0-12 years (excluding the adolescent), number of boys aged 13-17 years (excluding the adolescent), number of girls aged 13-17 years (excluding the adolescent), wealth index, head of the household is female, household is urban; three dichotomous variables for whether the household has changed community between rounds 1 and 2; at round 3 and at round 4.

Table 4. Decomposition of the household food insecurity gaps in adolescent learning by educational investments, health investments, and caregiver and adolescent psychosocial outcomes, OLS estimates

Panel A. Vocabulary				
	Basic model + educational investments[a]	**Basic model + Health investments[b]**	**Basic model + Psychosocial outcomes[c]**	**Basic model + all investments**
Food insecure when child was aged 5 years	-0.185*	-0.213**	-0.187**	-0.164**
	(0.095)	(0.088)	(0.075)	(0.076)
Became food insecure when child was aged 8 years	-0.096	-0.136	-0.067	-0.073
	(0.101)	(0.101)	(0.079)	(0.080)
Became food insecure when child was aged 12 years	-0.060	-0.068	-0.050	-0.041
	(0.100)	(0.100)	(0.105)	(0.105)
Any other food insecurity	-0.012	-0.032	-0.028	-0.012
	(0.055)	(0.053)	(0.046)	(0.048)
Chronic food insecurity	-0.327*	-0.328*	-0.285*	-0.269*
	(0.158)	(0.170)	(0.149)	(0.147)
Currently enrolled	0.664***			0.175
	(0.144)			(0.139)
Private school	0.111**			0.061
	(0.052)			(0.055)
Height-for-age z-score		0.072**		0.066**
		(0.026)		(0.026)
Parent would like child to complete at least Grade 12			0.307***	0.294***
			(0.081)	(0.084)
Child would like to at least graduate from college			0.487***	0.451***
			(0.073)	(0.073)
Self-efficacy			0.046	0.042
			(0.040)	(0.039)
Self-esteem			-0.025	-0.025
			(0.032)	(0.031)
Constant	-0.922	-0.076	-0.862	-1.106
	(0.868)	(0.844)	(0.778)	(0.749)
Observations	1,773	1,767	1,736	1,731
R-squared	0.195	0.184	0.229	0.234

**** p<0.01, ** p<0.05, * p<0.1 Notes: Standard errors clustered at the community level in parentheses, community fixed effects. Data from the Indian sample of Young Lives were used for the estimations. All models control for: adolescent age in months, gender, caste, child is first born; caregiver's age and education (in years of completed schooling); household size, number of boys aged 0-12 years (excluding the index adolescent), number of girls aged 0-12 years (excluding the adolescent), number of boys aged 13-17 years (excluding the adolescent), number of girls aged 13-17 years (excluding the adolescent), wealth index, head of the household is female, household is urban; three dichotomous variables for whether the household has changed community between rounds 1 and 2; at round 3 and at round 4. [a] Child currently enrolled; private school; [b] HAZ at 12 years; [c] Caregiver aspires for adolescent to finish Grade 12; adolescent aspires to finish Grade 12; adolescent self-efficacy and self-esteem; [d] This model includes a+b+c.*

Panel B. Reading				
	Basic model + educational investments[a]	**Basic model + Health investments[b]**	**Basic model + Psychosocial outcomes[c]**	**Basic model + all investments**
Food insecure when child was aged 5 years	-0.206*	-0.241**	-0.181*	-0.162
	(0.114)	(0.109)	(0.094)	(0.096)
Became food insecure when child was aged 8 years	0.022	-0.007	0.073	0.060
	(0.079)	(0.078)	(0.078)	(0.082)
Became food insecure when child was aged 12 years	-0.105	-0.106	-0.093	-0.091
	(0.092)	(0.091)	(0.093)	(0.096)
Any other food insecurity	-0.066	-0.077	-0.068	-0.063
	(0.067)	(0.065)	(0.066)	(0.067)
Chronic food insecurity	-0.210	-0.198	-0.174	-0.160
	(0.197)	(0.207)	(0.187)	(0.188)
Currently enrolled	0.890***			0.207
	(0.203)			(0.212)
Private school	0.058			0.017
	(0.038)			(0.037)
Height-for-age z-score		0.082***		0.076***
		(0.028)		(0.024)
Parent would like child to complete at least Grade 12			0.200***	0.195***
			(0.059)	(0.059)
Child would like to at least graduate from college			0.604***	0.571***
			(0.114)	(0.109)
Self-efficacy			0.143***	0.138***
			(0.030)	(0.031)
Self-esteem			-0.067**	-0.064**
			(0.023)	(0.023)
Constant	-0.710	0.346	-0.551	-0.837
	(1.029)	(1.010)	(0.989)	(1.026)
Observations	1,730	1,725	1,697	1,692
R-squared	0.196	0.188	0.245	0.252

**** p<0.01, ** p<0.05, * p<0.1 Notes: Standard errors clustered at the community level in parentheses, community fixed effects. Data from the Indian sample of Young Lives were used for the estimations. All models control for: adolescent age in months, gender, caste, child is first born; caregiver's age and education (in years of completed schooling); household size, number of boys aged 0-12 years (excluding the index adolescent), number of girls aged 0-12 years (excluding the adolescent), number of boys aged 13-17 years (excluding the adolescent), number of girls aged 13-17 years (excluding the adolescent), wealth index, head of the household is female, household is urban; three dichotomous variables for whether the household has changed community between rounds 1 and 2, at round 3 and at round 4. [a] Child currently enrolled; private school; [b] HAZ at 12 years; [c] Caregiver aspires for adolescent to finish Grade 12; adolescent aspires to finish Grade 12; adolescent self-efficacy and self-esteem; [d] This model includes a+b+c.*

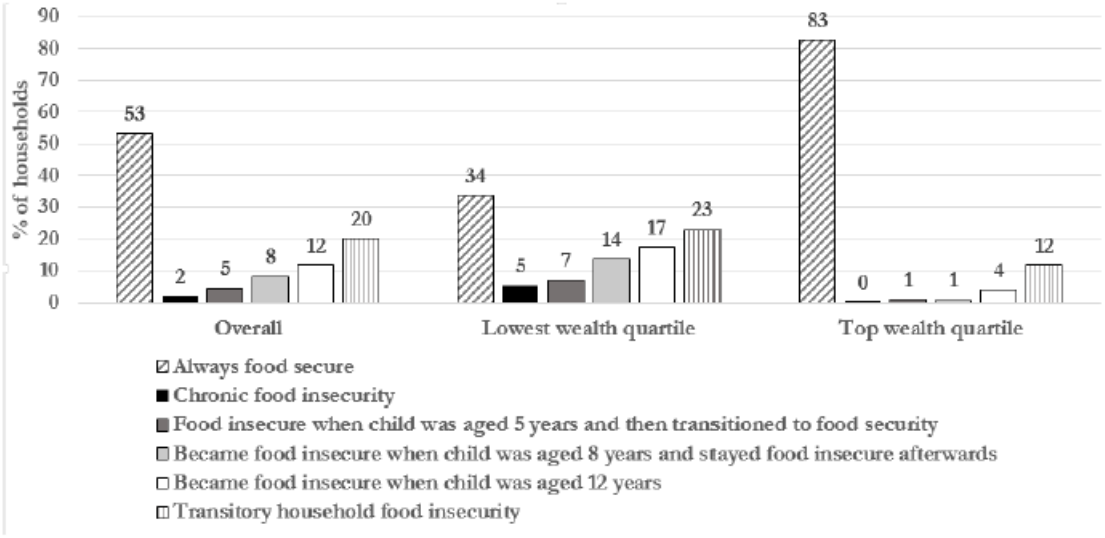
Panel C. Maths				
	Basic model + educational investments[a]	**Basic model + Health investments[b]**	**Basic model + Psychosocial outcomes[c]**	**Basic model + all investments**
Food insecure when child was aged 5 years	-0.267*	-0.316**	-0.272**	-0.221*
	(0.131)	(0.118)	(0.104)	(0.116)
Became food insecure when child was aged 8 years	-0.160*	-0.200**	-0.140*	-0.123
	(0.081)	(0.077)	(0.076)	(0.077)
Became food insecure when child was aged 12 years	-0.287***	-0.305***	-0.297***	-0.273***
	(0.071)	(0.067)	(0.073)	(0.075)
Any other food insecurity	-0.097*	-0.126**	-0.126**	-0.093*
	(0.051)	(0.052)	(0.050)	(0.046)
Chronic food insecurity	-0.268	-0.268	-0.269*	-0.240
	(0.162)	(0.177)	(0.155)	(0.156)
Currently enrolled	0.678***			0.296**
	(0.149)			(0.123)
Private school	0.239***			0.213***
	(0.057)			(0.058)
Height-for-age z-score		0.088***		0.080***
		(0.023)		(0.022)
Parent would like child to complete at least Grade 12			0.235***	0.196***
			(0.060)	(0.054)
Child would like to at least graduate from college			0.431***	0.382***
			(0.060)	(0.056)
Self-efficacy			0.110***	0.110***
			(0.025)	(0.024)
Self-esteem			-0.065**	-0.065**
			(0.025)	(0.025)
Constant	-0.365	0.544	0.014	-0.521
	(0.866)	(0.769)	(0.807)	(0.837)
Observations	1,733	1,727	1,701	1,696
R-squared	0.258	0.247	0.282	0.296

**** p<0.01, ** p<0.05, * p<0.1 Notes: Standard errors clustered at the community level in parentheses, community fixed effects. Data from the Indian sample of Young Lives were used for the estimations. All models control for: adolescent age in months, gender, caste, child is first born; caregiver's age and education (in years of completed schooling); household size, number of boys aged 0-12 years (excluding the index adolescent), number of girls aged 0-12 years (excluding the adolescent), number of boys aged 13-17 years (excluding the adolescent), number of girls aged 13-17 years (excluding the adolescent), wealth index, head of the household is female, household is urban; three dichotomous variables for whether the household has changed community between rounds 1 and 2, at round 3 and at round 4. [a] Child currently enrolled; private school; [b] HAZ at 12 years; [c] Caregiver aspires for adolescent to finish Grade 12; adolescent aspires to finish Grade 12; adolescent self-efficacy and self-esteem; [d] This model includes a+b+c.*

Panel D. English				
	Basic model + educational investments[a]	**Basic model + Health investments[b]**	**Basic model + Psychosocial outcomes[c]**	**Basic model + all investments**
Food insecure when child was aged 5 years	-0.032	-0.123	-0.081	0.017
	(0.121)	(0.118)	(0.123)	(0.117)
Became food insecure when child was aged 8 years	-0.189*	-0.274**	-0.202**	-0.152
	(0.100)	(0.106)	(0.095)	(0.097)
Became food insecure when child was aged 12 years	-0.103	-0.140**	-0.116*	-0.067
	(0.070)	(0.063)	(0.066)	(0.071)
Any other food insecurity	-0.099**	-0.144***	-0.147***	-0.085**
	(0.047)	(0.049)	(0.047)	(0.040)
Chronic food insecurity	-0.373**	-0.379**	-0.369**	-0.327*
	(0.163)	(0.148)	(0.163)	(0.172)
Currently enrolled	0.905***			0.433**
	(0.170)			(0.180)
Private school	0.464***			0.432***
	(0.066)			(0.068)
Height-for-age z-score		0.105***		0.097***
		(0.023)		(0.023)
Parent would like child to complete at least Grade 12			0.313***	0.250***
			(0.062)	(0.062)
Child would like to at least graduate from college			0.491***	0.409***
			(0.124)	(0.112)
Self-efficacy			0.090**	0.093**
			(0.035)	(0.036)
Self-esteem			-0.033	-0.040
			(0.026)	(0.024)
Constant	-1.442*	-0.167	-0.962	-1.810**
	(0.804)	(0.765)	(0.830)	(0.826)
Observations	1,739	1,733	1,706	1,701
R-squared	0.325	0.281	0.322	0.364

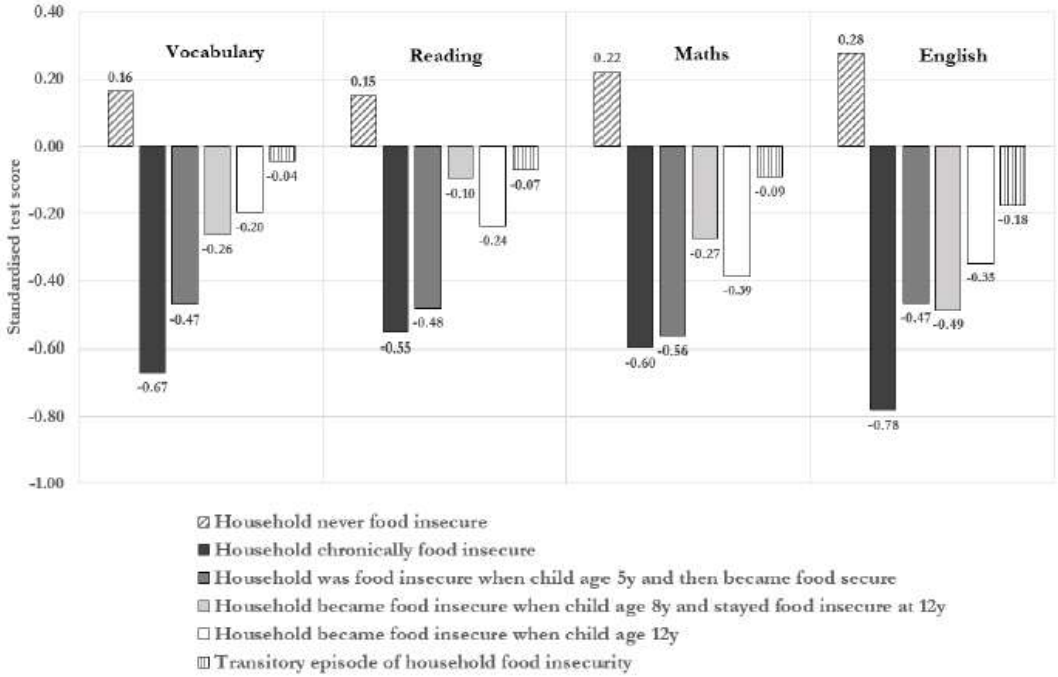
**** p<0.01, ** p<0.05, * p<0.1 Notes: Standard errors clustered at the community level in parentheses, community fixed effects. Data from the Indian sample of Young Lives were used for the estimations. All models control for: adolescent age in months, gender, caste, child is first born; caregiver's age and education (in years of completed schooling); household size, number of boys aged 0-12 years (excluding the index adolescent), number of girls aged 0-12 years (excluding the adolescent), number of boys aged 13-17 years (excluding the adolescent), number of girls aged 13-17 years (excluding the adolescent), wealth index, head of the household is female, household is urban; three dichotomous variables for whether the household has changed community between rounds 1 and 2; at round 3 and at round 4. [a] Child currently enrolled; private school; [b] HAZ at 12 years; [c] Caregiver aspires for adolescent to finish Grade 12; adolescent aspires to finish Grade 12; adolescent self-efficacy and self-esteem; [d] This model includes a+b+c.*

Figure 1. Household food insecurity trajectories between Round 2 (2006, age 5 years) and Round 4 (2013, age 12 years), overall and by wealth quartile in 2013



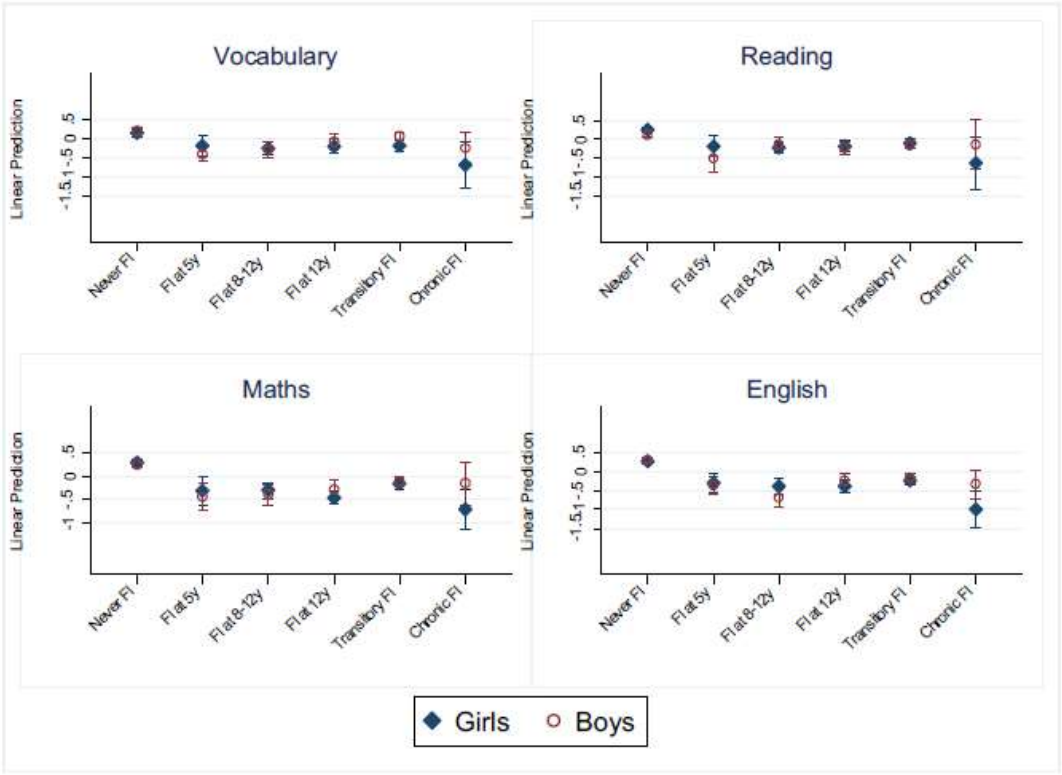
Notes: This figure presents household food insecurity trajectories, for the whole sample and for the lowest and top wealth quartiles

Figure 2. Adolescent learning achievements at 12 years by household food insecurity trajectories



Notes: This figure presents mean standardized test scores at 12 years old in different skills by household food insecurity trajectories. Each test score was standardized to have mean equal to 0 and standard deviation 1.

Figure 3. Predicted values of adolescent learning achievements by household food insecurity trajectories and adolescent gender



Notes: This figure presents predicted values of the interaction of adolescent gender and household food insecurity (FI) trajectories after controlling for child age in months, gender, caste, child is first born; caregiver's age and education (in years of completed schooling); household size, number of boys aged 0-12 years (excluding the index child), number of girls aged 0-12 years (excluding the index child), number of boys aged 13-17 years (excluding the index child), number of girls aged 13-17 years (excluding the index child), wealth index, head of the household is female, household is urban; three dichotomous variables for whether the household has changed community between rounds 1 and 2; at round 3 and at round 4. Each test score was standardized to have mean equal to 0 and standard deviation 1.

In order from left to right, the labels for the food insecurity trajectories stand for: household never food insecure; household was food insecure when adolescent was aged 5 years and then was never food insecure; household became food insecure when adolescent was aged 8 years and then stayed food insecure; household became food insecure at age 12 years; any other transitory episode of food insecurity; chronic food insecurity.