

WORKING PAPER / 2019.03

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In utero seasonal food insecurity and cognitive development: Evidence on gender imbalances from Ethiopia*

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April 23, 2019

Abstract

Food insecurity is pervasive and highly seasonal in Ethiopia. In this study, we investigate the effect of seasonal food insecurity on child development. Exploiting the Young Lives Ethiopia dataset, we study the gender-specific impact of in utero exposure to seasonal food insecurity on cognitive development and the probability of being on the expected grade for children of age 8 up to 12. We find that at age 8 in utero exposure to food insecurity negatively affects cognitive development, only for boys. At age 12, such exposure significantly reduces cognitive development for all children, but with a significantly higher magnitude for boys. The impact is almost three times bigger compared to the one estimated for girls. Corroborated with other outcomes, we explain such gender imbalances by the accumulative nature of the scarring effect rather than the culling effect or gender differences in parental investment.

Keywords: Ethiopia; Food Insecurity; Shocks In Utero; Gender Imbalances; Cognitive Development; Human Capital.

JEL Classification: I15; O13; O15

*We thank Ian Walker, Kalle Hirvonen, Maria Navarro Paniagua and Colin Green for their comments. All errors and opinions expressed remains our own. The data used in this publication come from Young Lives, a 15-year study of the changing nature of childhood poverty in Ethiopia, India, Peru and Vietnam (www.younglives.org.uk). Young Lives is funded by UK aid from the Department for International Development (DFID). The views expressed here are those of the authors. They are not necessarily those of Young Lives, the University of Oxford, DFID or other funders.

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1 Introduction

Early cognitive abilities play an important role in determining long-term schooling and wages (Currie and Thomas, 2001). The development of these skills begins in utero and continues to evolve over the life cycle through a dynamic process of skill formation (Heckman, 2007). Large-scale shocks such as famine, natural disasters, and civil wars experienced during prenatal and early life environment have been found to be strong predictors of future outcomes (Almond and Currie, 2011; Currie and Vogl, 2013). Nonetheless, food shortages are much more frequent and potentially more detrimental on most children’s life cycle. Each year, more people die from hunger than AIDS, malaria and tuberculosis combined (WFP, 2013).

Ethiopia is a case in point. According to FAO (2009), about 44 percent of the total population in Ethiopia were undernourished between 2004 and 2006. This could be attributed to chronic food insecurity, a pervasive phenomenon in the country. A substantial number of people in Ethiopia are facing difficulties in feeding themselves on a regular basis around the rainy and planting seasons. According to the International Food Policy Research Institute and the Ethiopian Development Research Institute, more than 25 percent of households in Tigray region, close to 30 percent of households in Oromia (the most populous region) and 25 percent of households in Southern Nations, Nationalities, and Peoples’(SNNP) region reported food gaps during the rainy season in 2006 (Hoddinott et al., 2011). For Amhara (the second most populous region) the food gap stands at less than 20 percent.¹ In the same year, close to 20 percent and 15 percent of households reported food gaps for 3 months and 4 months, respectively. Such chronic under-nutrition, in particular at early age, is likely to have long-term consequences in terms of health, schooling and socio-economic outcomes (Alderman et al., 2006; Miller, 2017). The positive impact of early childhood nutrition on education has also been established (Glewwe et al., 2001; Maluccio et al., 2009). The impact of prenatal exposure to seasonal food insecurity is largely unknown.

In this study, we examine the impact of in utero exposure to seasonal food insecurity on cognitive development and grade-for-age. We exploit a unique dataset from the Young Lives Ethiopia study and apply a novel identification strategy. We estimate the effect of variation in the number of days of exposure to prenatal food insecurity on cognitive development outcomes, controlling for community and birth month fixed effects together with child and household characteristics. We find that a standard deviation increase in relative food insecurity exposure in utero results in lower maths achievements score at age 12 by about 0.175 standard deviations. Exposure also decreases the odds of being on the correct educational track. More importantly, we shed light on the gender-specific impact of seasonal food insecurity in utero. We find that there are significant gender imbalances. Both at ages 8 and 12, in utero shock decreases boys’ maths score more severely than girls’. At age 12, we find that boys are significantly less likely to be on the right grade for their age.

¹The data may not be representative of the country since the information is obtained from chronically food-insecure woredas (districts).

Our paper directly relates to the emerging literature exploring the effect of prenatal shock on human capital development of children (Neelsen and Stratmann, 2011; Almond et al., 2015). The so called ‘foetal origins’ hypothesis advocated by Barker describes that conditions in utero (for instance, nutritional deficiencies) have long lasting health effects (Barker, 1990; Almond and Currie, 2011). Prenatal nutrition shocks should also have significant detrimental effects on brain development (Almond and Mazumder, 2011; Almond et al., 2015; Umana-Aponte, 2011). To establish causal effects, studies exploit famines and other shocks like natural disasters, wars, and disease epidemics as exogenous natural experiments. Almond and Currie (2011) and Currie and Vogl (2013) provide extensive review of the literature.² More directly related to the context of our study, there is a large number of studies investigating the impact of seasonality, price shocks and weather shocks on households’ vulnerability and child development in Ethiopia (Dercon, 2004; Dercon and Krishnan, 2000; Alem and Söderbom, 2012; Porter, 2012; Dercon and Porter, 2014; Hill and Porter, 2017; Abay and Hirvonen, 2017; Miller, 2017). However, this literature has not considered the individual exposure to shock in utero, except for Dercon and Porter (2014) and Miller (2017). Dercon and Porter (2014) find detrimental impact of the 1984/85 Ethiopian famine on height of young adults. However, no effect is found from exposure in utero. On the contrary, Miller (2017) finds significant effects of seasonal food scarcity in utero on height at ages 8 and 12, but no significant difference between boys and girls. Our paper extends Miller (2017)’s work by exploring the impact of seasonal food insecurity on cognitive development and by investigating possible gender imbalances in such an impact.³

Boys have been found to be more vulnerable to shocks in utero such as famine (Almond et al., 2010; Roseboom et al., 2011; Hernández-Julián et al., 2014), conflict (Valente, 2015; Dagnelie et al., 2018), alcohol consumption (Nilsson, 2017) or a parental grief (Black et al., 2016).⁴ However, the nature of gender imbalances in the effect of in utero and early life shocks on different health and socio-economic outcomes differs across existing studies. While the Great Chinese Famine has been found to be more detrimental for girls in terms of health and education (Luo et al., 2006; Mu and Zhang, 2011), stronger effects on boys have been found from famines during World War II in Greece, Germany and the Netherlands (Berg et al., 2016) and during the Dutch Potato Famine in the mid-nineteenth century (Lindeboom et al., 2010). Nilsson (2017) also finds stronger effects of in utero exposure to increased alcohol availability on long-term labour market and educational outcomes; and cognitive and non-cognitive ability of boys. The differences in the results are

²The literature on the long-term effect of in utero shocks has relied on rare and extreme events such as famine, war, terrorist attacks. In addition to the likely fiercer selection in utero, it has been difficult to distinguish the nutritional impact of shocks from the psychological stress associated with the shock (Currie and Vogl, 2013). We are not able to distinguish between these insults but in our case, similar to Miller (2017) and Nilsson (2017), we are more likely to directly capture the nutritional impact of shocks.

³Since childhood height is correlated with later cognitive development outcomes (Case and Paxson, 2008), our choice of outcomes (maths score and grade-for-age) also complement the analysis in Miller (2017).

⁴The vulnerability of boys in utero is consistent with the medical literature (Shettles, 1961; Mizuno, 2000; Kraemer, 2000; Eriksson et al., 2010; Catalano et al., 2006).

puzzling. The use of different outcome variables and contextual differences may be behind the mixed nature of the evidence but the impact of in utero shocks on outcomes later in life may result from different mechanisms (Valente, 2015; Nilsson, 2017; Dagnelie et al., 2018). The scarring effects result from a downward shift of the entire foetal health distribution. Since male foetuses disproportionately stand at the low end of that distribution, deficiencies due to the scarring effects may accumulate overtime and explain more detrimental effects for boys later in life. On the contrary, the culling effect directly relates to selective mortality in utero. If selection in utero is significant, surviving male children would be stronger since in utero shocks have more detrimental effects on boys than girls. As a result, we may find small, or no, effects on boys. Selection effects are likely to be particularly severe for large-scale shocks such as famines and civil wars (Neelsen and Stratmann, 2011; Gørgens et al., 2012). In the case of relatively mild shocks in food insecurity, we expect the culling effect (selection in utero) to be less of a concern. Results presented in Section 4.1 confirm that prior. Finally, interpreting the impact of shocks in utero on later outcomes requires to consider possible compensating (or exacerbating) investments made by parents in children in response to health endowments after birth (Almond and Mazumder, 2013; Adhvaryu and Nyshadham, 2016). For instance, Ayalew (2005) finds evidence of compensating health investment in Ethiopia. However, the same author shows evidence of reinforcing investment in terms of education. In our study, we confirm Miller (2017) in finding little evidence of subsequent investment responses by parents. Therefore, our results tend to support the existence of scarring effects that accumulate overtime and dominate possible selection effects or compensating mechanisms.

2 Data and Identification Strategy

We exploit data from the Young Lives Ethiopia (YLE) surveys. YLE is part of the Young Lives Project, an international study of childhood poverty tracking 12,000 children in four countries (Ethiopia, Peru, Vietnam, and India) over a 15-year period. The Ethiopian data originate from 20 sites located in four regions of the country and Addis Ababa, in which more than 96 percent of the Ethiopian children live. These regions include: Amhara, Oromia, Tigray, and the Southern Nations, Nationalities, and Peoples' Region (SNNPR) (Figure A.1 in Appendix A). To choose the 20 sites of the study in each country, a sentinel site sampling approach was applied (Barnett et al., 2013). In Ethiopia the purposive sampling process follows the following three principles: (1) oversampling of food deficit districts; (2) the profile of the selected districts/sites should reflect the diversity of the country; and (3) the possibility of tracking children in the future at a reasonable cost. The sites in Ethiopia are selected in such a way that: first, four regional states (Amhara, Oromia, SNNPR, Tigray), and one city administration (Addis Ababa) were chosen; second, up to five woredas (districts) were selected from each region (this accounts for 20 districts in total); third, from each woreda at least one kebele (local administrative area) was selected. The selected community may be a sentinel site itself or could be

combined with neighbouring communities to create a site. Finally, 100 households with children born in 2001-2002 that constitute the younger cohort and 50 households with a child born in 1994-1995 that make up the older cohort were randomly chosen from each site.⁵ The YLE survey contains information on children’s health, education, schooling, time-use, feelings and attitudes, and cognitive tests. Household information includes family background, education, consumption, social networks, livelihoods and wealth indicators. In this study, we exploit information about the so-called young cohort. The young cohort for Ethiopia comprises 1,999 children born between 2001 and 2002 in the 20 sites across the country. In the baseline survey of 2002, these children were aged between 6 and 18 months old.⁶ These children were then surveyed again in 2006, 2009 and 2013 (Figure A.2 in Appendix A).⁷ We focus on 24 out of 26 communities, since two communities lack the food security information needed for our analysis.

We seek to identify the causal impact of in utero exposure to food insecurity on cognitive development and educational progression using the following ordinary least-square specification.⁸ To shed light on the gender imbalances in the effect of the food insecurity shock, we estimate equation (1) separately for boys and girls.

$$Y_{idc} = \alpha_c + \theta_m + \beta \text{Exposure}_{dc} + X_{idc} + \varepsilon_{idc}, \quad (1)$$

where Y_{idc} is the outcome variable designated by various cognitive development measures for individual i , born on date d , in community c . Exposure_{dc} is the number of days of exposure to seasonal food insecurity in utero, based on each child’s date of birth.⁹ In the analysis, similar to Miller (2017), we standardize the treatment variable to have a mean of zero and a standard deviation of one within each community to reduce the influence of communities with more severe periods of food insecurity.¹⁰ X_{idc} denote the household and child characteristics. We also introduce community and month of birth fixed effects, α_c and θ_m , to deal with

⁵See <http://www.younglives.org.uk/content/sampling-and-attribution> for details.

⁶The survey also collects similar information for the older cohort, born around 1994-1995. These children were 7-8 years old during the first round survey in 2002. We do not have birth information such as prematurity for this cohort that are essential for computing our exposure variables. Thus, this cohort cannot be exploited for our main analysis. We will nonetheless use the information about this cohort to assess the relationship between cognitive development and long-term education outcomes to shed light on the long-run significance of our results.

⁷Our main outcome variables are measured in round 3 and round 4 of the YLE surveys. It is important to note that round 3 surveys were implemented between November and February of 2009/10 and round 4 surveys were implemented between November and February of 2013/14. As discussed below, these months are relatively food secure months as they correspond to the post harvest period.

⁸For binary outcomes, logistic regressions are used instead.

⁹Similar to Miller (2017), date of birth for each child is calculated using age of child in days and the date of interview from the first survey round.

¹⁰In Appendix D.2, we discuss the importance of standardization within communities, together with other functional assumptions (e.g. linearity). Moreover, we show the robustness of our results to using non-standardized treatment variable.

omitted factors at the community level that would threaten the causal interpretation of our results. Our coefficient of interest, β captures the average effect of a standard deviation change (within a community) in exposure to in utero seasonal food insecurity on maths score and on grade-for-age outcomes. Standard errors are clustered at the community level to deal with correlation within location of residence. Given the low number of communities (24) which might underestimate intra-group correlation, we also show the robustness of our results to the use of wild bootstrapping method (Cameron et al., 2008; Cameron and Miller, 2015). We report both the robust standard errors clustered at the community level and the wild bootstrap p-values for our main results.

Our specification deals with several identification concerns. Community fixed effects deal with the threat of systematic differences across communities. For instance, food security is known to vary significantly across communities, mainly due to diverse agro-ecological zones and differences in terms of access to infrastructure. Stifel and Minten (2017) indeed find that households in Ethiopia living in remote areas are systematically more likely to be food insecure. Cognitive developments are also likely to differ across communities. We therefore not only control for household and child characteristics, X_{idc} , but also for community fixed effects, α_c . Another issue relates to the confounding role of seasonality. The season of birth has indeed been found to be a strong predictor of health during childhood and later life outcomes (McEniry and Palloni, 2010; Lokshin and Radyakin, 2012; Buckles and Hungerman, 2013). Similarly, experiencing Ramadan fasting during pregnancy has been found to impact short-term and long-term health (Almond and Mazumder, 2011; Van Ewijk, 2011) and education outcomes (Almond et al., 2015; Majid, 2015). To deal with national seasonality effects that are unrelated to food insecurity (e.g. Ramadan, national policies), we introduce month of birth fixed effects, denoted θ_m . In Section 4 and Appendix D.4, we will discuss further threats to identification, namely the threats inherent to mortality selection, endogenous parental responses, fertility selection, reporting errors, exposure to seasonal food security after birth, the existence of other mechanisms, attrition and missing data issues and after birth exposure.

We now discuss the variables in turn. The dependent variables, designated by Y_{idc} , are maths achievement scores used to measure children’s quantitative skills, and a measure of grade-for-age.¹¹ We define grade-for-age as a binary variable that takes 1 if a child is in the correct grade for his or her age. The YLE survey

¹¹We also report results from other cognitive development measures collected by the YLE study: the Early Grade Reading Assessment (EGRA) and the Peabody Picture Vocabulary Test (PPVT). The Early Grade Reading Assessment (EGRA) is orally assessed only at age 8. It is implemented to measure the most basic skills for literacy acquisition in the early grades. It involves recognising letters of the alphabet, reading simple words, understanding sentences and paragraphs, and listening with comprehension. The Peabody Picture Vocabulary Test is a widely used test of receptive vocabulary. The descriptive statistics of these variables are presented in Panel A of Table D.1. These tests are adapted to different languages spoken in the country. Difficulty levels may have changed during translation, and as a result, it is recommended that comparison must be within languages (Cueto and Leon, 2012; Singh, 2015). We cannot limit our data to a certain language in the country since the geographical concentration of languages in Ethiopia would cancel out the variation in the exposure variable. As a result, we are cautious about interpreting results from these two tests.

only contains completed grade. We need current grade to indicate whether the child is on one’s educational expected track. We calculate the current grade level using the information on whether the child is currently enrolled and data on completed grade. Specifically, current grade is equal to completed grade plus 1 if the child is enrolled.

Panel A in Table 1 shows the descriptive statistics of our outcome variables: maths score and grade-for-age. As indicated in column (10) the mean values for boys and girls are not statistically different from each other. These descriptive statistics only reveal general patterns in our outcomes and nothing about the role of food insecurity exposure in utero. In our regression analysis, we use the maths standardized within a sample to have a mean of 0 and a standard deviation of 1. Maths achievement tests and grade-for-age have been widely used to measure cognitive development and educational progression (Almond et al., 2015; Shah and Steinberg, 2017).

To understand the response of parents towards children and whether it is related with exposure to the shock, we employ several parental investment outcomes. These include an indicator to school enrolment, the number of study hours at home (including extra tuition), and an indicator to whether a child is enrolled into a private or a public school, an indicator if parents paid for school fees or tuition (last 12 months), an indicator if parents paid any medical expenditure (last 12 months), the number of meals a child had in the last 24 hours, and the total number of food variety a child experienced in the last 24 hours.¹² Panel D in Table D.1 reports the descriptive statistics of these variables.

Table 1: Descriptive statistics

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Full sample			Boys			Girls			Mean diff(Boys-Girls)
	Mean	Std. Dev.	N	Mean	Std. Dev.	N	Mean	Std. Dev.	N	P-values
Panel A: Outcome variables										
Maths score, restricted sample										
Maths Age 8	7.153	5.421	1461	7.253	5.493	768	7.043	5.342	693	0.461
Maths Age 12	10.615	6.032	1461	10.551	6.002	768	10.685	6.069	693	0.670
Maths score, unrestricted sample										
Maths Age 8	6.525	5.368	1695	6.670	5.448	878	6.370	5.280	817	0.250
Maths Age 12	10.503	6.053	1508	10.428	6.030	796	10.587	6.080	712	0.611
Grade-for-age										
Grade-for-age Age 8	0.606	0.489	1768	0.601	0.490	920	0.612	0.488	848	0.638
Grade-for-age Age 12	0.410	0.492	1757	0.393	0.489	916	0.428	0.495	841	0.135
Panel B: Exposure variable										
Exposure, 9 months	111.050	49.696	1875	111.385	48.895	970	110.691	50.564	905	0.762

Source: Authors’ computation from Young Lives Data. For maths outcome, in the restricted sample, we restrict the sample to children for whom the outcomes of interest are observed all rounds (ages).

Our main variable of interest, $Exposure_{dc}$ seeks to capture seasonal food insecurity in utero, by exploiting

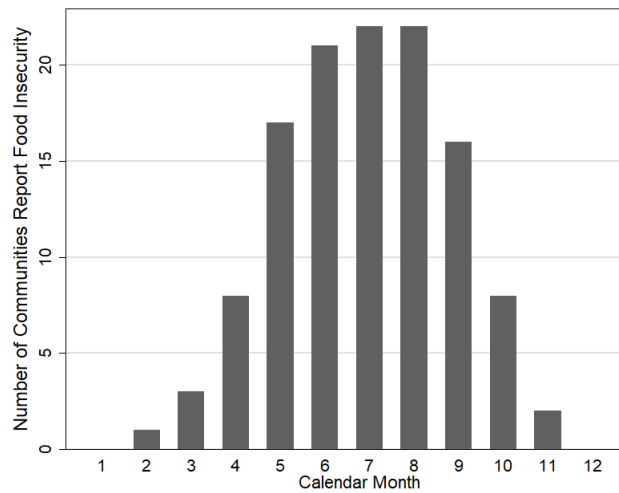
¹² Parents/children were asked 7 yes/no questions related to meal frequency for a child. Specifically, they were asked if the child ate any food before breakfast, breakfast, food between breakfast and midday meal, midday meal, food between midday meal and evening meal, evening meal, and food after the evening meal. We computed meal frequency for each round (age) as the sum of these frequencies. We top coded at six meals. Moreover, parents/children were asked whether the child ate different types of foods in the last 24 hours. They were asked 17 (at age 8) and 15 (at age 12) yes/no questions. We computed food variety variables for each round (age) as the sum of these frequencies. We top coded at 10 food types.

both food security information at the community level and variations at the individual level based on the date of birth. At the community level, food insecure months are identified in the YLE community surveys, where the community leaders are asked in which months of the year food becomes harder or more expensive to obtain. The alternative is to use weather shocks as a proxy for food insecurity. However, it has been established that early life weather shocks affect long-term outcomes through many channels such as maternal stress, nutritional changes, and infectious diseases (Aguilar and Vicarelli, 2011; Thai and Falaris, 2014; Rosales-Rueda, 2018; Shah and Steinberg, 2017; Rocha and Soares, 2015). Using community level reported seasonal food insecurity data instead of rainfall variability, for instance, has nonetheless an advantage of estimating the direct effect of hunger on cognitive development. One disadvantage of reported food insecurity data may be the risk of systematic reporting bias. However, the fact that we are using data collected at community level from community representatives (not at household or individual level) makes the reporting bias minimal. The food insecurity information requested from community leaders was not a measure of food insecurity experienced at personal level that can be subject to erroneous and biased reporting. In addition, community leaders were asked about months that food becomes expensive and scarce in their respective community. Since this is a recurrent occurrence, we believe community representatives would be accurate in their reporting. We use information on community-level food insecurity from the community survey that was conducted in the second round (2006). The same information was also collected in the first round (2002). However, the pattern does not correspond to the conventionally observed seasonality in Ethiopia.¹³ In particular, the 2002 survey on food insecurity reports higher average relative food insecurity from October to January. But, this period coincides with post harvest in Ethiopia, and is thus characterised by relatively higher availability of food and lower prices. Thus, the information must have been reported and documented with errors. On the contrary, the food insecurity information reported in 2006 corresponds with the reality in Ethiopia. This is further corroborated by monthly food price data. Figure 1 depicts that relative food insecurity is reported from May to September. Figures C.1 and C.2 in Appendix C also show that food prices both in rural and urban parts of the country are higher from May to September. This is also further confirmed by specific grain prices during 2001-2002 (see, Figures C.3; C.4; C.5, C.6 in Appendix C)

As indicated in Figure 1, food insecurity is more likely to be reported during the rainy and planting periods of the main harvesting season. The harvesting season vary across agro-ecological zones but the main harvesting season would usually fall from October to December. In each month from June to August, more than 20 of the surveyed communities report relative food insecurity. More than 15 of them also report relative food insecurity in May or September. The rest of the year is largely food secure. The seasonal pattern of food insecurity should not come as a surprise. In rural Ethiopia where subsistence agriculture is the prominent form of livelihood, households experience severe food shortages during the rainy/ planting season. Post

¹³Using food insecurity information from 2002 community survey confirms our results but with much lower magnitude. Results are discussed in Appendix D.2.

FIGURE 1. Reported Seasonal Food Insecurity by Calendar Month



Source: Authors' calculations using data from Young Lives Study, Ethiopia

harvest, farmers have usually enough food with a high level of supply associated with relatively low prices (Figures C.1 and C.2 in Appendix C). That is why we observe less food insecurity following harvests (from November to April). But when the rainy and planting seasons come, food availability decreases and pushes market prices upward, threatening food security. More than 60 percent communities report food insecurity for 4 to 5 months in a similar range to Hoddinott et al. (2011) (Figure B.1 in Appendix B).

The community-level measurement of food insecurity is then used to determine how much a child is exposed to food insecurity in utero.¹⁴ Similar to Miller (2017), we compute the number of days a child has faced a food insecure environment while he/she was in utero. One lives in utero for approximately 38 weeks or 266 days starting from conception. Premature births may be an issue here. 8.7 percent of the children in our sample are indeed born before the end of the term. We have data on the number of weeks of prematurity for only 73 percent of pre-term babies. For the remaining 27 percent, we substitute the missing observations by the median weeks of prematurity, 2 weeks. Thus, for premature babies, the number of days of exposure are calculated after adjustment is made for the reported number of weeks of prematurity. Miller (2017) adopts the same correction. As a result, our measure of food insecurity exposure in full 9 months is calculated as the number of days a child is facing food insecurity in utero from conception to birth in those 266 days of prenatal experience. The calculation of our prenatal food insecurity exposure is described in Table 2. Assume for example, a child is conceived in a particular community on 26 May 2001. In theory the child will be born on 16 February 2002. In this community, food is relatively unavailable in May, June, July, August and September. The child born in that community will be exposed to prenatal food insecurity for 4 months (June, July, August and September) and 6 days (from May), resulting in 126 days of prenatal food

¹⁴We describe the reliability of the community-level food insecurity information in the construction of our in utero exposure in Appendix C.

insecurity exposure. Panel B shows a child born in another community on 11 January 2002. This child will be exposed to 3 months (June, July, August) of prenatal food insecurity, resulting in 91 days of exposure.

Table 2: Calculating the number of days a child exposed to prenatal seasonal food shortage

Panel A, Community X										
Date	Conceived on 26 May 2001									Born on 16 Feb 2002
Month	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Food insecurity	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No
Panel B, Community Y										
Date	Conceived on 10 Apr 2001									Born on 11 Jan 2002
Month	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
Food insecurity	No	No	Yes	Yes	Yes	No	No	No	No	No

Panel B in Table 1 reports the means, standard deviations, minimums and maximums of exposure in full 9 months. On average, a child has experienced 111 days (3.70 months) of food insecurity out of 266 days. Figure B.2 in Appendix B also provides the histogram of the exposure measure in full 9 months of gestation. Panel B of Table 1 also shows that both boys and girls are equally affected by food insecurity in utero.

3 Results

Table 3 presents the estimated effects of in utero exposure to food insecurity on maths score and the probability of being on the correct educational track at ages 8 and 12. For each outcome, the first panel presents the results without household controls, while the second panel introduces such control variables. Columns (1) and (2) provide estimates from regressions pooling boys and girls together, while the following columns contrast the results between boys (columns 3-4) and girls (columns 5-6). Column (1) in Panels A and B indicates a non-significant effect of exposure on maths score at age 8. However, columns (3) and (5) show there is a significant difference between boys and girls. At age 8, while the coefficients remain non-significant for girls, maths scores for boys are between 0.09 and 0.12 standard deviation lower as a result of one standard deviation change in the exposure to food insecurity (column 3). The detrimental effects of in utero exposure seem to accumulate with age to the point where in utero exposure to food insecurity has a significant and detrimental impact on cognitive development at age 12 for both sexes.¹⁵ This is consistent with the idea highlighted by Heckman and Masterov (2007): disadvantages just like advantages accumulate overtime. Gender imbalances are further confirmed. At age 12, the decrease in maths score for boys by almost one third of a standard deviation (0.27-0.29, in column (4)) is significantly different from the decrease in girl’s score (about 0.1 standard deviation, in column (6)). Gender imbalances are also apparent with the other outcome. At

¹⁵We also investigate the impact by trimester, finding stronger effects for boys in the first and second trimesters. For the sake of presentation, we only discuss these results in Appendix D based on Table D.7.

age 12, a standardised deviation increase in food insecurity in utero also decreases the odds of being on the correct grade for one's age, but only for boys. The gender imbalances in the effects of in utero exposure echo recent findings by [Nilsson \(2017\)](#) of higher vulnerability of male foetuses to alcohol consumption in utero.¹⁶

¹⁶Detailed results of Table 3 including control variables are provided in Tables D.2 and D.3 of [Appendix D](#). [Appendix D](#) provides and discusses additional robustness checks. Gender imbalances in the effect of exposure on other tests are also apparent in Table D.4. Exposure decreases reading at age 8, significantly more for boys. Though we find no significant effect on PPVT, exposure has unexpected and positive effect on girl's PPVT score at age 12. We do not, however, interpret further results from these two outcomes given the lack of accuracy of the cognitive tests in Ethiopia (see footnote 11). Although efficiency might be affected in some cases, our results are largely robust to not standardizing the measure of exposure to food insecurity in utero (more subject to high-leverage communities, see Table D.8), to using round 1 food insecurity information (similar to [Miller \(2017\)](#)) to capture seasonal food insecurity at the community level (Table D.10), to non-linear effects in exposure (Table D.11), to relaxing the restriction of including only children for which we observe the outcomes of interest at all age (round) stages in the samples of regressions using the maths score as a dependent variable (Table D.12). These results are further discussed in [Appendix D](#).

Table 3: Estimated effect of in utero food insecurity exposure, (full pregnancy)

	(1)	(2)	(3)	(4)	(5)	(6)
	Full sample		Boys		Girls	
	Age 8	Age 12	Age 8	Age 12	Age 8	Age 12
Panel A: Maths without HH controls						
Exposure-Std	-0.016 (0.027) [0.606]	-0.169*** (0.035) [0.002]	-0.120** (0.056) [0.082]	-0.290*** (0.067) [0.002]	0.071 (0.047) [0.100]	-0.090* (0.052) [0.082]
P-value Boys=Girls (Age 8)					0.034	
P-value Boys=Girls (Age 12)					0.038	
Observations	1,461	1,461	768	768	693	693
Panel B: Maths with HH controls						
Exposure-Std	-0.017 (0.023) [0.504]	-0.175*** (0.039) [0.002]	-0.093* (0.053) [0.092]	-0.268*** (0.066) [0.004]	0.055 (0.045) [0.18]	-0.111* (0.059) [0.05]
P-value Boys=Girls (Age 8)					0.086	
P-value Boys=Girls (Age 12)					0.089	
Observations	1,441	1,441	755	755	686	686
Panel C: Grade-for-age(odds ratio) without HH controls						
Exposure-Std	0.977 (0.113)	0.804** (0.086)	0.934 (0.103)	0.713** (0.119)	1.029 (0.152)	0.860 (0.166)
Observations	1,768	1,757	909	916	844	841
Panel D: Grade-for-age(odds ratio) with HH controls						
Exposure-Std	0.945 (0.102)	0.781** (0.086)	0.920 (0.100)	0.701* (0.128)	0.982 (0.147)	0.817 (0.170)
Observations	1,745	1,734	895	901	836	833
Community FE	Yes	Yes	Yes	Yes	Yes	Yes
Birth Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors (clustered at the community level) in parentheses. Wild bootstrap p-values in brackets. The asterisks next to the coefficients are for p-values associated with our main (non-wild bootstrap) regressions. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The dependent variables are standardized maths score, reading score and grade-for-age at age 8 and 12. The variable of interest captures prenatal exposure to seasonal food insecurity (full 9 months exposure) standardized to have mean 0 and standard deviation 1 with in each community. Ind. controls include : age of child in months, number of older siblings, and dummies for gender, child ethnicity, prematurity. HH Controls include household wealth index, and dummies for gender of household head, and mother's education. For maths outcome, we restrict the sample to children for which we observe the outcomes of interest at all age (round) stages. Note that the odds ratio are interpreted as follows: if the odds are greater than one, they indicate positive effects; but if the odds are less than one, they are interpreted as negative effects.

4 Discussion

Three broad classes of factors may drive our results on the gender imbalances in seasonal food insecurity in utero. First, gender imbalances may be explained by the fact male foetuses are more vulnerable than girls in utero. Deficiencies in human capital development, the so-called scarring effects, may accumulate overtime. Second, the higher vulnerability of boys in utero may result in higher selective mortality in utero, the so-called culling effect and the survival of the stronger boys at and after births. Such alternative explanation would

bias the coefficient of interest downward. Third, gender discrimination is usually expected against girls in such a context. Compensating mechanisms would therefore have mitigated the gender imbalances found in the previous section.¹⁷

4.1 Mortality selection

Our sample only includes surviving children. Although our prenatal shock is of relatively mild (and frequent) nature, we cannot exclude that mortality in utero would drive our estimates towards zero. Surviving children may indeed appear to be the strongest, the healthiest, and those with better genes. Similarly, the gender-based analysis could be biased due to differentiated mortality risk for boys and girls. The medical research indeed documents that male foetuses are more vulnerable to shocks and at greater mortality risk than female foetuses (Shettles, 1961; Mizuno, 2000; Kraemer, 2000; Catalano et al., 2006; Eriksson et al., 2010). Empirical studies also document how negative prenatal exposure could alter sex composition at birth (Almond et al., 2010; Van Ewijk, 2011; Almond and Mazumder, 2011; Valente, 2015; Nilsson, 2017; Dagnelie et al., 2018).

We cannot directly test the effect of the shock on prenatal death differential between boys and girls. We do not have information about miscarriages and prenatal deaths. However, following Van Ewijk (2011), we test the role of selection by estimating the exposure effect on the probability of being a male at ages 1, 5, 8, and 12. We do not find strong evidence for mortality selection. Food insecurity shocks in utero do not seem to translate into changes in the sex ratio (Table 4). Only at age 5, we find a positive coefficient significantly different from zero at 90 percent level of confidence. Such coefficient cannot explain the stronger detrimental impact for boys compared to girls at ages 8 and 12. So, the causal interpretation of our main results is not threatened by mortality selection in utero or after birth. Gender imbalances in cognitive development cannot be explained by selective mortality.

4.2 Parental Responses vs Biological Effects

Parents may respond to in utero shocks by adapting their investment towards children either to compensate or reinforce children's endowments. If investment responses are compensatory, the effect of prenatal food insecurity shock will tend to understate biological effects. However, parents may also decide to reinforce children's endowment. In that case our baseline results may overestimate the true biological effect. Recent empirical studies reviewed in Almond and Mazumder (2013) indeed find that parental investments reinforce

¹⁷Those mechanisms can equally be seen as threats to the general identification but help us to understand the gender imbalances. Other identification threats, with no obvious gender bias, may affect the magnitude of our coefficients. In Appendix D, we therefore also examine how our results may be threatened by (1) fertility selection; (2) reporting errors; (3) the existence of other mechanisms; (4) attrition and missing data; and (5) exposure to seasonal food insecurity after birth. Some of these identification threats are also tested on gender-stratified samples to assess their possible consequences on the consistency of our results on the gender imbalances of seasonal food security in utero.

Table 4: Effect of exposure on the probability of the child surveyed is male

	Logit odds ratio			
	(1)	(2)	(3)	(4)
	Age 1	Age 5	Age 8	Age 12
Child surveyed is male, without controls				
Exposure-Std	1.108 (0.074)	1.112 (0.076)	1.108 (0.079)	1.105 (0.078)
Observations	1,875	1,793	1,768	1,754
Child surveyed is male, with controls				
Exposure-Std	1.094 (0.065)	1.109* (0.070)	1.106 (0.071)	1.098 (0.071)
Observations	1,846	1,770	1,745	1,731
Community FE	Yes	Yes	Yes	Yes
Birth Month FE	Yes	Yes	Yes	Yes

Robust standard errors (clustered at the community level) in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The dependent variable is dummy indicating child born is boy. The main independent variable is standardized prenatal exposure to seasonal food insecurity (exposure in whole nine months). Note that the odds ratio are interpreted as follows: if the odds are greater than one, they indicate positive effects; but if the odds are less than one, they are interpreted as negative effects.

initial endowment differences. In our case, that would mean that parents discriminate against boys more vulnerable in utero. That would be quite surprising given the abundant report on gender discrimination against girls in Ethiopia (Ayalew, 2005). On the contrary, compensatory investments would attenuate the established gender imbalances in the previous section.

Following Adhvaryu and Nyshadham (2016) and using the YLE survey, we assess whether the behavioural response from parents is driven by food insecurity shock in utero. Specifically, we test the effect of the shock on parental investments at ages 8 and 12 to investigate parental response once the cognitive endowment is realized.¹⁸ In Table 5, we explore the role of parental investments which are directly related to education that happened at age 8 and 12.¹⁹ Overall, with other outcomes, we confirm the conclusions by Miller (2017) that there is limited role for parental investment. One exception is the fact the shock decreases the odds of being enrolled in school for girls at age 12. Under-investment in girls' education at age 12 would tend to attenuate the gender imbalances against boys found earlier. Such under-investment is not confirmed using the time available for study at home or the probability to be sent to a private school or expenditures on school fees or tuition (educational expenditures).

Table 6 reports results from parental health and nutritional investments such as: medical expenditures;

¹⁸We focus on investment carried out at ages 8 and 12. On the one hand, parents at this stage can observe the realized cognition of their children to decide to reinforce or compensate it. On the other hand, it helps us understand whether differential investment at ages 8 and 12 could explain the difference in the observed effect of the shock on cognition between ages 8 and 12.

¹⁹Nonetheless, in Table D.5, we also report results on investment on preschool, an educational investment that happened on or before age 5. We find no significant effect of exposure on preschool investment.

Table 5: Childhood parental educational investments

	Full sample		Boys		Girls	
	(1) Age 8	(2) Age 12	(3) Age 8	(4) Age 12	(5) Age 8	(6) Age 12
Panel A: Enrolled in to school						
Exposure-Std	0.892* (0.061)	0.652 (0.188)	0.836 (0.150)	0.726 (0.364)	1.015 (0.093)	0.359** (0.184)
Observations	1,629	1,398	749	666	742	437
Panel B: Study hour at home(including extra tuition)						
Exposure-Std	-0.005 (0.025)	0.043 (0.031)	-0.003 (0.043)	0.034 (0.043)	-0.005 (0.036)	0.052 (0.052)
Observations	1,744	1,732	904	900	840	832
Panel C: In private school						
Exposure-Std	1.192 (0.278)	0.940 (0.166)	1.144 (0.356)	0.996 (0.264)	1.277 (0.653)	0.945 (0.260)
Observations	757	851	269	353	323	308
Panel D: Education expenditures (school fees or tuition)						
Exposure-Std	0.868 (0.101)	1.035 (0.126)	1.072 (0.222)	0.836 (0.117)	0.787 (0.129)	1.247 (0.225)
Observations	1,555	1,631	782	825	724	723
Community FE	Yes	Yes	Yes	Yes	Yes	Yes
Birth Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes

For binary outcomes (indicators of school enrolment and type of school enrolled in to), Logit odds ratio are reported. Robust standard errors (clustered at the community level) in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The dependent variable are indicator to school enrolment (panel A), study hours at home (including extra tuition) (panel B), and indicator to whether a child is enrolled in to private or public school (panel C), indicator if parents paid for school fees or tuition for the child (panel D). Controls include (X): household wealth index, number of older siblings, and dummies for gender, gender of household head, mother's education, child ethnicity, prematurity. In the school enrolment regressions many observations are dropped because in several communities all children reported being in school. Note that the odds ratio are interpreted as follows: if the odds are greater than one, they indicate positive effects; but if the odds are less than one, they are interpreted as negative effects.

meal frequency or the food variety. In this case too, we find little evidence that parents respond to the shock through health and nutritional investments. At age 12, in utero exposure to food insecurity decreases the number of meal frequency, but with no apparent significant difference between boys and girls.²⁰

²⁰Gender-specific pre-natal investment is not expected since sex detection before birth is very uncommon in Ethiopia. We nonetheless test the impact of in utero exposure on pre-natal and neo-natal (BCG) investments. We do not find any significant impact of in utero exposure to food insecurity (Table D.6). Furthermore, other sources of heterogeneity may explain why the effects accumulate overtime, indirectly shedding light on differentiated ability of households to deal with food insecurity in utero. Results from heterogeneity analysis based on wealth (D.13), access to market (D.14) and access to road (D.15) are commented and discussed in Appendix D.

Table 6: Childhood parental health and nutritional investments

	Full sample		Boys		Girls	
	(1) Age 8	(2) Age 12	(3) Age 8	(4) Age 12	(5) Age 8	(6) Age 12
Panel A: Medical expenditures						
Exposure-Std	1.145 (0.133)	1.140 (0.163)	1.097 (0.192)	1.214 (0.328)	1.203 (0.235)	1.094 (0.283)
Observations	1,746	1,734	905	901	841	829
Panel B: Meal frequency in the last 24 hours						
Exposure-Std	0.010 (0.021)	-0.052* (0.027)	-0.004 (0.040)	-0.055 (0.048)	0.019 (0.035)	-0.064 (0.041)
Observations	1,746	1,728	905	897	841	831
Panel C: Food variety in the last 24 hours						
Exposure-Std	-0.054 (0.054)	-0.030 (0.073)	-0.092 (0.137)	0.041 (0.124)	-0.040 (0.144)	-0.077 (0.078)
Observations	1,745	1,727	905	897	840	830
Community FE	Yes	Yes	Yes	Yes	Yes	Yes
Birth Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes

For binary outcomes (indicators of school enrolment and type of school enrolled in to), Logit odds ratio are reported. Robust standard errors (clustered at the community level) in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The dependent variable are indicator if parents paid any medical expenditure to the child (panel A), the number of meals a child ate in the last 24 hours (panel B); and total number of food variety a child ate in the last 24 hours (panel C). Controls include (X): household wealth index, number of older siblings, and dummies for gender, gender of household head, mother's education, child ethnicity, prematurity. In the school enrolment regressions many observations are dropped because in several communities all children reported being in school. Note that the odds ratio are interpreted as follows: if the odds are greater than one, they indicate positive effects; but if the odds are less than one, they are interpreted as negative effects.

5 Conclusions

We examine the effect of in utero seasonal food insecurity on childhood cognitive development and grade-for-age. We exploit a unique dataset from the Young Lives Ethiopia. We estimate the effect of variation in the number of days of exposure to prenatal food insecurity on these outcomes, controlling for community and birth month fixed effects together with child and household characteristics. The inclusion of community and month of birth fixed effects means our estimations are unlikely to be affected by seasonality effects, or unobserved heterogeneity at the community level (for example, climatic conditions). We find that at age 8, maths are adversely affected by in utero exposure to seasonal food insecurity, but only for boys. At age 12, gender imbalances exacerbate. At age 12, a standard deviation increase in food insecurity in utero decreases maths scores by about one third of a standard deviation for boys, almost three times the decrease observed for girls. Moreover, at age 12, we find that food insecurity in utero decreases the odds of being on the correct

grade, but only for boys. Based on the lack of selective mortality in utero and after birth and weak evidence for differentiated parental investment, we conjecture that scarring effects, particularly fierce for male fetuses, accumulate overtime.

Such detrimental impacts are likely to have long-term consequences on socio-economic outcomes. Policy interventions that address seasonal food insecurity and programs that target pregnant women to enhance their resilience to seasonal food shortages could protect the development of children and minimize the long-term economic cost. Social safety net or cash transfer programs together with nutrition and micro-nutrient supplementation programs are obvious policy options. In Ethiopia, starting from 2005, the Productive Safety Net Programme (PSNP) aims at addressing seasonal food insecurity. Unfortunately, our data do not allow us to investigate the mitigating effect of the PSNP since the sampled children were in utero between 2000 and 2002, before the implementation of the PSNP. Understanding how specific programs build resilience to seasonal food insecurity is a path for future research.

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Separate Appendixes with Supplemental Material for:

In utero seasonal food insecurity and cognitive development:
Evidence on gender imbalances from Ethiopia

April 23, 2019

Abstract

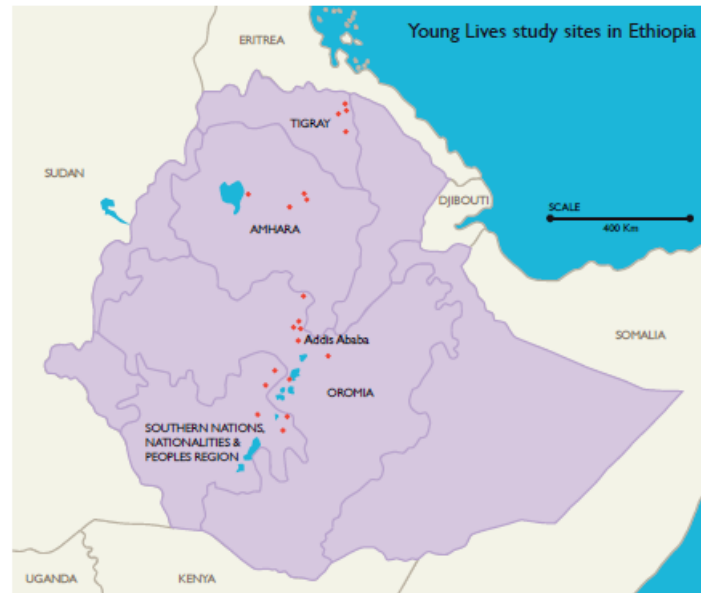
This document contains a set of appendixes with supplemental material.

Keywords: Food Insecurity; Ethiopia; In utero; Cognitive Development.

JEL Classification: I15; O13; O15

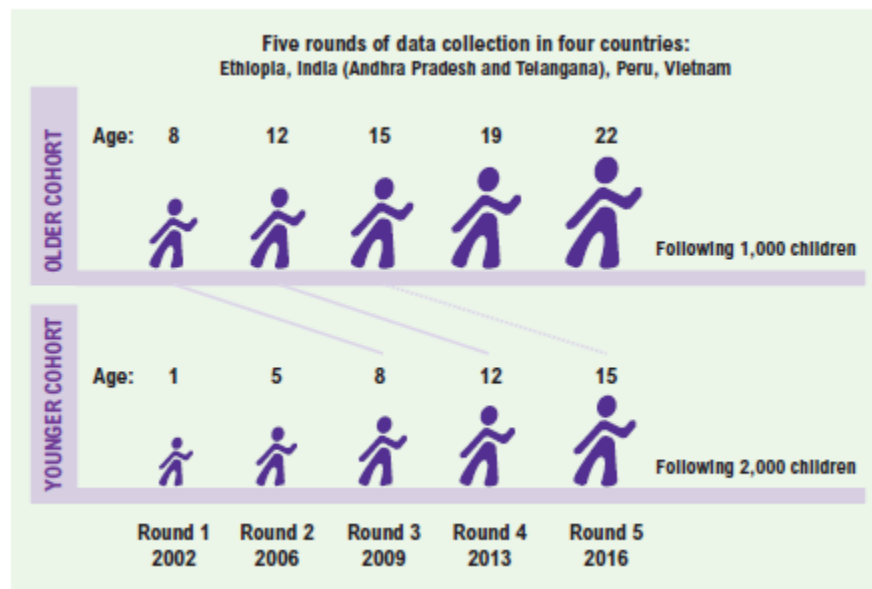
Appendix A Young Lives Study Area and Cohorts

FIGURE A.1. Young Lives study sites in Ethiopia



Source: (<http://www.younglives.org.uk/content/sampling-and-attrition>)

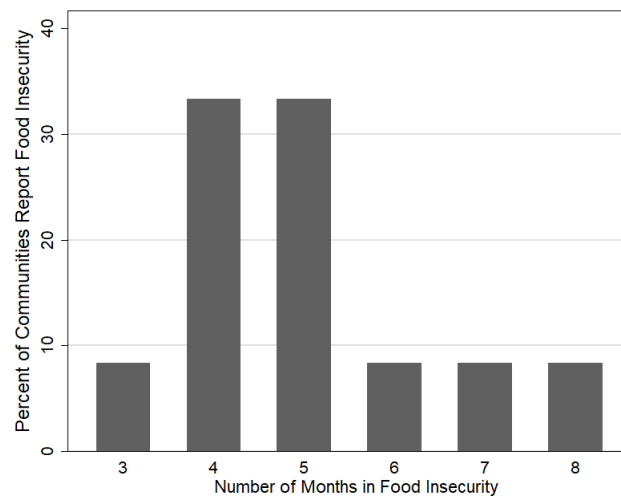
FIGURE A.2. Young Lives longitudinal cohort



Source:(<http://www.younglives.org.uk/content/sampling-and-attrition>)

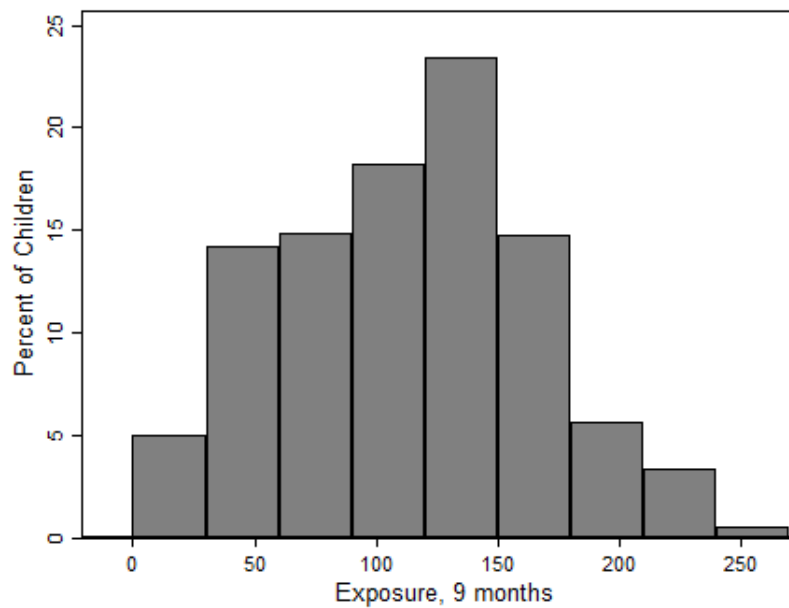
Appendix B Intensity of food insecurity and exposure

FIGURE B.1. Number of Reported Months of Seasonal Food Insecurity



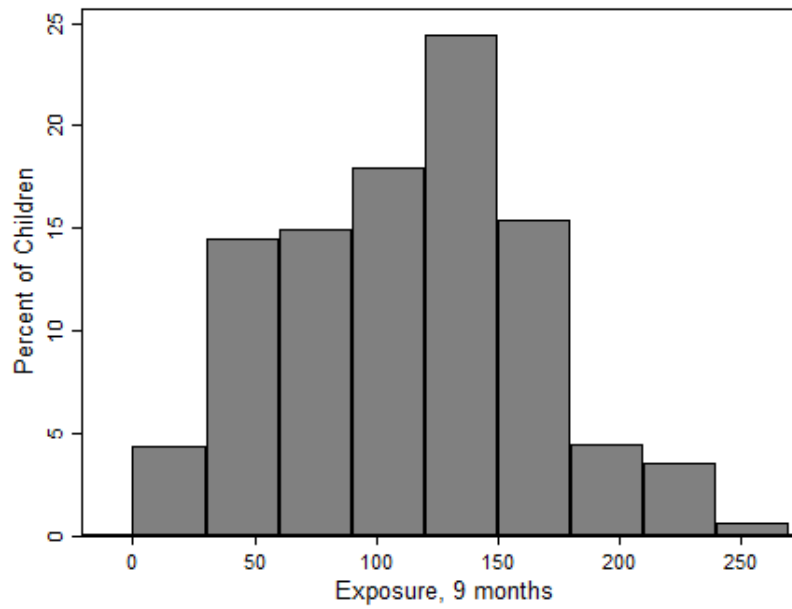
Source: Authors' calculations using data from Young Lives Study, Ethiopia

FIGURE B.2. Prenatal days exposure to reported seasonal food insecurity, all children



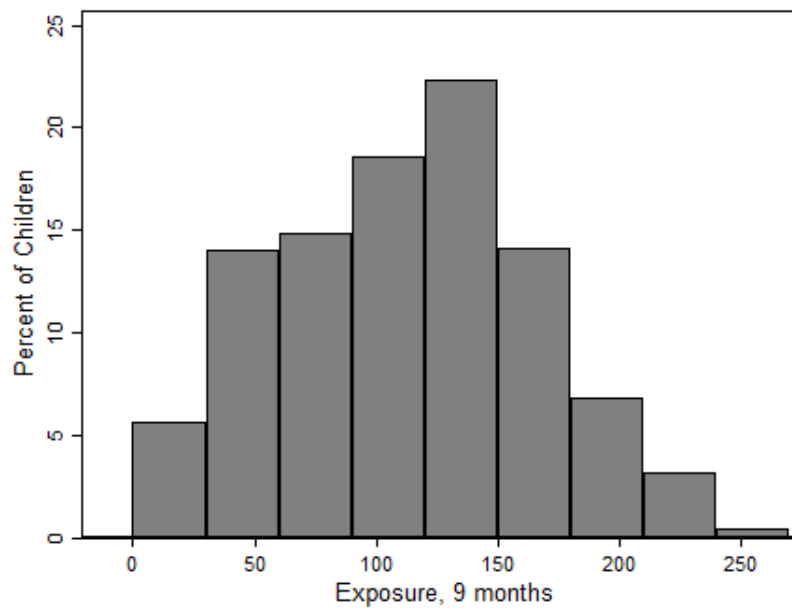
Source: Authors' calculations using data from Young Lives Study, Ethiopia. Histogram is calculated with a 30 days window for each bin.

FIGURE B.3. Prenatal days exposure to reported seasonal food insecurity, boys



Source: Authors' calculations using data from Young Lives Study, Ethiopia. Histogram is calculated with a 30 days window for each bin.

FIGURE B.4. Prenatal days exposure to reported seasonal food insecurity, girls

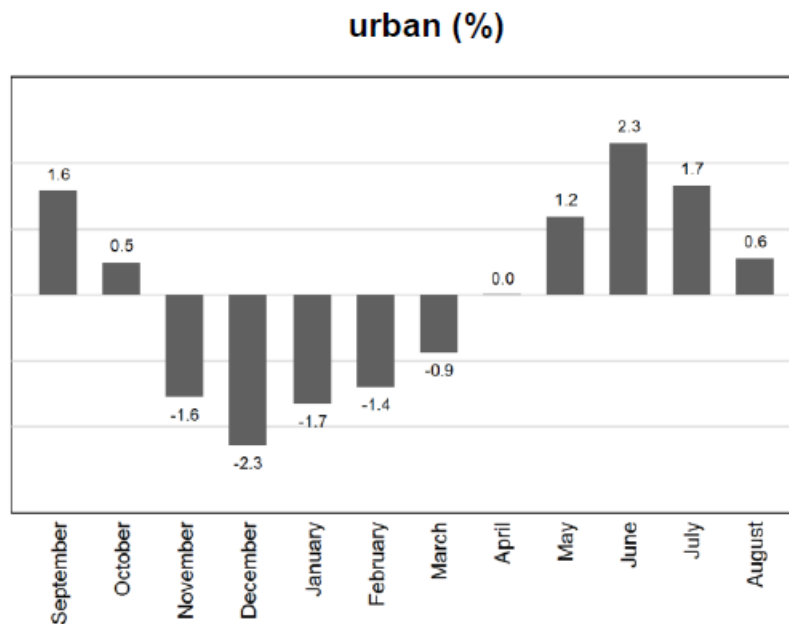


Source: Authors' calculations using data from Young Lives Study, Ethiopia. Histogram is calculated with a 30 days window for each bin.

Appendix C Food Insecurity Data vs Time the Children were In Utero

Children in our sample were in utero between July, 2000 and June, 2002. The seasonal variation in food insecurity is defined from 2006 data. This gap may be a concern. However price data (Figures C.1 and C.2) confirm the repeated nature of the seasonal pattern in the country. To be more precise, we provide information on the seasonality of prices in major grains harvested in Ethiopia. We use monthly price data from the Central Statistical Authority of Ethiopia.²¹ We use the price data on Teff, Wheat, Barley, and Sorghum. Figures C.3; C.4; C.5, C.6 show that nationally averaged monthly prices from July, 2001 to June, 2002. The graphs show higher prices from May to October and lower from November to April. Moreover, Figure 1 shows many communities report food insecurity from May to September and few report from November to March. By comparing and contrasting the price information with food insecurity data, one can conclude that the variations in the prices during the period children were in utero show similar seasonality to the food insecurity data we used in this study.

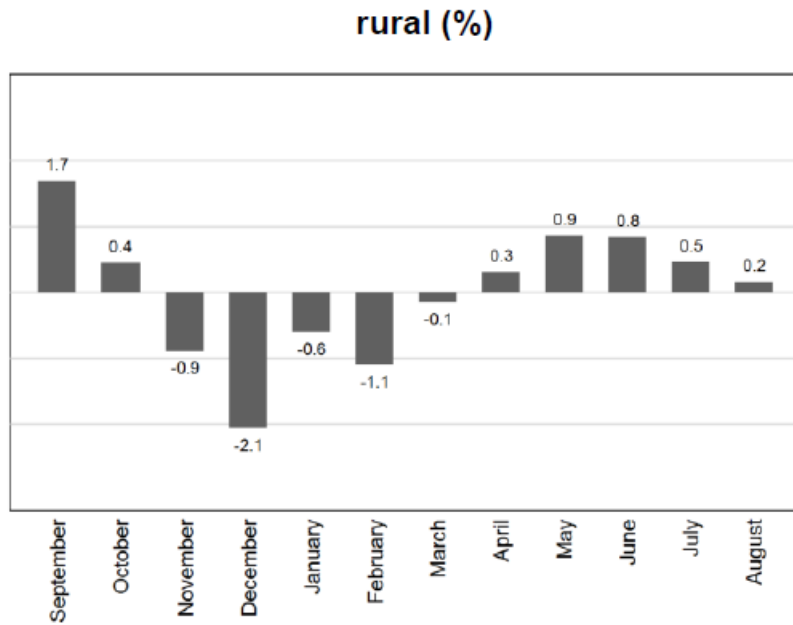
FIGURE C.1. Monthly food price deviation from annual average in urban Ethiopia



Source: Hirvonen et al. (2016). Notes: It is calculated from Central statistical Authority of Ethiopia price data spanning 2002-2011. Price deviations reflect the average monthly departures from the annual mean of the seasonal food price index.

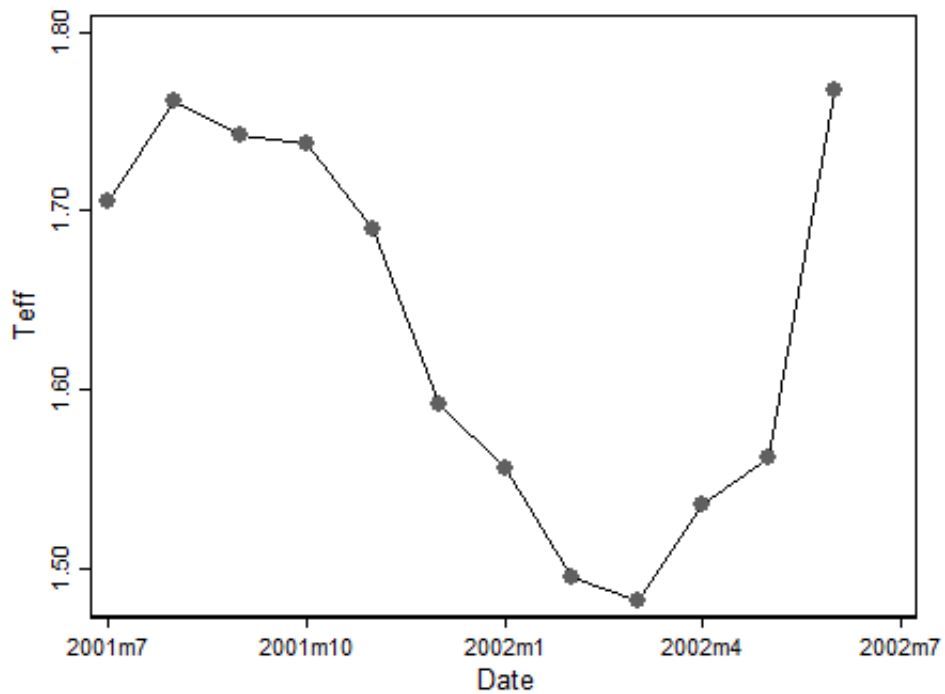
²¹The children were in utero between July, 2000 and June, 2002. Unfortunately the price data only covers dates after July, 2001.

FIGURE C.2. Monthly food price deviation from annual average in rural Ethiopia



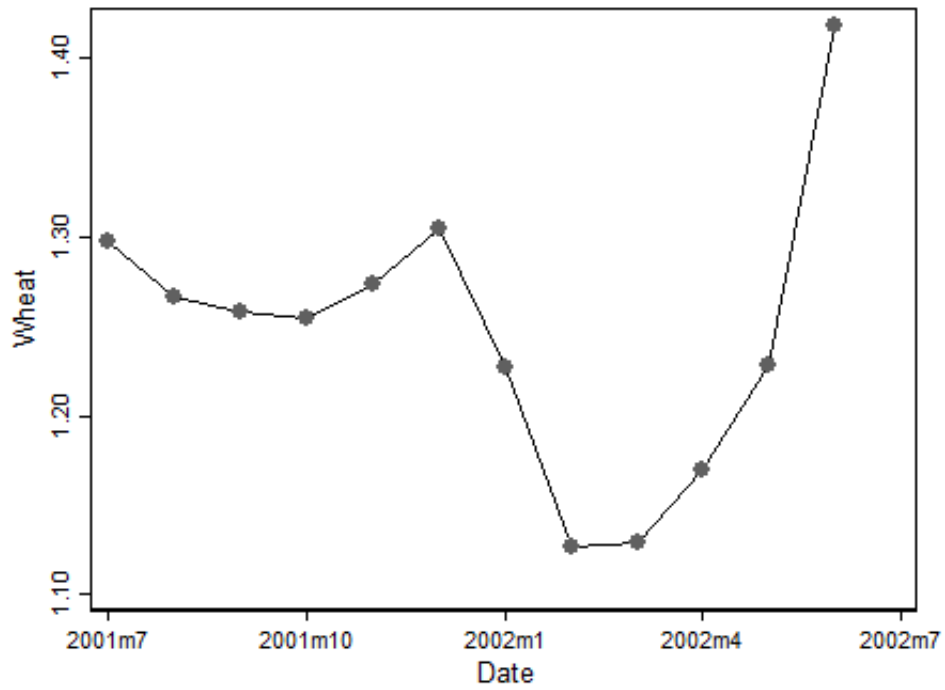
Source: Hirvonen et al. (2016). Notes: It is calculated from Central statistical Authority of Ethiopia price data spanning 2002-2011. Price deviations reflect the average monthly departures from the annual mean of the seasonal food price index.

FIGURE C.3. Seasonality in the price of Teff



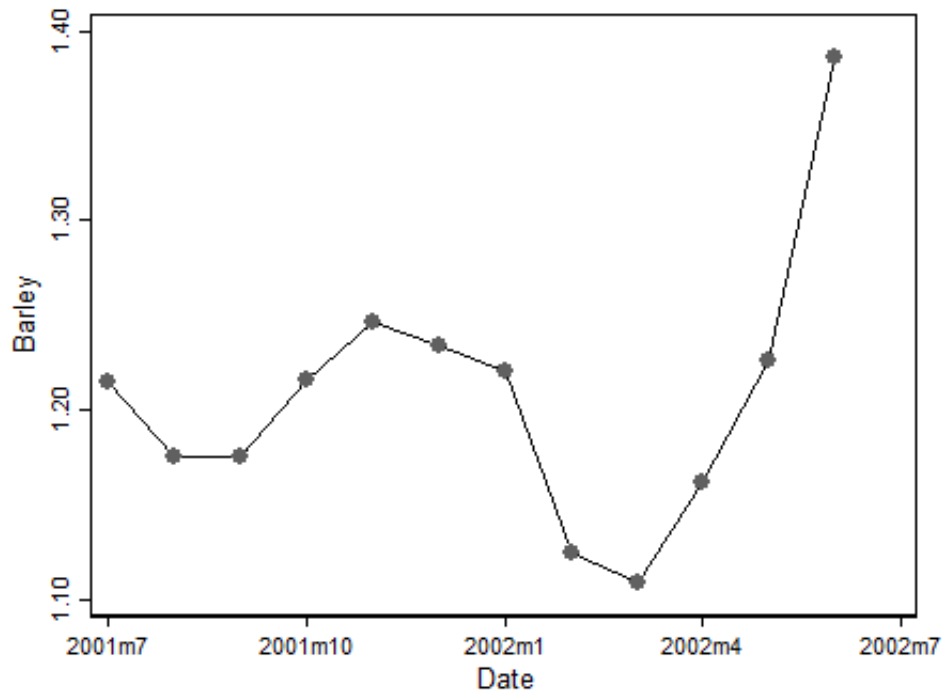
Source: Authors' calculation using Central statistical Authority of Ethiopia price data in 2001 and 2002.

FIGURE C.4. Seasonality in the price of Wheat



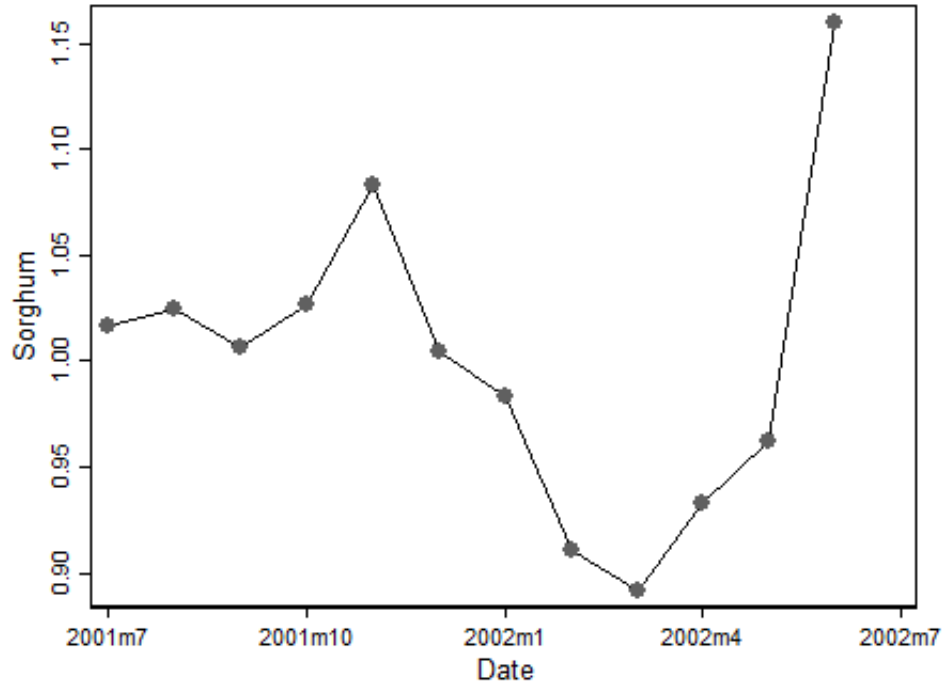
Source: Authors' calculation using Central statistical Authority of Ethiopia price data in 2001 and 2002.

FIGURE C.5. Seasonality in the price of Barley



Source: Authors' calculation using Central statistical Authority of Ethiopia price data in 2001 and 2002.

FIGURE C.6. Seasonality in the price of Sorghum



Source: Authors' calculation using Central statistical Authority of Ethiopia price data in 2001 and 2002.

Appendix D Additional Analysis and Supplementary Tables

In this section, we present discussions from additional results. These include: analysis of the shock by trimester; sensitivity analysis; heterogeneity analysis based on socio-economic status of households and community level access to infrastructures; and threats of identification.

Appendix D.1 Timing of Shocks

We investigate the effect of food insecurity exposure on cognitive development by pregnancy trimester. The evidence so far is quite mixed. While the first and second trimester seem to be crucial for academic outcomes, the third trimester is especially important for short term health outcomes like birth weight. [Almond et al. \(2015\)](#) establish that the early stage of prenatal Ramadan experience (first and to some extent second trimester) is very important for child academic development. [Schwandt \(2017\)](#) finds evidence of a labour market effect of influenza exposure in the second trimester. On the contrary, [Painter et al. \(2005\)](#) and [Schwandt \(2017\)](#) identify stronger impacts resulting from shocks occurring at later stage of pregnancy (third trimester) on birth weight.

To stratify the exposure to food insecurity by trimester, we compute the number of days the child has been exposed to food insecurity in each trimester of gestation. In our study, the first and second trimesters (after conception) are 90 days each and the third trimester accounts for 86 days. All exposure variables are

then standardized to have mean zero and standard deviation one within community. Table D.7 presents the estimated effects of food insecurity exposure in each trimester on maths achievements score and grade-for-age. For the pooled sample, we find significant and negative effects of exposures from all trimesters (seemingly stronger effects from first and second trimesters) for maths score at age 12 (column (2), panel A) and only from second trimester for grade-for-age at age 12 (column (2), panel B). Specifically, a standard deviation increase in exposure to in utero food insecurity during the first and second trimester decreases the maths score at age 12 by about 0.16 standard deviations. More importantly, gender imbalances are observed across all stages of gestation. For maths score at age 12, exposures from all stages of trimester are significant for boys, while only the first and second trimesters are significant for girls. The effects are stronger for boys similar to the baseline results. For the grade-for-age outcome at age 12 the second trimester is the most important one, even though we find significant negative effect from exposure in the third trimester at age 8. By and large, there is some evidence that exposures from early stages of pregnancy (first and second trimesters of gestation) have stronger effects. The stronger effect during the first and second trimesters confirms the importance of the early stage of pregnancy for child development (Almond et al., 2015).

Appendix D.2 Sensitivity Analysis

We explore the robustness of our results to not standardizing the measure of exposure to food insecurity in utero (more subject to high-leverage communities); to using round 1 food insecurity information (similar to Miller (2017)) to capture seasonal food insecurity at the community level; to non-linear effects in exposure; to relaxing the restriction of using only children for whom we observe the maths score at all stages (round) (in the regressions using the maths score as a dependent variable).

Table D.8 shows the results from not standardizing the measure of exposure to food insecurity in utero. In this case, exposure is converted into monthly units by dividing the number of exposure days by 30 so that our results can be interpreted on a monthly basis. Our results are robust to not standardizing exposure to food insecurity in utero within community. However, the point estimates are larger in the case of not standardizing the measure of exposure to food insecurity. For instance, in panel B column 2, an extra month exposure to food insecurity in utero decreases maths score at age 12 by 0.13 standard deviation. This implies that a standard deviation (50 days, see Table 1) increase in exposure to food insecurity in utero would decrease maths score at age 12 by 0.22 standard deviation. Miller (2017) also find similar results.

Given the fact a child in our analytical sample faces on average 111 days of in utero food insecurity, a child loses on average approximately 0.49 standard deviations of maths scores at age 12 as a result of in utero shock. For boys it is equivalent to a loss of 0.75 standard deviations. These are large effects compared to other existing studies. Berhane et al. (2016), for instance, document the effect of childhood positive shock (exposure to productive safety net) and negative shock (drought) in Ethiopia on Peabody Picture

Vocabulary Test (PPVT). They find that exposure to drought reduces child cognitive skills by 0.18 standard deviations, while access to safety net increases cognition by 0.18 standard deviations. We provide evidence that exposure to food shortages at the prenatal stage has a greater impact to that of childhood exposure to drought and safety net. Such detrimental impact is likely to have long-term consequences on socio-economic outcomes. Using data from the older cohort at ages 18 or 19 in round 4 (2013) and conditional on the same individual control variables, we estimate correlations between cognitive development (maths scores) at age 12 and graduating from high school or joining college at ages 18 or 19. The maths score of the older cohort was collected in round 2 (2006).²² We find correlations of about 0.17 and 0.09 between maths score and the probability of graduating from high school or joining college, respectively. This analysis is presented in Table D.9. For boys, the correlations increase to 0.2 and 0.13, respectively. In other words, one standard deviation (24.6% among the old cohort) increase in maths score, for instance, is associated with a 17 percentage points and 9 percentage points increase in graduating from high school or joining college, respectively. Given a standard deviation in maths score is equal to 21.5 percent in our analytical sample (young cohort), the correlations are equivalent to 15 percentage points and 7.9 percentage points increases in graduating from high school or joining college, respectively. Given that a child on average has lost 0.49 (0.75 for boys) standard deviations in maths score as a result of the in utero food insecurity exposure, we can conjecture that exposed children would have a 7.4 percentage points and 3.8 percentage points lower probability of graduating from high school or joining college, respectively. For boys, this would be 11.3 percentage points and 6 percentage points lower probability of graduating from high school or joining college, respectively. We have to be cautious in interpreting these results as they are predicted from correlations rather than causal relationships between maths and long-term schooling outcomes. The predicted effects of the exposure on graduating from high school or joining college are likely to be upper bound estimates.

Table D.10 presents results from exploiting round 1 (2002) food insecurity information instead of round 2 (2006). Exposure to food insecurity has significant effect on cognitive development. The effect is more pronounced for maths test than other outcomes. However, the estimated effects in this case are much smaller (about a quarter) compared to the baseline results.

In Table D.11, we categorize children into four groups based on the number of days they are exposed to food insecurity in utero: <60, 60-120, 120-180, >180 days. Then, defining the group with the least number of days of exposure as a reference group, we run regressions where the interest variables are now indicators of whether a child is exposed within a certain range of days (60-120 days, 120-180, or >180). The results show that the effect of the shock may be driven by children who are exposed to more than 120 days.

²²The maths questionnaire used in round 2 (when older cohort were tested at age 12) has fewer questions compared to the maths questionnaire used in round 4 (when the younger cohort were tested at age 12). For the sake of comparison, we therefore convert maths scores to percentages of correct answers. One standard deviation of the maths score is equal to 24.6% for older cohort and that is equivalent to 21.5% for the younger cohort in the restricted sample (analytical sample).

Finally, in the baseline analysis where maths score is the outcome, we restrict the sample to include only children for which we observe the outcomes of interest at all age (round) stages. In Table D.12, we relax this restriction. Even though the size of the coefficients seem to be smaller compared to the baseline, the sign and significance of the estimates are similar to the baseline results.

Appendix D.3 Further Heterogeneity

In this section, we investigate whether the impact of food insecurity in utero and in particular the gender imbalances found in this paper are conditional on socio-economic status or access to markets and roads at the community level.

According to Tables D.13 for maths score there is no heterogeneity based on household wealth. For grade-for-age outcome, however, there seems to be some evidence that children from wealthier families are less affected by the shock. In Table D.14, we find that even though the effects are not significant, closer access to market diminishes the effect of the shock. For age 12 maths and grade-for-age outcomes, albeit insignificantly, having access to market within 10 kilometre distance diminishes the negative effect of the shock. Table D.15 presents heterogeneous effect based on access to different types of road. Access to cement road slows down the negative effect of in utero shock.

Appendix D.4 Threats to Identification

In this section, we examine how our results may be threatened by (1) fertility selection; (2) reporting errors; (3) the existence of other mechanisms; (4) attrition and missing data and (5) the exposure to seasonal food insecurity after birth.

Appendix D.4.1 Fertility Selection

If parents plan the timing of having children and if this is correlated with seasonal food insecurity patterns, our results may be biased. For instance, [Do and Phung \(2010\)](#) find that parents may give birth during good years and these planned children tend to have more years of schooling. In our case, parents may end up investing more in children whose birth was planned during less food insecure periods. Therefore, our results might not be due to exposure to food insecurity but due to unplanned pregnancies in bad times. Given that about 37 percent of pregnancies in our sample were unplanned, this may be a non-trivial issue.

Moreover, inclusion of birth month fixed effects only controls for seasonality effects that happen at the country level. However, even within community, fertility patterns may vary based on socio-economic characteristics of women. If poorer, unmarried and less educated women conceived during the period of food insecure seasons, the effect of food insecurity exposure on our outcome variables might be a result of the

attributes of women rather than exposure. Indeed, studies like [Buckles and Hungerman \(2013\)](#) document that women that give birth in different seasons have different attributes.

To address these issues, first, we check whether the raw birth data show seasonal fertility pattern. We graph the timing of all births by calendar date. [Figure D.1](#) report the percentage of all children born in a given time. The figure shows that fertility declines in August and September of 2001 followed by a hike in the next period. Births also decrease in January-March of 2002, followed by a spike in the following period. Similar pattern is also observed in [Figure D.2](#) and [Figure D.3](#), which depict boys' and girls' birth date, respectively. More importantly, in all cases, there seems to be no correlation between the fertility patterns and the seasonal food insecurity data presented in [Figure 1](#).

Second, similar to [Lokshin and Radyakin \(2012\)](#) and [Miller \(2017\)](#), we investigate if the unplanned pregnancies in our sample coincide with food insecure seasons. If this is true, we should find correlation between unplanned pregnancies and our measure of exposure to food insecurity. We estimate the effect of being "unplanned" (an indicator that takes the value of one if the pregnancy was reportedly unwanted) on the number of food insecure days in utero. A positive and significant coefficient of "unplanned" with large magnitude would imply unplanned pregnancies experiencing more exposure days in utero. Columns (1) and (2) of [Table D.16](#) indicate that there is a negative weakly significant relationship between the two. Contrary to our expectations, unwanted pregnancies faced 3.4 days less exposure. So, fertility selection problem due to planning of pregnancies does not threaten the causal interpretation of our results.²³

Third, we explore if family characteristics influence fertility patterns and thereby food insecurity exposure within communities. Specifically, we test the correlation between household and mother characteristics and our exposure variable. We regress the days of exposure against our control variables including community fixed effects.²⁴ Columns (3) of [Table D.16](#) reports that except for an indicator for mothers having attended between 5 and 8 years of education, other characteristics are insignificant. The correlation with an intermediate level of education is even of small magnitude. As a result, we may not expect substantial fertility selection. Nonetheless, the result strengthens the case for controlling for such characteristic in our main analysis.

Appendix D.4.2 Reporting Errors

Our estimates assume that within a month the timing of birth can be considered as random. One concern may be that dates of birth are reported with errors and such reporting errors would be correlated with household socio-economic characteristics. We do not have any prior on the direction of the resulting bias.

²³Even though the magnitude is very small (3.4 days, which is only 3% of the average in utero food insecurity exposure), we cannot exclude the fact that unplanned pregnancies are surprisingly more likely to occur in less food insecure months reflects possible lagged effects. The existence of lagging effects could contaminate our control group. However, such a risk would point to the lower-bound nature of our results and could not explain the gender imbalances in seasonal food insecurity in utero.

²⁴Regressing the household and mother background characteristic against the exposure to see if there is difference between women in these characteristics based on exposure also gives similar results.

To explore the importance of the issue, we estimate the probability of being born in a particular week of a month as a function of mother education and household wealth. Our dependent variable birth week has unordered structure of four responses. The appropriate model to estimate the relationship between birth week and household characteristics is a multinomial logit model. We have also done the same exercise for month of birth. In Table D.17, we present results from multinomial logit regressions by defining four possible outcomes depending on the week a child is born within a month. In Table D.18, we report results from regressions showing relationship between household characteristics and the likelihood of a child is born in a certain month. In both cases, we do not find any systematic evidence that being born at the beginning or at the end of a month and also at any given month is correlated with socio-economic characteristics.

Appendix D.4.3 Other Mechanisms

Our results may be driven by omitted factors that vary by month and community. We see two possibilities, either exposure to more and harder work during pregnancy, or the occurrence of Ramadan. The first concern is that mothers may engage in more physically demanding work during their pregnancy period. This may lead then to burn more calories, which could in turn affect child development in utero (Strand et al., 2011; Miller, 2017). The concern is that pregnancies may coincide with seasonal variation in labour demand/supply. Labour demand/supply is seasonal in Ethiopia due to the nature of seasonality in agricultural production. The causal impact on cognitive development might be due to an increase in work requirements and the resulting stress that coincides with food insecure times rather than the direct effect of food insecurity exposure. To assess the importance of this alternative mechanism, we estimate the main specification, augmented with a proxy for exposure to work during pregnancy.²⁵ Panels A and B of Table D.19 show that work exposure does not have a significant impact on cognitive development. The inclusion of this auxiliary variable does not alter the main coefficients of interest that capture the impact of seasonal food insecurity.

Second, the literature tends to show that Ramadan has a detrimental effect on academic test scores (Almond et al., 2015; Majid, 2015). If the observance of Ramadan coincides with food insecure months, our results may be explained by a higher proportion of Ramadan-exposed Muslim pregnancies during times of relative food scarcity as opposed to the exposure to seasonal food insecurity. Although the introduction of month of birth fixed effects deals with seasonality effect induced by the adoption of Ramadan at the national level, we cannot exclude the possibility that even children born the same month, may end up with different days of exposure to Ramadan.²⁶ Given the fact about 17 percent of children in our analytical sample are originating from Muslim households, the issue cannot be overlooked. We assess the importance

²⁵We use the following question to construct exposure to work in utero: “In which months of the year is there relatively more work to do?” In utero work exposure is constructed in a similar way to that of exposure to food insecurity.

²⁶Ramadan in this paper is defined as an indicator variable equal to 1 if a child is exposed to the Ramadan fasting even for few days in utero.

of that channel by augmenting the model with a Ramadan effect. Panels C and D of Table D.19 report the results that include effects of Ramadan on the test scores. The main coefficient of interest remains virtually unchanged even after controlling for Ramadan effects.

Appendix D.4.4 Attrition and Missing Data

Attrition appears to be small in our sample. The attrition on the younger cohort between round 1 and round 4 is 2.2 percent.²⁷ Missing data with respect to our measures of cognitive developments is a larger concern, especially in round 4 (at age 12). In round 4, 13 percent of children have missing information on maths outcome. If the probability of having missing information is correlated with our exposure measure, our results might be biased. Moreover, the significant result that we found at age 12 might be driven by missing information on the outcome variable. In particular, if strongest children are missing (have missing outcome) by age 12 and that is systematically correlated with our exposure measure, the estimated coefficients would be biased upwards. We therefore assess if the probability to have missing data on maths score is related to exposure; and an interaction term between exposure and children's height (to measure children's strength, height at the first round of the survey is used as a proxy). Table D.20 reveals no significant correlations. Moreover, our results of the effect of exposure on maths outcome are based on a longitudinal sample where the same children are considered in all rounds. Nonetheless, not imposing such a sample restriction does not alter our main results (Tables D.12).

Appendix D.4.5 After Birth Exposure

Our analysis only considers the effect of exposure during the 9 months of gestation. However, the seasonal nature of food insecurity in Ethiopia means that we may capture the cumulative effect of food insecurity during childhood. Children affected by the shock in utero may also be affected after birth in childhood. To assess the importance of that issue, we follow Hoynes et al. (2016) who investigate childhood exposure to participation into a safety net program. Hoynes et al. (2016) study the effect of early life exposure to safety net on long-term health and economic outcomes in the US. Individuals exposed to the introduction of safety net early in life have also been exposed to it later in childhood. So, their comparison is based on the additional number of months of safety net exposure in early life, conditional on exposure during later childhood. Similarly, given the level of exposure to food insecurity after birth, our specification identifies the effect of additional days of food insecurity exposure in utero. However, given the variation in age in months during the time of interview, we cannot be certain the coefficient of interest will only capture the effect of exposure in utero. We therefore show the robustness of our result in controlling for exposure to food insecurity from birth to interview date. Specifically, we calculate the number of days of exposure between

²⁷See <http://www.younglives.org.uk/content/sampling-and-attrition> and also Barnett et al. (2013).

birth and the interview date at round 3 (age 8) as well as the number of days of exposure between birth and the interview date at round 4 (age 12). As indicated in Table [D.21](#), the effects of in utero food insecurity exposure are robust to controlling for after birth shocks. For the grade-for-age outcome, the coefficients of interest are not any more precisely estimated but they remain similar in magnitude with the baseline.

Appendix D.5 Supplementary Tables

Table D.1: Additional descriptive statistics

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Full sample			Boys			Girls		
	Mean	Std. Dev.	N	Mean	Std. Dev.	N	Mean	Std. Dev.	N
Panel A: Other Cognitive outcomes									
EGRA Age 8	5.148	3.102	1762	5.151	3.080	915	5.145	3.127	847
PPVT Age 8	79.052	44.5	1741	79.532	44.582	903	78.535	44.431	838
PPVT Age12	38.322	8.878	1523	38.474	8.849	795	38.157	8.912	728
Panel B: Other Exposure variables									
Exposure in 1st Trimester	37.945	35.261	1875	37.951	35.520	970	37.938	35.000	905
Exposure in 2nd Trimester	37.513	36.824	1875	37.671	36.540	970	37.343	37.145	905
Exposure in 3rd Trimester	35.599	34.015	1875	35.763	34.039	970	35.424	34.008	905
Work Exposure	100.570	53.076	1875	98.186	53.343	970	103.125	52.698	905
Panel C: Household variables									
Female headed	0.141	0.348	1874	0.135	0.342	969	0.147	0.354	905
Wealth round 1	0.212	0.174	1857	0.215	0.178	958	0.209	0.170	899
Number of older siblings	2.132	1.981	1875	2.101	1.913	970	2.166	2.052	905
Mom educ. (none)	0.609	0.488	1865	0.605	0.489	966	0.614	0.487	899
Mom educ. (1 to 4 years)	0.144	0.351	1865	0.136	0.343	966	0.154	0.361	899
Mom educ. (5 to 8 years)	0.157	0.364	1865	0.164	0.370	966	0.150	0.357	899
Mom educ.(>8 years)	0.090	0.286	1865	0.096	0.295	966	0.082	0.275	899
Panel D: Individual variables									
Age round 3	97.476	3.767	1875	97.560	3.770	970	97.385	3.765	905
Age round 4	145.655	3.976	1875	145.700	3.947	970	145.608	4.008	905
Child Boy	0.517	0.500	1875	1.000	0.000	970	0.000	0.000	905
Premature	0.087	0.282	1875	0.097	0.296	970	0.076	0.266	905
Amhara	0.297	0.457	1875	0.313	0.464	970	0.278	0.448	905
Tigrian	0.234	0.424	1875	0.244	0.430	970	0.223	0.417	905
Oromo	0.180	0.385	1875	0.173	0.379	970	0.188	0.391	905
Wolayta	0.056	0.230	1875	0.049	0.217	970	0.063	0.243	905
Gurage	0.082	0.274	1875	0.073	0.261	970	0.091	0.287	905
Other	0.151	0.359	1875	0.146	0.354	970	0.157	0.364	905
Panel E: Additional variables									
Muslim	0.171	0.376	1875	0.166	0.372	970	0.176	0.381	905
Ramadan X Muslim	0.127	0.334	1875	0.121	0.326	970	0.135	0.342	905
Ramadan	0.808	0.394	1875	0.793	0.406	970	0.824	0.381	905
Unplanned	0.374	0.484	1779	0.372	0.484	932	0.377	0.485	847
Enrolled in school									
Age 8	0.764	0.425	1765	0.752	0.432	919	0.777	0.417	846
Age 12	0.943	0.232	1756	0.925	0.264	915	0.963	0.189	841
Study hour at home(including extra tuition)									
Age 8	0.977	0.861	1767	0.985	0.867	919	0.968	0.856	848
Age 12	1.404	0.874	1755	1.354	0.890	915	1.458	0.854	840
In private school									
Age 8	0.114	0.318	1166	0.121	0.326	596	0.107	0.309	570
Age 12	0.060	0.238	1654	0.065	0.247	847	0.056	0.230	807
Meal frequency (in the last 24 hours)									
Age 8	3.925	0.698	1769	3.934	0.682	920	3.916	0.715	849
Age 12	3.918	0.766	1751	3.921	0.762	912	3.914	0.771	839
Food variety (in the last 24 hours)									
Age 8	5.027	1.779	1768	5.032	1.803	920	5.021	1.755	848
Age 12	5.371	1.584	1750	5.264	1.546	912	5.487	1.617	838
Access to market									
Market with in <1 km	0.5	0.5	1600	0.49	0.5	820	0.51	0.5	780
Market with in 2 to 10 km	0.25	0.433	1600	0.246	0.431	820	0.254	0.435	780
Market with in >10 km	0.25	0.433	1600	0.263	0.441	820	0.236	0.425	780
Access to road									
Cement/tar	0.276	0.447	1809	0.289	0.454	934	0.263	0.44	875
Gravel/dirt	0.502	0.5	1809	0.482	0.5	934	0.525	0.5	875
None	0.221	0.415	1809	0.229	0.42	934	0.213	0.409	875

Source: Young Lives Study (Survey), Ethiopia

Table D.2: Estimated effect of in utero food insecurity exposure on maths outcome, with controls

	(1)	(2)	(3)	(4)	(5)	(6)
	Full sample		Boys		Girls	
	Age 8	Age 12	Age 8	Age 12	Age 8	Age 12
Exposure-Std	-0.017 (0.023)	-0.175*** (0.039)	-0.093* (0.053)	-0.268*** (0.066)	0.055 (0.045)	-0.111* (0.059)
Age round 3	0.039*** (0.010)		0.042*** (0.014)		0.039*** (0.014)	
Age round 4		0.030*** (0.008)		0.034*** (0.012)		0.032** (0.016)
Child is boy	0.003 (0.045)	-0.026 (0.051)				
Female headed	-0.187*** (0.062)	-0.240*** (0.048)	-0.047 (0.091)	-0.207*** (0.068)	-0.347*** (0.071)	-0.315*** (0.078)
Wealth round 1	1.352*** (0.225)	1.225*** (0.245)	1.217*** (0.391)	1.408*** (0.401)	1.469*** (0.371)	0.939* (0.498)
Number of older siblings	0.004 (0.011)	0.002 (0.010)	0.006 (0.018)	-0.000 (0.019)	0.006 (0.012)	0.007 (0.014)
Mom educ. (1 to 4 years)	0.092 (0.083)	0.151 (0.113)	0.128 (0.084)	0.058 (0.106)	0.057 (0.104)	0.246 (0.155)
Mom educ. (5 to 8 years)	0.229*** (0.086)	0.219*** (0.070)	0.288** (0.115)	0.205* (0.115)	0.129 (0.101)	0.205* (0.110)
Mom educ.(>8 years)	0.366*** (0.097)	0.459*** (0.084)	0.376*** (0.107)	0.421*** (0.122)	0.359** (0.156)	0.471*** (0.156)
Premature	-0.038 (0.058)	-0.096* (0.057)	-0.122 (0.088)	-0.142** (0.068)	0.086 (0.111)	-0.006 (0.107)
Amhara	0.094 (0.166)	-0.043 (0.104)	0.015 (0.123)	0.134 (0.145)	0.031 (0.259)	-0.240 (0.165)
Tigrian	0.070 (0.110)	0.099 (0.109)	0.147 (0.195)	0.077 (0.149)	-0.010 (0.145)	0.057 (0.143)
Oromo	0.002 (0.129)	-0.077 (0.127)	-0.063 (0.089)	0.168 (0.135)	-0.027 (0.190)	-0.372*** (0.137)
Wolayta	-0.121 (0.176)	-0.362*** (0.130)	-0.313 (0.335)	-0.241 (0.162)	-0.045 (0.230)	-0.563** (0.239)
Gurage	0.242* (0.128)	0.206* (0.108)	0.363** (0.176)	0.444*** (0.134)	-0.084 (0.170)	-0.085 (0.152)
Observations	1,441	1,441	755	755	686	686
R-squared	0.082	0.082	0.085	0.102	0.111	0.090
Community FE	Yes	Yes	Yes	Yes	Yes	Yes
Birth Month FE	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors (clustered at the community level) in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table D.3: Estimated effect of in utero food insecurity exposure on grade-for-age (odds ratio), with controls

	(1)	(2)	(3)	(4)	(5)	(6)
	Full sample		Boys		Girls	
	Age 8	Age 12	Age 8	Age 12	Age 8	Age 12
Exposure-Std	0.945 (0.102)	0.781** (0.086)	0.920 (0.100)	0.701* (0.128)	0.982 (0.147)	0.817 (0.170)
Age round 3	0.894*** (0.032)		0.880** (0.049)		0.896* (0.054)	
Age round 4		0.927** (0.036)		0.944 (0.053)		0.923 (0.052)
Child is boy	0.830 (0.133)	0.696** (0.120)				
Female headed	0.739 (0.147)	0.596** (0.134)	0.842 (0.275)	0.665 (0.193)	0.692 (0.184)	0.487* (0.206)
Wealth round 1	12.406*** (8.433)	6.384** (5.631)	4.375 (4.281)	4.995 (6.435)	34.086*** (36.821)	12.081* (17.203)
Number of older siblings	0.930* (0.036)	0.970 (0.039)	0.945 (0.046)	0.971 (0.059)	0.908* (0.049)	0.952 (0.055)
Mom educ. (1 to 4 years)	1.789*** (0.288)	1.682** (0.352)	1.631* (0.458)	1.467 (0.386)	1.612** (0.319)	1.684 (0.588)
Mom educ. (5 to 8 years)	1.292 (0.310)	1.416 (0.336)	1.478 (0.443)	1.509 (0.489)	1.130 (0.459)	1.187 (0.481)
Mom educ.(>8 years)	1.412 (0.419)	1.641* (0.492)	1.587 (0.477)	2.374*** (0.761)	1.744 (0.972)	1.265 (0.642)
Premature	1.035 (0.267)	0.892 (0.229)	0.761 (0.280)	0.653 (0.198)	1.591 (0.479)	1.436 (0.600)
Amhara	0.822 (0.313)	0.589 (0.262)	1.194 (0.357)	0.539 (0.334)	0.366 (0.295)	0.484 (0.333)
Tigrian	0.670 (0.387)	0.611 (0.462)	1.540 (1.345)	0.600 (0.780)	0.179** (0.138)	0.566 (0.447)
Oromo	1.195 (0.364)	0.906 (0.342)	0.744 (0.239)	0.677 (0.447)	2.128 (1.176)	1.165 (0.616)
Wolayta	0.943 (0.398)	0.452** (0.174)	1.088 (1.228)	0.151** (0.142)	0.610 (0.531)	0.590 (0.461)
Gurage	2.440 (1.382)	0.955 (0.448)	5.520* (4.956)	0.663 (0.535)	0.791 (0.619)	1.026 (1.062)
Observations	1,745	1,734	895	901	836	833
Community FE	Yes	Yes	Yes	Yes	Yes	Yes
Birth Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors (clustered at the community level) in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table D.4: Estimated effect of in utero food insecurity exposure on EGRA and PPVT

	(1)	(2)	(3)	(4)	(5)	(6)
	Full sample		Boys		Girls	
	Age 8	Age 12	Age 8	Age 12	Age 8	Age 12
Panel A: Early Grade Reading Assessment (EGRA)						
Exposure-Std	-0.055** (0.023) [0.004]		-0.114** (0.049) [0.008]		-0.006 (0.040) [0.832]	
Observations	1,739		900		839	
Panel B: PPVT						
Exposure-Std	0.017 (0.027)	0.020 (0.030)	-0.015 (0.035)	-0.047 (0.042)	0.056 (0.049)	0.084** (0.034)
Observations	1,718	1,504	888	783	830	721
Community FE	Yes	Yes	Yes	Yes	Yes	Yes
Birth Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors (clustered at the community level) in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The dependent variable is standardized PPVT at age 8 and 12. The variable of interest captures prenatal exposure to seasonal food insecurity (full 9 months exposure) standardized to have mean 0 and standard deviation 1 with in each community. Ind. controls include : age of child in months, number of older siblings, and dummies for gender, child ethnicity, prematurity. HH Controls include household wealth index, and dummies for gender of household head, and mother's education.

Table D.5: Preschool investments before age 5

	(1)	(2)	(3)
	Full sample	Boys	Girls
Exposure-Std	1.000 (0.174)	1.259 (0.434)	0.834 (0.244)
Observations	1,386	687	508
Community FE	Yes	Yes	Yes
Birth Month FE	Yes	Yes	Yes s
Controls	Yes	Yes	Yes

Robust standard errors (clustered at the community level) in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The dependent variable is whether or not the child attended preschool since age 3. The variable of interest captures prenatal exposure to seasonal food insecurity (full 9 months exposure) standardized to have mean 0 and standard deviation 1 with in each community. Controls include (X): household wealth index, number of older siblings, and dummies for gender, gender of household head, mother's education, child ethnicity, prematurity.

Table D.6: Prenatal and neonatal investments

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Prenatal		Delivery		Vaccination		
	Antenatal visit	Birth size	Formal Delivery	Assisted Delivery	BCG		
	Full sample	Full sample	Full sample	Full sample	Full sample	Boys	Girls
Exposure-Std	0.998 (0.117)	0.984 (0.085)	1.129 (0.201)	0.834 (0.105)	1.048 (0.129)	1.097 (0.244)	1.025 (0.098)
Observations	1,790	1,781	1,639	1,680	1,691	874	795
Community FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Birth Month FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors (clustered at the community level) in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The dependent variable across columns are indicators to antenatal visit, birth size above average, formal delivery, assisted delivery, BCG vaccination. The variable of interest captures prenatal exposure to seasonal food insecurity (full 9 months exposure) standardized to have mean 0 and standard deviation 1 with in each community. Controls include (X): household wealth index, number of older siblings, and dummies for gender, gender of household head, mother's education, child ethnicity, prematurity.

Table D.7: Estimated effect of in utero food insecurity exposure, by trimester

	(1)	(2)	(3)	(4)	(5)	(6)
	Full sample		Boys		Girls	
	Age 8	Age 12	Age 8	Age 12	Age 8	Age 12
Panel A: Maths with HH controls						
First Trimester	-0.008 (0.028)	-0.157*** (0.038)	-0.071 (0.053)	-0.210*** (0.062)	0.044 (0.051)	-0.112** (0.056)
Second Trimester	-0.024 (0.030)	-0.160*** (0.047)	-0.080 (0.061)	-0.212*** (0.064)	0.029 (0.058)	-0.151* (0.080)
Third Trimester	0.011 (0.033)	-0.122** (0.050)	-0.068 (0.051)	-0.243*** (0.077)	0.101* (0.054)	0.013 (0.078)
Observations	1,441	1,441	755	755	686	686
Panel B: Grade-for-age(odds ratio) with HH controls						
First Trimester	0.917 (0.122)	0.864 (0.130)	1.035 (0.166)	0.832 (0.168)	0.852 (0.151)	0.935 (0.203)
Second Trimester	0.989 (0.104)	0.690** (0.115)	0.851 (0.095)	0.626* (0.158)	1.177 (0.179)	0.705 (0.225)
Third Trimester	0.865 (0.104)	0.879 (0.106)	0.943 (0.145)	0.764 (0.135)	0.763* (0.107)	0.940 (0.166)
Observations	1,745	1,734	895	901	836	833
Community FE	Yes	Yes	Yes	Yes	Yes	Yes
Birth Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors (clustered at the community level) in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The dependent variables are standardized maths score and grade-for-age at age 8 and 12. The variables of interest are standardized prenatal exposure to seasonal food insecurity (exposure at trimester level). Ind. controls include : age of child in months, number of older siblings, and dummies for gender, child ethnicity, prematurity. HH Controls include household wealth index, and dummies for gender of household head, and mother's education. For maths outcome, we restrict the sample to children for which we observe the outcomes of interest at all age (round) stages.

Table D.8: Estimated effect of in utero food insecurity exposure , round 2 exposure (non-standardized)

	(1)	(2)	(3)	(4)	(5)	(6)
	Full sample		Boys		Girls	
	Age 8	Age 12	Age 8	Age 12	Age 8	Age 12
Panel A: Maths without HH controls						
Exposure	-0.015 (0.020)	-0.129*** (0.029)	-0.092** (0.043)	-0.221*** (0.055)	0.046 (0.036)	-0.069* (0.040)
Observations	1,461	1,461	768	768	693	693
Panel B: Maths with HH controls						
Exposure	-0.014 (0.018)	-0.133*** (0.032)	-0.070* (0.041)	-0.204*** (0.055)	0.036 (0.035)	-0.084* (0.046)
Observations	1,441	1,441	755	755	686	686
Panel C: Grade-for-age (odds ratio) without HH controls						
Exposure	0.962 (0.091)	0.827** (0.067)	0.926 (0.080)	0.740** (0.089)	0.998 (0.123)	0.882 (0.136)
Observations	1,768	1,757	909	916	844	841
Panel D: Grade-for-age (odds ratio) with HH controls						
Exposure	0.939 (0.082)	0.806*** (0.067)	0.914 (0.078)	0.725** (0.098)	0.968 (0.120)	0.854 (0.140)
Observations	1,745	1,734	895	901	836	833
Community FE	Yes	Yes	Yes	Yes	Yes	Yes
Birth Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors (clustered at the community level) in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The dependent variables are standardized maths score, reading score and grade-for-age at age 8 and 12. The variable of interest captures prenatal exposure to seasonal food insecurity (full 9 months exposure). Ind. controls include : age of child in months, number of older siblings, and dummies for gender, child ethnicity, prematurity. HH Controls include household wealth index, and dummies for gender of household head, and mother's education. For maths outcome, we restrict the sample to children for which we observe the outcomes of interest at all age (round) stages.

Table D.9: Correlation between cognition and long-term academic achievements

	(1)	(2)	(3)	(4)
	Marginal Effects			
	Graduated from high school		Went to college	
Panel A: Full sample				
1 standard deviation=24.6 percent				
Maths age 12 (% correct)	0.162*** (0.012)	0.166*** (0.013)	0.095*** (0.013)	0.090*** (0.014)
Observations	797	785	750	738
Outcome mean(obs, 908)	0.222		0.12	
Panel B: Boys				
Maths age 12 (% correct)	0.198*** (0.023)	0.204*** (0.025)	0.135*** (0.023)	0.131*** (0.023)
Observations	375	371	377	373
Outcome mean(obs, 488)	0.198		0.12	
Panel C: Girls				
Maths age 12 (% correct)	0.175*** (0.021)	0.172*** (0.023)	0.096*** (0.023)	0.085*** (0.027)
Observations	377	369	318	310
Outcome mean(obs, 419)	0.251		0.131	
Community FE	Yes	Yes	Yes	Yes
Birth Month FE	Yes	Yes	Yes	Yes
Controls	No	Yes	No	Yes

Robust standard errors (clustered at the community level) in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The dependent variables across columns are indicators that show whether a child graduates from high school (column 1 and 2) and go to college (column 3 and 4) at age 18 or 19. The independent variable is percentage correct in maths score at age 12 (standardized to have mean 0 and standard deviation 1). Controls include (X): age of child in months, household wealth index, and dummies for gender, mother's education, and child ethnicity. Some observations are dropped because in some communities there are no variations in the outcome variables (i.e. all observations have either 1 or 0 values with in those communities).

Table D.10: Estimated effect of in utero food insecurity exposure , exposure using round 1

	(1)	(2)	(3)	(4)	(5)	(6)
	Full sample		Boys		Girls	
	Age 8	Age 12	Age 8	Age 12	Age 8	Age 12
Panel A: Maths without HH controls						
Exposure-miller-Std	0.001 (0.021)	-0.032* (0.017)	-0.009 (0.033)	-0.066* (0.036)	0.000 (0.033)	-0.003 (0.034)
Observations	1,481	1,481	782	782	699	699
Panel B: Maths with HH controls						
Exposure-miller-Std	-0.013 (0.023)	-0.044*** (0.017)	-0.021 (0.032)	-0.076** (0.034)	-0.022 (0.033)	-0.024 (0.030)
Observations	1,459	1,459	768	768	691	691
Panel C: Grade-for-age (odds ratio) without HH controls						
Exposure-miller-Std	1.009 (0.069)	0.982 (0.065)	0.932 (0.055)	0.930 (0.088)	1.099 (0.109)	1.033 (0.123)
Observations	1,791	1,780	938	934	849	846
Panel D: Grade-for-age (odds ratio) with HH controls						
Exposure-miller-Std	0.997 (0.073)	0.947 (0.063)	0.939 (0.059)	0.894 (0.090)	1.052 (0.101)	0.993 (0.128)
Observations	1,766	1,755	922	918	840	837
Community FE	Yes	Yes	Yes	Yes	Yes	Yes
Birth Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors (clustered at the community level) in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The dependent variables are standardized maths score, reading score and grade-for-age at age 8 and 12. The variable of interest captures prenatal exposure to seasonal food insecurity (full 9 months exposure) standardized to have mean 0 and standard deviation 1 with in each community. Ind. controls include : age of child in months, number of older siblings, and dummies for gender, child ethnicity, prematurity. HH Controls include household wealth index, and dummies for gender of household head, and mother's education. For maths outcome, we restrict the sample to children for which we observe the outcomes of interest at all age (round) stages.

Table D.11: Non-linear effect of in utero food insecurity exposure

	(1)	(2)	(3)	(4)	(5)	(6)
	Full sample		Boys		Girls	
	Age 8	Age 12	Age 8	Age 12	Age 8	Age 12
	Panel A: Maths					
Exposure days (60 to 120)	0.029 (0.065)	-0.124 (0.105)	-0.061 (0.114)	-0.168 (0.149)	0.108 (0.115)	-0.095 (0.130)
Exposure days (120 to 180)	-0.041 (0.102)	-0.248** (0.126)	-0.028 (0.170)	-0.242 (0.208)	-0.081 (0.141)	-0.333** (0.143)
Exposure days (>180)	-0.085 (0.130)	-0.426** (0.170)	-0.131 (0.243)	-0.565* (0.309)	-0.048 (0.184)	-0.376** (0.186)
Observations	1,441	1,441	755	755	686	686
	Panel B: Grade-for-age (odds ratio)					
Exposure days (60 to 120)	0.958 (0.213)	0.989 (0.218)	1.060 (0.323)	1.034 (0.312)	0.812 (0.198)	0.931 (0.267)
Exposure days (120 to 180)	1.006 (0.222)	0.549** (0.134)	0.999 (0.313)	0.590 (0.277)	1.115 (0.431)	0.496* (0.200)
Exposure days (>180)	1.045 (0.409)	0.500* (0.182)	0.969 (0.467)	0.521 (0.294)	1.144 (0.816)	0.421 (0.286)
Observations	1,745	1,734	895	901	836	833
Community FE	Yes	Yes	Yes	Yes	Yes	Yes
Birth Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors (clustered at the community level) in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The dependent variables are standardized maths score, reading score and grade-for-age at age 8 and 12. The variable of interest are dummies of prenatal exposure to seasonal food insecurity (full 9 months exposure). Ind. controls include : age of child in months, number of older siblings, and dummies for gender, child ethnicity, prematurity. HH Controls include household wealth index, and dummies for gender of household head, and mother's education. For maths outcome, we restrict the sample to children for which we observe the outcomes of interest at all age (round) stages.

Table D.12: Estimated effect of in utero food insecurity exposure on maths outcome, not restricting the sample to those followed overtime

	(1)	(2)	(3)	(4)	(5)	(6)
	Full sample		Boys		Girls	
	Age 8	Age 12	Age 8	Age 12	Age 8	Age 12
Panel A: Maths without controls						
Exposure-Std	-0.013 (0.023)	-0.123*** (0.032)	-0.074** (0.037)	-0.214*** (0.051)	0.031 (0.035)	-0.076 (0.048)
Observations	1,695	1,508	878	796	817	712
Panel B: Maths with HH controls						
Exposure-Std	-0.017 (0.021)	-0.136*** (0.036)	-0.071* (0.041)	-0.213*** (0.056)	0.024 (0.032)	-0.101* (0.057)
Observations	1,674	1,486	865	781	809	705
Community FE	Yes	Yes	Yes	Yes	Yes	Yes
Birth Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors (clustered at the community level) in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The dependent variable is standardized maths score at age 8 and 12. The variable of interest captures prenatal exposure to seasonal food insecurity (full 9 months exposure) standardized to have mean 0 and standard deviation 1 with in each community. Ind. controls include : age of child in months, number of older siblings, and dummies for gender, child ethnicity, prematurity. HH Controls include household wealth index, and dummies for gender of household head, and mother's education.

Table D.13: Estimated effect of in utero food insecurity exposure, heterogeneity by wealth

	(1)	(2)	(3)	(4)	(5)	(6)
	Full sample		Boys		Girls	
	Age 8	Age 12	Age 8	Age 12	Age 8	Age 12
Panel A: Maths						
Exposure-Std	0.009 (0.031)	-0.156*** (0.040)	-0.054 (0.056)	-0.248*** (0.064)	0.042 (0.060)	-0.104 (0.074)
Exposure-Std X Wealth	-0.100 (0.096)	-0.072 (0.098)	-0.156 (0.114)	-0.083 (0.168)	0.048 (0.154)	-0.025 (0.188)
Observations	1,441	1,441	755	755	686	686
Panel B: Grade-for-age (odds ratio)						
Exposure-Std	0.958 (0.122)	0.838 (0.123)	0.940 (0.120)	0.646** (0.112)	0.993 (0.152)	1.048 (0.257)
Exposure-Std X Wealth	0.937 (0.315)	0.762 (0.246)	0.900 (0.370)	1.361 (0.659)	0.954 (0.483)	0.391* (0.213)
Observations	1,745	1,734	895	901	836	833
Community FE	Yes	Yes	Yes	Yes	Yes	Yes
Birth Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors (clustered at the community level) in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The dependent variables are standardized maths score and grade-for-age at age 8 and 12. The variables of interest capture standardized prenatal exposure to seasonal food insecurity measures (full 9 months exposure) and its interaction with household wealth. Controls include (X): age of child in months, household wealth index, number of older siblings, and dummies for gender, gender of household head, mother's education, child ethnicity, prematurity. For maths outcome, we restrict the sample to children for which we observe the outcomes of interest at all age (round) stages.

Table D.14: Estimated effect of in utero food insecurity exposure, heterogeneity by access to market

	(1)	(2)	(3)	(4)	(5)	(6)
	Full sample		Boys		Girls	
	Age 8	Age 12	Age 8	Age 12	Age 8	Age 12
Panel A: Maths						
Exposure-Std	0.047 (0.055)	-0.200*** (0.042)	-0.114* (0.063)	-0.314*** (0.075)	0.191* (0.113)	-0.100 (0.100)
Exposure-Std X Market<1km	-0.085 (0.056)	0.010 (0.041)	-0.038 (0.059)	0.036 (0.060)	-0.122 (0.102)	-0.021 (0.080)
Exposure-Std X Market2-10km	-0.051 (0.051)	0.031 (0.027)	-0.006 (0.034)	0.036 (0.053)	-0.082 (0.102)	0.031 (0.068)
Observations	1,236	1,236	649	649	587	587
Panel B: Grade-for-age (odds ratio)						
Exposure-Std	1.100 (0.162)	0.765** (0.088)	0.941 (0.170)	0.531*** (0.099)	1.230 (0.242)	0.937 (0.191)
Exposure-Std X Market<1km	0.910 (0.108)	1.118 (0.144)	0.885 (0.132)	1.375 (0.271)	0.896 (0.165)	0.998 (0.154)
Exposure-Std X Market2-10km	0.975 (0.103)	1.129 (0.137)	1.062 (0.147)	1.169 (0.149)	0.914 (0.113)	1.342* (0.211)
Observations	1,489	1,479	765	762	724	717
Community FE	Yes	Yes	Yes	Yes	Yes	Yes
Birth Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes

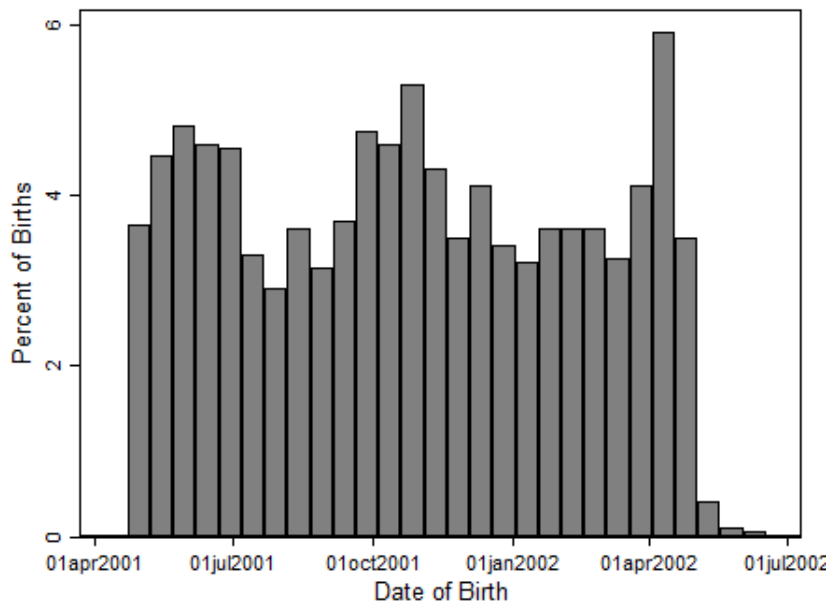
Robust standard errors (clustered at the community level) in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The dependent variables are standardized maths score and grade-for-age at age 8 and 12. The variables of interest capture standardized prenatal exposure to seasonal food insecurity measures (full 9 months exposure) and its interaction with the types of access to market to the community of birth. Controls include (X): age of child in months, household wealth index, number of older siblings, and dummies for gender, gender of household head, mother's education, child ethnicity, prematurity. For maths outcome, we restrict the sample to children for which we observe the outcomes of interest at all age (round) stages. We lost many observations due to several of the communities do not have available information with regard to access to market. The comparison group is Market with in >10 km

Table D.15: Estimated effect of in utero food insecurity exposure, heterogeneity by access to road

	(1)	(2)	(3)	(4)	(5)	(6)
	Full sample		Boys		Girls	
	Age 8	Age 12	Age 8	Age 12	Age 8	Age 12
Panel A: Maths						
Exposure-Std	0.006 (0.035)	-0.151*** (0.051)	-0.058 (0.068)	-0.248*** (0.095)	0.047 (0.042)	-0.102 (0.067)
Exposure-Std X Cement	0.029 (0.052)	-0.001 (0.052)	-0.010 (0.080)	0.028 (0.068)	0.091* (0.053)	0.006 (0.102)
Exposure-Std X Dirt/Gravel	-0.033 (0.040)	-0.031 (0.039)	-0.069 (0.054)	-0.034 (0.059)	0.025 (0.058)	0.009 (0.078)
Observations	1,385	1,385	726	726	659	659
Panel B: Grade-for-age (odds ratio)						
Exposure-Std	0.996 (0.091)	0.772* (0.112)	0.894 (0.097)	0.540** (0.133)	1.071 (0.184)	0.944 (0.192)
Exposure-Std X Cement	0.953 (0.095)	1.189 (0.218)	0.860 (0.154)	1.667* (0.478)	0.928 (0.162)	0.839 (0.174)
Exposure-Std X Dirt/Gravel	1.002 (0.099)	1.038 (0.169)	1.110 (0.143)	1.180 (0.239)	0.948 (0.164)	1.038 (0.199)
Observations	1,686	1,675	874	870	808	805
Community FE	Yes	Yes	Yes	Yes	Yes	Yes
Birth Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes

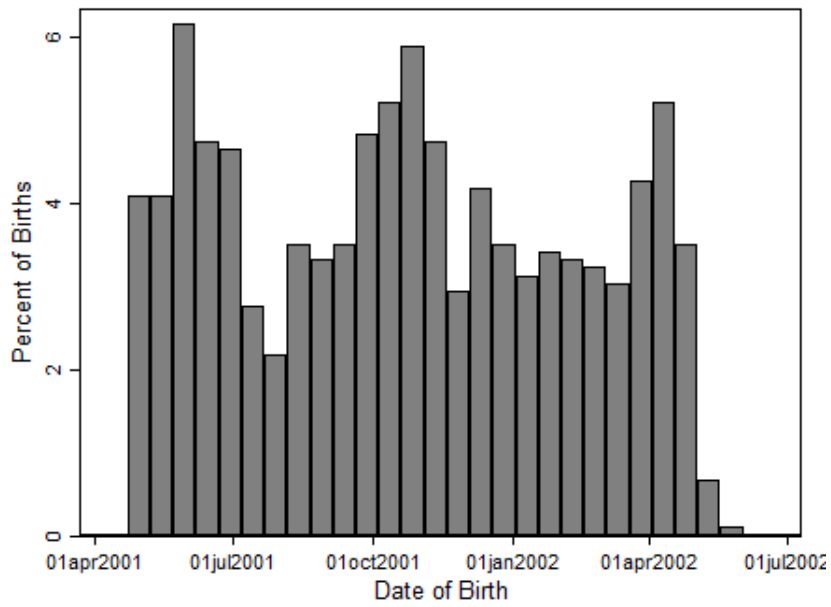
Robust standard errors (clustered at the community level) in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The dependent variables across columns are standardized maths score and grade-for-age at age 8 and 12. The variables of interest capture standardized prenatal exposure to seasonal food insecurity measures (full 9 months exposure) and its interaction with indicator of access to the type of road in the community. We categorized responses given by the community in to no road, access to gravel/dirt road, and access to cement/tar road. Controls include (X): age of child in months, household wealth index, number of older siblings, and dummies for gender, gender of household head, mother's education, child ethnicity, prematurity. For maths outcome, we restrict the sample to children for which we observe the outcomes of interest at all age (round) stages. The comparison group is None (no access to road)

FIGURE D.1. Date of birth, all children



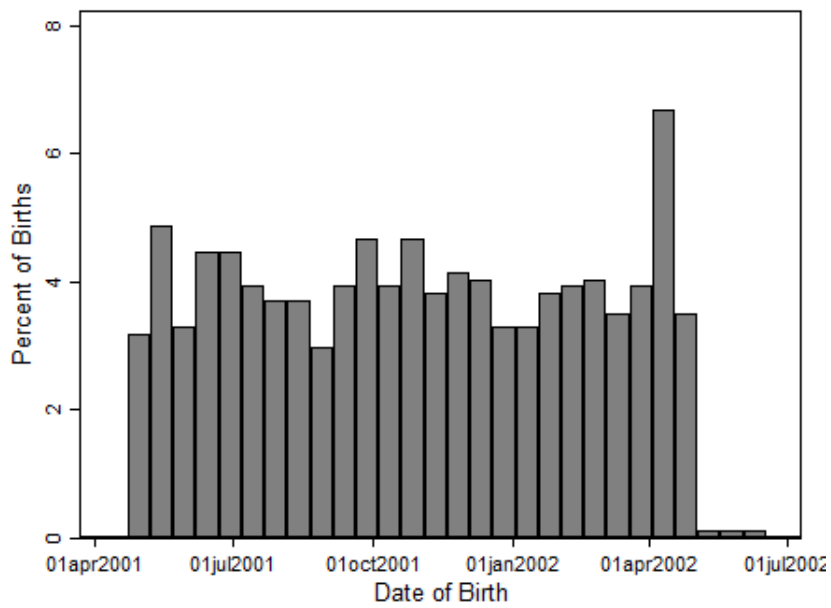
Source: Authors' calculations using data from Young Lives Study, Ethiopia. Histogram is calculated with 15 days window for each bin.

FIGURE D.2. Date of birth, boys



Source: Authors' calculations using data from Young Lives Study, Ethiopia. Histogram is calculated with 15 days window for each bin.

FIGURE D.3. Date of birth, girls



Source: Authors' calculations using data from Young Lives Study, Ethiopia. Histogram is calculated with 15 days window for each bin.

Table D.16: Relationship between prenatal days of exposure and individual and household characteristics

	(1)	(2)	(3)
Unplanned	-3.595*	-3.391*	
	(1.895)	(1.797)	
Wealth round 1			-6.491
			(11.495)
Number of older siblings			-0.357
			(0.575)
Mom educ. (1 to 4 years)			1.689
			(3.096)
Mom educ. (5 to 8 years)			7.673***
			(2.938)
Mom educ.(>8 years)			3.103
			(3.299)
Observations	1,779	1,761	1,846
Controls	No	Yes	Yes

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The dependent variable is days of exposure to seasonal food insecurity during full gestation. The main independent variables are an indicator whether the baby is desired in the first and second columns and household characteristics in the third column. Other unreported controls include: number of older siblings, and dummies for gender, gender of household head, child ethnicities, prematurity, and community .

Table D.17: Relationship between household characteristics and probability of being born in a certain week

	(1)	(2)	(3)
	Multinomial Logit		
	Born in 1 st week	Born in 3 rd week	Born in 4 th week
	Full sample		
Wealth round 1	0.694	0.102	0.451
	(0.556)	(0.511)	(0.478)
Mom educ. (1 to 4 years)	-0.197	0.024	0.203
	(0.227)	(0.201)	(0.191)
Mom educ. (5 to 8 years)	-0.139	0.016	0.019
	(0.237)	(0.217)	(0.206)
Mom educ. (>8 years)	-0.112	-0.098	0.216
	(0.320)	(0.310)	(0.279)
Observations		1,846	
Log-likelihood value		-2509.53	

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The dependent variable across columns is the probability of being born in the first, second, third or fourth week of a certain month. The second week is left as a base/reference. The variables of interest are household and mother socio-economic characteristics: education of the mother and household wealth. We also controlled for number of older siblings, and set of dummies for gender, child ethnicity, and prematurity.

Table D.18: Relationship between household characteristics and probability of being born in a certain month

	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Multinomial Logit										
	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Full sample											
Wealth round 1	0.352 (0.922)	1.162 (0.947)	0.086 (0.834)	0.724 (0.860)	0.481 (0.834)	1.368 (0.902)	0.906 (0.955)	0.626 (0.885)	-0.386 (0.845)	0.564 (0.886)	0.535 (0.956)
Mom educ. (1 to 4 years)	-0.023 (0.371)	-0.378 (0.368)	-0.184 (0.324)	-0.395 (0.351)	-0.366 (0.345)	-0.091 (0.356)	-0.498 (0.384)	-0.485 (0.367)	-0.135 (0.351)	-0.479 (0.369)	-0.189 (0.370)
Mom educ. (5 to 8 years)	0.479 (0.424)	-0.422 (0.449)	-0.316 (0.412)	-0.356 (0.408)	0.433 (0.392)	-0.102 (0.433)	-0.164 (0.449)	0.202 (0.400)	0.696* (0.384)	0.309 (0.408)	0.320 (0.410)
Mom educ. (>8 years)	0.000 (0.551)	-0.461 (0.565)	0.129 (0.468)	-0.357 (0.488)	-0.500 (0.512)	-0.449 (0.533)	-0.314 (0.568)	-0.637 (0.543)	-0.167 (0.525)	-0.039 (0.499)	-0.030 (0.543)
Observations	1,846										
Log-likelihood value	-4474.485										

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The dependent variable across columns are the probability of being born at a certain month of the year. The first month is left as a base/reference. The variables of interest are household and mother socio-economic characteristics: education of the mother and household wealth. We also controlled for number of older siblings, and set of dummies for gender, child ethnicity, and prematurity.

Table D.19: Controlling for Work and Ramadan exposures

	(1)	(2)	(3)	(4)	(5)	(6)
Add work exposure						
	Full sample		Boys		Girls	
	Age 8	Age 12	Age 8	Age 12	Age 8	Age 12
Panel A: Maths						
Exposure-Std	-0.020 (0.025)	-0.179*** (0.037)	-0.091* (0.049)	-0.284*** (0.063)	0.047 (0.046)	-0.111* (0.057)
Work Exposure	-0.010 (0.019)	-0.015 (0.016)	0.004 (0.029)	-0.042 (0.027)	-0.037 (0.028)	-0.001 (0.039)
Observations	1,441	1,441	755	755	686	686
Panel B: Grade-for-age (odds ratio)						
Exposure-Std	0.942 (0.101)	0.761** (0.089)	0.914 (0.099)	0.691** (0.123)	0.978 (0.149)	0.786 (0.171)
Work Exposure	0.980 (0.059)	0.922 (0.057)	0.952 (0.066)	0.962 (0.103)	0.969 (0.097)	0.867 (0.088)
Observations	1,745	1,734	895	901	836	833
Add Ramadan exposure						
Panel C: Maths						
Exposure-Std	-0.018 (0.024)	-0.172*** (0.039)	-0.092* (0.053)	-0.262*** (0.066)	0.053 (0.045)	-0.108* (0.059)
Ramadan X Muslim	-0.078 (0.106)	-0.072 (0.105)	-0.165 (0.183)	-0.109 (0.179)	-0.084 (0.159)	-0.179 (0.114)
Observations	1,441	1,441	755	755	686	686
Panel D: Grade-for-age (odds ratio)						
Exposure-Std	0.949 (0.103)	0.784** (0.087)	0.916 (0.098)	0.703** (0.124)	0.987 (0.147)	0.814 (0.167)
Ramadan X Muslim	0.892 (0.265)	0.557 (0.206)	1.164 (0.937)	0.439 (0.289)	0.643 (0.397)	0.631 (0.246)
Observations	1,745	1,734	895	901	836	833
Community FE	Yes	Yes	Yes	Yes	Yes	Yes
Birth Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Control	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors (clustered at the community level) in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The dependent variable are standardized maths scores and grade-for-age at age 8 and 12. The variables of interest are prenatal exposure to seasonal food insecurity and work (in Panel A, B, and C) exposure to food insecurity and Ramadan (in Panel D, E, and F). In panel D, E, and F we also controlled for Muslim and Ramadan exposure dummies. Controls include (X): age of child in months, household wealth index, number of older siblings, and dummies for gender, gender of household head, mother's education, child ethnicity, prematurity. For maths outcome, we restrict the sample to children for which we observe the outcomes of interest at all age (round) stages.

Table D.20: Correlation between exposure and probability of missing

	(1)	(2)	(3)	(4)
	Maths missing Age 8	Maths missing Age 12	Maths missing Age 8	Maths missing Age 12
Panel A: Full sample				
Exposure-Std	-0.004 (0.015)	-0.003 (0.014)	0.025 (0.079)	-0.023 (0.103)
Height Round 1 X Exposure			-0.000 (0.001)	0.000 (0.001)
Observations	1,875	1,875	1,825	1,825
Panel B: Boys				
Exposure-Std	0.000 (0.020)	-0.022 (0.023)	-0.147 (0.111)	-0.022 (0.141)
Height Round 1 X Exposure			0.002 (0.001)	-0.000 (0.002)
Observations	970	970	945	945
Panel C: Girls				
Exposure-Std	-0.007 (0.014)	0.017 (0.028)	0.128 (0.135)	-0.102 (0.149)
Height Round 1 X Exposure			-0.002 (0.002)	0.002 (0.002)
Observations	905	905	880	880
Community FE	Yes	Yes	Yes	Yes
Birth Month FE	Yes	Yes	Yes	Yes

Robust standard errors (clustered at the community level) in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The dependent variable across columns is a dummy variable that shows whether the particular outcome is missing at that specific age (round). The independent variables are prenatal exposure to seasonal food insecurity and an interaction of round 1 height and the exposure measure.

Table D.21: Estimated effect of in utero food insecurity exposure on maths outcome, including childhood food exposure

	(1)	(2)	(3)	(4)	(5)	(6)
	Full sample		Boys		Girls	
	Age 8	Age 12	Age 8	Age 12	Age 8	Age 12
Panel A: Maths without controls						
Exposure-Std	-0.057 (0.036)	-0.173*** (0.044)	-0.149** (0.071)	-0.241*** (0.060)	0.024 (0.064)	-0.134* (0.079)
Birth to Age 8 Interview date Exposure	-0.002* (0.001)		-0.003 (0.002)		-0.002 (0.002)	
Birth to Age 12 Interview date Exposure		0.000 (0.001)		0.001 (0.001)		-0.001 (0.002)
Observations	1,441	1,441	755	755	686	686
Panel B: Grade-for-age (odds ratio)						
Exposure-Std	1.020 (0.138)	0.867 (0.121)	1.042 (0.198)	0.797 (0.178)	1.081 (0.214)	0.893 (0.197)
Birth to Age 8 Interview date Exposure	1.003 (0.003)		1.005 (0.006)		1.004 (0.004)	
Birth to Age 12 Interview date Exposure		1.006 (0.005)		1.007 (0.007)		1.005 (0.005)
Observations	1,745	1,734	895	901	836	833
Community FE	Yes	Yes	Yes	Yes	Yes	Yes
Birth Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors (clustered at the community level) in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The dependent variable is standardized maths score at age 8 and 12. The variable of interest captures prenatal exposure to seasonal food insecurity (full 9 months exposure) standardized to have mean 0 and standard deviation 1 with in each community. Birth to Age 8 Interview date Exposure is seasonal food insecurity exposure between birth to age at round 3 (age 8) interview date. Birth to Age 12 Interview date Exposure is seasonal food insecurity exposure between birth to age at round 4 (age 12) interview date. Ind. controls include : age of child in months, number of older siblings, and dummies for gender, child ethnicity, prematurity. HH Controls include household wealth index, and dummies for gender of household head, and mother's education.