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Fetal Malnutrition and Cognitive Development: Evidence from Ethiopia
Master Thesis

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Abstract

This thesis investigates the impact of potential fetal malnutrition on the cognitive development. It accounts for the endogeneity of fetal malnutrition by using the exposure to the two months of Easter fasting (Lent) during the time in utero as a natural experiment. The study assumes some Orthodox mothers might have fasted when they were pregnant. Non-Orthodox Christian children are considered in the specifications as a control group to use a diffrence-in-diffrence framework. The results show exposure to fasting while in utero has a negative effect on cognitive development of Orthodox Christian children. Moreover, the result reveals the negative impact is severe on females and children from low socioeconomic background families. This study highlights the importance of prenatal interventions and the need to focus more on the disadvantaged groups.

1 Introduction

Analyzing the impact of prenatal environment on later age social and economic outcomes has been a great interest to both economists and policy makers. For example, Barker et al. (1990), Alderman et al. (2001a), and Behrman (1996) have shown how early age malnutrition and consecutive negative health outcomes adversely affect long term education, crime rate and labor market performance respectively. Similarly, Heckman (2006) also provides evidence on early age skill formation, later age outcomes and how they are strongly correlated and complementary, which makes the childhood health and later age cognitive outcomes detrimental for the country's future and persuade policymakers and researchers to put more effort on the matter.

The main objective of this study is to investigate the effect of fetal malnutrition on cognitive development of the children using an innovative identification strategy, exposure to the Easter Fasting, assuming some Orthodox Christian mothers in Ethiopia might have fasted during pregnancy. I, therefore, compare children just born before the fasting period, and thereby not exposed during pregnancy, to those exposed at different levels of their gestation using the intent to treat (ITT) approach. As it is dogmatic for Orthodox Christians in Ethiopia to refrain from any meat, dairy and poultry products during the Easter fasting season, it is likely the fetus suffer from lack of important nutrients. Therefore, the overlap between time in utero of the child and fasting period of Easter provides an important identification strategy to investigate the effects of prenatal malnutrition on cognitive development.

The majority of studies on malnutrition have emphasized on the effects of severe but rare sources of malnutrition such as drought, famine, and epidemic diseases. For instance, Almond et al. (2010) and Umana-Aponte (2011) document that severe malnutrition caused by drought has a negative and significant effect on long-term health and economic outcomes. However, while understanding the impact of such disastrous occurrences might be important, the rarity of such events may reduce their significance for policies of the majority of the developing and developed world. It is also few parts of the world and few countries that experience such events and in a very infrequent manner. However, other milder forms of malnutrition mainly due to the poverty status of societies are usually experienced by many across the globe though they are not given enough attention by both researchers and policymakers. Most children and pregnant mothers across many developing and developed countries suffer from milder forms of malnutrition caused by factors such as fasting, environmental degradation, pollution, and meal skipping among others.

Understanding the impact of mild forms of malnutrition has become as important as understanding the impact of severe forms of malnutrition. For example, Almond and Mazumder (2013), Greve et al. (2015), and Doyle et al. (2009) are studies that complement the recent literature on analyzing the impact of fetal malnutrition on cognitive development. Related studies that have investigated the long-term effects of mild forms of malnutrition uses *Ramadan*, which basically represent only Muslims (see, for example, Almond and Currie (2011); Almond and Mazumder (2013); Almond et al. (2011); Greve et al. (2015)). This study complement the existing literature by exploring the Easter fasting which represent Christians. The most related study with mine is a study by Greve et al. (2015) that uses *Ramadan* as identification strategy to investigate the academic performance of the children who were in utero during fasting. Using data obtained from Danish administrative registers, the study considers immigrants from majority and minority Muslim countries as treatment and control group respectively. By employing difference-in difference strategy the study finds negative and significant academic performance on immigrant Muslim students who were in utero during *Ramadan* compared to non-Muslim students.

In this thesis I use the Easter fasting (mainly known as lent in most Christian countries). This fasting lasts for 40 days immediately right before the Easter holiday, but in Ethiopia, this fasting season lasts for 55 days and is known as the "Great Easter Fasting as it is the biggest religious practice among many Ethiopian orthodox Christians. All above age 7 Christian are expected to fast from any food and drink for 15 hours every day except the weekend. In addition, they should also be abstain from eating meat, eggs and dairy products during the whole fasting season. During this time a considerable level of hunger, feeling of tiredness and physical exhaustion due to the fasting is believed in helping to fulfil the ritual requirements by the followers. However, besides the ritual fulfilment, it is difficult for followers to skip this fasting due to the social stigma. In Ethiopia, during this fasting period, the strong social stigma not only affects followers of the religion but also restricts all Christian food stores from providing most products that are not allowed to be consumed during the fasting period. The majority of butcher shops who sells meat products to Christians all over the country halt their services during lent. Those who break their fast are considered as committing a sin, and businesses who provide meat products are ostracised by their customers and the larger society. For instance, a paper by Boyltston (2012) shows that there is an economic slowdown during lent brought by the numerous butcher-restaurant shut down everywhere even in a cosmopolitan Addis Ababa. This presents a particularly useful setting in which to examine the effects of malnutrition in utero on cognitive development. I further investigate how the impact varies across gender and socio-economic group.

Additionally, I believe my study provides the following advantages. First, most existing literature use only *Ramadan* which is practiced only by Muslims as identification strategy. However, I argue that this paper is the first to investigate fetal malnutrition by using its Christian counterpart, Easter fasting which is practiced by most Christians in different parts of the globe. Second, this thesis has also an advantage of finding stronger effect compared to the existing literature that uses *Ramadan*, given Easter fasting lasts for two months and that some important food types are also avoided from the menu during this period. Third, this paper considers a developing country where there is no problem of identifying children and their mothers as part of their respective religion, unlike the previous studies who use proxy to control for religion. Finally, unlike many other studies, this paper exploit a rich micro data set where children have been tracked for long time since their infancy. However, the absence of strong statistical power can be considered as one of the current study's main limitation. Unfortunately, the sample size is smaller than most related studies, which potentially may understate the true effect of exposure to fasting during the time in utero.

The study considers test scores of two standardized tests as outcome variables, Pea-body Picture Vocabulary Test (PPVT) and Early Grade Reading Assessment (EGRA) test score. These two outcome variables and other data in this study are obtained from young-lives Ethiopia (YLP). In order to compare the Orthodox Christian children based on their exposure to the Easter fasting in utero, I also use a sample of non-Orthodox children as an additional control group. This study employs a difference-in-difference strategy which would help us to eliminate the potential seasonality in cognitive test performance. We further investigate how the impact varies across gender and socio-economic group. A growing paper on fetal malnutrition are evidencing effects of prenatal health shocks on cognitive development and the following interventions long-lasting gender different impacts (see, for example, Currie and Almond (2011); Currie and Yelowitz (2000)). However, the fetal malnutrition study mainly conducted by economists are not yet deep into the effect of gender differences. Similarly, several studies have assessed early childhood effects on later age effect and its heterogeneous impact due to the different socio-economic background of the family (e.g Guryan et al. (2008) and Kalil et al. (2012)). This mainly affects the behaviour of the family's response towards early childhood health shocks. By the same token prenatal exposure to fasting may have different effects among groups with different socio-economic status. Therefore, studies that fail to account this considerable source of heterogeneous effect may give us unreliable estimates.

The results shows that the PPVT test score of Orthodox children, who are exposed to fasting period during their first and second trimester are 0.20 and 0.13 lower in their standardized score than the non-Orthodox children, and these results are significant at 1% and 10% significance level respectively. Additionally, female Orthodox children who are exposed to fasting in the first trimester performed lower than non-Orthodox children on both PPVT and EGRA outcome measures. Moreover, the study tries to see if there is heterogeneous effect among children from the different socio-economic family background. The study further reveals that especially the effect is more exacerbate on female children from low-SES than their male counterparts and children from non low-SES family background.

The rest of the paper is organized as follows. Section 2, reviews literature. Section 3, presents the theoretical framework, and section 4 discuss the data. Section 5, presents the empirical strategy. Section 6, discuss findings and Section 7 Concludes the paper.

2 Literature Review

A sizeable theoretical and empirical literature in the field of economics and epedimology are employing the *fetal origin hypothesis*[1] to investigate the impact of insults in fetus conditions on health outcome variables; particularly those experienced during infancy and early childhood (Maccini and Yang, 2008). The main reason why economists use this hypothesis is its vital implication in human capital development beyond the health outcomes. Based on this, Shrimpton et al. (2001) shows that the availability of appropriate nutrients are crucial to support the well-functioning of the brain and its developments over time.

Beyond its effect on adulthood health status, malnutrition in early life is also negatively associated with cognitive development; implying that stunted children will most likely demonstrate worse academic performance than their healthy counterparts as evidenced by Alderman et al. (2009). Thus, poor health resulting from malnutrition may result in lower cognitive test scores, delay in school enrolment and lower performance in schooling. This, in turn, has a significant and negative impact on the level of human capital and the overall productivity of an economy (Alderman et al., 2001b; Glewwe et al., 2001).

Moreover, several studies investigated the malnutrition in utero and early infancy insults on later health and education outcomes from different dimensions. For example, Brown and Pollitt (1996) shows that the brain grows to roughly 80 percent of its adult size in these periods. Hence, failure to have access to the right mix of nutrients necessary for brain

[1] The fetal origins hypothesis is originally developed by an epidemiologist Baker in 1990, it discusses that the perinatal environment has significant impacts on the health and wellbeing outcomes of an individual

development at this important period might deteriorate the cognitive development of the child later in life. Furthermore, a study by Alderman et al. (2009) argues that a child who is malnourished in the first stage of his/her life faces a higher probability of remaining stunted through adolescence periods. Subsequently, this argument is further strengthened by Martorell (1996) in a way that it is very hard for individuals to catch-up once stunted in these sensitive years.

Currently, a growing empirical literature on child health and its long-term consequences agree on the importance of time of nutrition interventions. The fetal insults and stresses experienced while in utero and early childhood are believed to have a far-reaching influence on adulthood health outcomes. And most of the consequences may not be reversed once it is too late. Hence, the prenatal and early childhood periods are considered to be "windows of opportunity" for nutrition interventions (Currie, 2009; Gluckman et al., 2005; Heckman, 2007) interventions that come after these periods may not be productive in increasing human capital, and are not also economically efficient (Heckman, 2007).

However, recent studies recognize the endogeneity of health in the education equation and hence try to account for this problem. Employing different exogenous sources of variation for health, studies in this topic try to establish a true causality between child health and education achievement. For example, severe malnutrition due to drought and resulted hunger and mild malnutrition due to skipping meal, fasting, pollution and infectious disease are some of them among the others(Almond and Currie, 2011). Most of these studies report significant and negative effect of fetal malnutrition on latter age cognitive development and educational achievement along with low earnings.

Until recently, most of the studies (Almond et al. (2010); Dercon and Porter (2014); Umana-Aponte (2011) focus on investigating the effects of malnutrition which is caused by severe but rare events such as wars, epidemic diseases, drought, and famines. The findings of these studies demonstrate that early childhood malnutrition negatively effects later health and education outcome variables. Most importantly, these studies have a common feature in the sense that they consider rare events which might be less appealing for most countries. Moreover, the overemphasis placed on such rare events may also result in overlooking other mild but important sources of malnutrition which may significantly affect many societies in different countries.

Consequently, there is a glaring absence of empirical evidence that systematically investigates the effect of mild malnutrition on child health. A study by Almond et al. (2010) is one of the few studies that analyze the effects of such mild malnutrition. The study shows that the adverse events of mild malnutrition in utero have significant negative impact on the survivor's health. They also argue that studying mild sources of malnutrition has important policy advantages compared to studying extreme malnutrition caused by disasters and different disastrous situations. The main reason for this is that intervention following extreme malnutrition are immediate and rarely depend on cost-benefit analysis. However, interventions aimed at mild malnutrition can benefit from a thorough cost-benefit analysis. Thus, in the following paragraphs, I review some of the empirical studies that are conducted on both extreme and mild sources of malnutrition.

A study by Almond et al. (2010) examines the relationship between severe malnutrition and long-term health, education, and labor market outcomes. The study uses the famine in China from 1959 to 1961 as a natural experiment to investigate the long-term effect of the famine on those who were in utero during the period. The study uses the 2000 Chinese Census data along with the 1984-2004 Hong Kong Nationality micro data; and employs OLS estimation techniques. The robustness of the estimates is tested by considering geography as a fixed effect in famine intensity, and by using Hong Kong as control group since it wasn't affected by the famine and was under British colony by the time. Findings of this study uncovered that women who are exposed to the famine in utero are 7.5% more likely to be non-educated and 3% more likely not to participate in the labor market. Similarly, men who were in utero during the famine are 9% more likely to be illiterate and 5.9% more likely to be unemployed compared to the cohort not exposed to the famine. In terms of their health outcome, women exposed to the famine are 13% more likely to be disabled and while the effect for men is even stronger at 12%, compared to the cohort not exposed. Moreover, the study compares the effects by using various long-term socio-economic status indicators in which men who are exposed to the famine are 6.5% less likely to be married some forty years after the famine than the cohorts born after the famine, and 8.2% have never married.

A study by Umana-Aponte (2011) investigates the severe form of malnutrition. Using the 1980 Ugandan famine as a natural experiment, the study examines the effect of early childhood malnutrition on a later cognitive development and schooling outcomes. The study uses the Ugandan census data from 1991 and 2002 rounds along with the 2006 Ugandan Demographic Health Survey (DHS). By employing OLS and probit estimation techniques, they find those individuals exposed to the famine have 0.364 low years of schooling compared to those not exposed to the famine. Cohorts exposed to the famine are 4.2 % less likely to complete primary education compared to the cohort not exposed to the famine. Moreover, his finding shows that the cohorts exposed to famine are 3.1 percent more likely to be illiterate and 7-10 % are even less likely to ever attend school, compared to the cohorts born later.

The 1984 Ethiopian famine is another tragedy of the recent time that left about a million people dead, and many more destitute. A paper by Dercon and Porter (2014) examines the effect of this famine on the survivors many years later after their exposure. Measures such as height and other socio-economic variables are considered to explain the effect 20 years after the famine happened. The paper used longitudinal data of 550 young adults aged 17-27 years old in 2004. By using household fixed effect (FE), the study compared affected and non-affected siblings across cohorts both in utero and in the early infancy years using the birth weight of young and old siblings. The study finds that individuals who were under the age of 36 months at the peak of the crisis are 5 centimetre shorter than their older counterparts who were at a less vulnerable age during the famine. In addition, the paper also shows the low nutrition effect on the long-term socio-economic status of individuals. They find that affected children's are more likely to face income losses of 5% per annum over their lifetime compared to those not exposed to the famine.

Moving to the milder forms of malnutrition, we can find a number of factors causing such type of malnutrition. Infectious diseases of different type are one of such factors (Crimmins and Finch, 2006). These diseases have a potential impact on fetal health by reducing food intake and/or by inflaming own body. Concerning their economic impact, several studies find negative and significant results (e.g (Barreca, 2010; Case and Paxson, 2009; Costa and Lahey, 2005)). These studies show the negative economic impact by reducing schooling, labor market participation and economic return at a later age for those who suffer from malnutrition in utero. According to the *fetal origin hypothesis* the issue of global warming and environment is also another factor that can lead to mild malnutrition. Air pollution is one of such factors that disturb intrauterine environment and leads to fetal malnutrition. A study by Almond and Mazumder (2011) shows that even low-frequency exposure to automobile exhaust and cigarette smoke have significant negative impact on fetal health. This indicates that having bad fetal health during pregnancy will potentially result in low children health, education and economic outcomes. Currently, the literature on child health are paying attention to mild malnutrition as well. Given this development, a number of studies are developing different and improved identification strategies. These studies use fasting as identification strategy to study the long-term impact of mild malnutrition on academic performance. In order to address the endogenity problem of the econometric analysis, the study relies on the exposure to the fasting month of *Ramadan* during pregnancy as a natural experiment. The main identification assumption is that some of the pregnant Muslim women fasted during *Ramadan*.

A study by Greve et al. (2015) uses students originally from predominantly Muslim and non-Muslim countries as a treatment and control group and investigate the impact of fetal malnutrition on academic performance by employing a difference-in-difference framework. The study finds that exposure to *Ramadan* while in utero has a negative and significant effect on the standardized test scores of female and students from low Socio-economic background. In this study, a child is defined as Muslim if both the mother and the child are immigrants from a country with more than 90% of Muslim and a child is define as Non-Muslim if both the mother and the child are immigrants from a country with lower up to 15% of Muslims (non-muslim majority). However, this classification of an individual as a Muslim or non-Muslim given the size of Muslims and non-Muslims in their country of origin seems problematic and ambiguous. This definition may not accurately capture the religious status of the individuals. Moreover, it may actually be capturing the opposite if for example, those migrating from a predominantly Muslim countries are Christian individuals running away from persecution due to their religion. In this case, the variable Muslim captures a Christian religious status rather than the intended Muslim status. The same could be true for the Non-Muslim definition. In relation with this, this study has an advantage on having no problem in identifying individuals with their religious group since I use rich micro data with information of mother's religion.

A similar study by Almond et al. (2011) investigates a long-term effect of maternal fasting during *Ramadan* on children in utero. They use *Ramadan* as a natural experiment to control for prenatal and intra-urine environment health condition. The study shows the effect of fasting on birth outcomes, and long-term health and education outcomes. This study uses census data of Iraq, Uganda and Michigan reportedly Muslim birth micro data for 1989 to 2006. The study uses intent to treat (ITT) approach as they do not control for the direct decision of individuals to fast or not. However, assuming the decision to fast as exogenous is problematic since it determined by the personal and social characteristics of the individuals. They use children whose pregnancy period does not overlap with *Ramadan* in utero as a control group and employ difference-in-difference estimation technique. They find a 20% higher adult mental disability from the census data of Uganda and Iraq for those exposed cohorts to *Ramadan* compared to the others. And this result is consistent with the one obtained from Michigan sample which finds those children reportedly from 'Arab ancestors' are 19% more likely to have a mental disability. They also find a 12% decline in the likelihood of male birth when the cohort exposed to *Ramadan* in the early pregnancy period and relatively high period of daylight fasting hours.

In general, these studies provides information on the adverse effect of milder forms of malnutrition on the long-term health, economic, crime, and labor market outcome of an individual, and the their result are consistent and strong compared to the effects obtained from severe malnutrition. Finally, from the generalizability perspective, the mild forms of malnutrition have a potential to affect a large proportion of the society than malnutrition caused by disaster, drought, hunger and war that occurred few places of the world in an infrequent manner.

3 Theoretical Framework

Studying prenatal environment and understanding it's implication on later health and economic outcome of an individual is becoming an active research area among both development economics and medical literature. The first of its kind to lay the theoretical foundation for the empirical studies in this area is the *"fetal origins hypothesis"* proposed by Barker et al. (1990). The *"fetal origins hypothesis"* discusses that environmental influences experienced during gestation cause permanent changes in organ development and predisposition to chronic diseases in adult life (Barker et al., 1990). This idea that environmental conditions experienced in a certain sensitive period of life may have lasting, irreversible effect is often known as "critical-period programming" (Maccini and Yang, 2008).

The term "fetal origins hypothesis" has been used to refer to programming caused by conditions experienced in womb. The effects of in-utero on later health and education outcomes are strongly asserted on different dimensions. First, study show that the brain grows to roughly 80 percent of its adult size in the first thousand days since conception (Brown and Pollitt, 1996). Hence, failure to have access to the right mix of nutrients necessary for brain development at this important period might deteriorate the cognitive development of the child later in life. Second, a child who is malnourished in the first stage of life faces higher probability of remaining stunted through adolescence (Alderman et al., 2009).

The negative association between malnutrition and cognitive development; imply that exposed children will most likely demonstrate worse academic performance than their healthy counterparts (Alderman et al., 2009). Thus, poor health resulting from fetal malnutrition may result in lower cognitive test scores, delay in enrolment and lesser learning from their time at school. The consequence of these all pronounced on productivity in labor market (Alderman et al., 2001b; Glewwe et al., 2001).

According to the fetal origins hypothesis environmental shocks experienced while the fetus is in utero have lasting pervasive effects. The medical literature explains that the fetal origin hypothesis environmental shocks experienced while the fetus is in utero have lasting pervasive effects and the fetal growth is mainly regulated by fetal nutrition (Martorell, 1996). A presence of maternal under-nutrition leads to a situation where the fetal substrate fail to meet the fetal demand, and hence, causing a delay in the fetal growth trajectory (Bloomfield and Harding, 1998). As noted by Morgane et al. (1993), protein under-nutrition, especially during the critical periods of rapid cell division also affects brain development. Children who face the danger of malnutrition are more likely to face deficiency of important micronutrients such as iodine, zinc and vitamin A. Deficiency of these micronutrients might result in retarded brain development of children (Martorell et al., 1997).

From biological path way, prenatal fasting effects seem to be cause by under nutrition, but it also cause by stress, lack of sleep, and glucose surges resulting because of much sweet consumption cause same effects (Almond et al., 2015). One possible way ascends over a set of biochemical changes known as 'accelerated starvation' that happens in pregnant women who experience lengthy period of fasting. Pregnant women involvement marked drops in blood glucose levels and sharp increases in ketones and free fatty acids as they begin to metabolise their stores of fat (Almond et al., 2015). A study in animals have shown the link between early pregnancy ketnotes on neurological deficiencies (Hunter et al., 1987). Similarly, a few hour study on *Ramadan* demonstrate same effect (Almond et al., 2015). The effect of fasting in intrauterine environment is severe on brain compared to other organs. According to Gluckman and Hanson (2005, p. 46): brain is very sensitive to environmental stimuli that might irreversibly damage it. This also indicate the fetal malnutrition especially in the first half of the pregnancy is crucial and any bad experience during this time may play a huge role on psychiatric diseases.

From economic path way, the causal link between fetal malnutrition and cognitive development can be conceptualized by human capital model. Which describes the skill formation as a continuous process that starts with conception (Heckman, 2007). Let I_1 denote investments occurring during the prenatal period and I_2 investments during the post-natal period. Given that cognitive development happens in in the early stage of children, I_1 and I_2 are likely imperfect substitutes in the production of capacity.

Using to the human capital model of Grossman (1972), this section try to rovie explanation how the prenatal malnourishment is related with cognitive development:

$$H_t = (1 - \delta)H_{t-1} + I_t, \tag{1}$$

where I_t represents investments in health capital and δ represents the depreciation rate. As we can see, the model shows that the health capital has a trend of decreasing health stock overtime. In the same way this implies early health shock in period t will depreciate overtime as well. This may also indicate less significance of early life shock in later life health outcome, as the health shock occured in early life going to fade away just like the health stock we have in early period constantly affected by the subsequent investment in the coming years. However, if the investment in the future are affected by the health stock the person has, then any shock in any period could also affect the investments that may happen in the future. Therefore, prenatal shock also potentially could affect adult health and the investment that follows in the subsequent period. According to Almond and Mazumder (2011) the effects of fetal conditions might be larger than those of postnatal conditions. In the extreme case of a Leontieff technology, human capacity cannot exceed that determined by the minimum of investments during the prenatal period (Heckman, 2007). Investments in stage t of childhood are more productive when there is a high level of capability in stage t_1.

4 Data and Summary statistics

4.1 Data

The data is obtained from the Young Lives Program (YLP) longitudinal survey of Ethiopia[1]. The survey tracks children grouped into two cohorts: the young cohort and the old cohort. The young comprises about 2000 children who were 6 to 18 months old during the first round of the survey in 2002. Older cohort, with 1000 children, on the other hand, comprises those within the age range of 4 to 6 years during the first round of the survey. From these two cohorts, this study considers the young cohort as the sample size is larger for the young cohorts and the size of the control and treatment group is smaller in the old cohorts case than the young cohorts. The sample is obtained from 20 villages (communities), covering five major regional states of the country[2]. From these 20 villages, 12 are rural and the rest 8 are urban sites. As the primary objective of the survey was to collect data about the extent and determinants of child poverty, the sampling purposely emphasized to cover poorer rural and urban sites[3].

[1]The data used in this thesis came from Young Lives, a 15-year study of the changing nature of childhood poverty in Ethiopia, India, Peru and Vietnam

[2]The regions are Addis Ababa (Capital city), Amhara, Oromia, Southern Nations, Nationalities and Peoples (SNNP) and Tigray which altogether account for about 80% of the country's population

[3]Outes-Leon and Sanchez, (2008) shows the survey data is comparable to national figures in many aspects.

The selection of the households within the sample sites is more random-like approach, and was done by door-to-door search of the eligible households having a child of 6 to 18 months of age during the first round of the survey[4]. This study use of only data from the first (2002/03) and the third (2009/10) rounds of the YLP survey. While the first round provides information regarding the age of a child and birth date of a child, the third round provides information mainly about the cognitive test scores, and other individual and household characteristics. Out of 1999 observation surveyed in the first round, 1885 of them are available in the third round. The third round of the survey was conducted in 2009/10 when the children were 6 to 8 years old. Between the two rounds, the attrition rate is only about 2.15%, which is quite small compared to other similar longitudinal surveys (e.g Outes-Leon and Dercon (2008); Woldehanna (2011)). During the third round, two different cognitive tests were administered for children under the survey. All children in the sample, irrespective of their school enrolment status, have participated in both cognitive tests.

Definition of the outcome variables

I use two direct cognitive measures of outcome variables in this thesis. The first cognitive measure test is the Peabody Picture Vocabulary Test (PPVT). It was originally developed in 1959 by Dunn and Dunn, who both were experts in special needs education. The main purpose of the PPVT is to measure vocabulary acquisition in individuals, adaptable to their age. The test is administered for individuals age of 2 and above. In the PPVT, the child is first let hear a word (say, boat, lamp, etc) and then is asked to identify which of the figure, from the four given, correctly corresponds to the word. This cognitive measurement has widely been used by many researchers; for instance, Rosenzweig and Wolpin (1994) and McCulloch and Joshi (2002) can be mentioned. The second cognitive measure is the Early Grade Reading Assessment (EGRA). It was is originally developed by Research triangle Institute (RTI) in 2006 with the main objective of assessing childs progress towards learning to read in their earlier grades Gove and Wetterberg (2011); Tamang (2012). It is a 15 minutes oral assessment method designed to measure the five[2] most basic foundations of pre-reading and reading skills. In order to have a sound measure of the cognitive development, this paper

[4]SeeAlemu et al. (2003) for details about the sampling technique used in the survey

[2]The five types of assessments are: phonemic awareness, phonics, fluency, vocabulary and listening comprehension

use the standardized scores of the two tests scores.

Construction of main explanatory variables

The treatment variables, for each child in the sample, binary indicators are constructed to determine whether the child's period in utero overlapped with the fasting period. In addition, binary indicators of three gestation level (First, Second and Third) trimester are also created. This thesis consider the normal gestation period (266 days).The first Trimester represent months of 1-3 in utero, the second Trimester 4-6, and the third Trimester include 7-9 months in utero. These binary indicators are created based on the beginning of the fasting period coincided with particular (first,second or third) trimester of the mother pregnancy. In addition to generating for the each nine month of pregnancy, it is also contracted a "Month 0" indicator, which represent individuals who were conceived during fasting. Those who are Orthodox and are not overlapped with the fasting period grouped as "Certainly not Exposed" to fasting. Thus, the study considers binary indicators of Orthodox Christian if children are exposed to fasting or not.

4.2 Summary Statistics

Table 1 presents the descriptive statistics of the full sample. The two outcome variables we discussed above, PPVT and EGRA are presented in the table among the other treatment and control variables. 1885 and 1505 children are participated in the cognitive tests of PPVT and EGRA respectively. As it can be seen in the Table the average score for PPVT and egra tests are 68.3 and 3.5 standardized score respectively. In addition, the Orthodox Christian average PPVT score shows 63.27 while the non-Orthodx average score is 70.40 (see Table 2). The female average test score is slightly lower than the male average test score of PPVT which are 67.92 and 68.72 respectively. Furthermore, the female EGRA average test score is higher than the male average test score 3.55 and 3.48 respectively (see Table 3).

Moving to the summary statistics of the treatment variables, Orthodox Christian children represent 71% of the sample and the remaining 28% represent non-Orthodox Christian. Among the Orthodox children, 85% of them are exposed to the fasting period and 15% of them are non-exposed which considered as certainly not exposed to fasting. Similarly, from the total non-Orthodox sample 87% them are overlapped with the fasting period though they are not expected to be exposed to fasting while they were in utero. This shows the

Table 1: Summary statistics of the Full Sample

Variable	Mean	Std. Dev.	N	Min	Max
Orthodox Christian	0.712	0.453	1883	0	1
non-Orthodox	0.288	0.453	1883	0	1
Sex(Female=2)	1.473	0.499	1883	1	2
Exposed Child	0.849	0.358	1885	0	1
non-Exposed	0.151	0.358	1885	0	1
Month Zero	0.14	0.347	1885	0	1
First Trimester	0.258	0.438	1885	0	1
Secood Trimester	0.402	0.49	1885	0	1
Third Trimester	0.05	0.219	1885	0	1
PPVT	68.343	36.765	1855	8	167
EGRA	3.517	2.197	1505	0	12
Mother's Education	3.002	3.816	1865	0	15
Mother's Age	27.478	6.389	1834	15	55
Siblings(yes=2)	1.217	0.412	1881	1	2
Marital Status	.864	.342	1885	0	1
Wealth index	.329	.175	1883	.007	.864
Age in months	97.487	4.048	1881	86	138

Table 2: Descriptive statistics of Orthodox and non-Orthodox children

	Non-Orthodox			Orthodox		
	Mean	Std.Dev.	N	Mean	Std. Dev.	N
Exposed	0.871	0.336	542	0.841	0.366	1341
Non-Exposed	0.129	0.336	542	0.159	0.366	1341
Month Zero	0.144	0.351	542	0.138	0.345	1341
First Trimester	0.295	0.457	542	0.243	0.429	1341
Secood Trimester	0.395	0.489	542	0.404	0.491	1341
Third Trimester	0.037	0.189	542	0.056	0.23	1341
PPVT	70.406	35.413	537	63.279	37.117	1318
EGRA	3.552	1.996	221	3.511	2.231	1284
Mothers' Education	2.536	3.395	537	3.187	3.961	1326
Month of Birth	6.873	3.333	542	6.574	3.377	1341
Mother's age	27.228	5.628	536	27.581	6.678	1298
Siblings	1.172	0.378	541	1.235	0.424	1340
Marital Status	1.085	0.404	542	1.269	0.671	1341
Wealth index	0.301	0.169	542	.341	.176	1341

Table 3: Summary statistics of gender specific non-Orthodox Christian children

	Male			Female		
	Mean	Std.Dev.	N	Mean	Std. Dev.	N
Exposed	0.873	0.334	275	0.869	0.338	267
Non-Exposed	0.127	0.334	275	0.131	0.338	267
Month Zero	0.113	0.317	275	0.176	0.382	267
First Trimester	0.327	0.47	275	0.262	0.441	267
Second Trimester	0.393	0.489	275	0.262	0.441	267
Third Trimester	0.04	0.196	275	0.034	0.181	267
PPVT	64.395	37.124	271	62.143	33.612	266
EGRA	3.38	1.876	100	3.76	2.123	121
Mothers' Education	2.581	3.467	272	2.491	3.326	265
Month of Birth	6.767	3.358	275	6.981	3.309	267
Mother's age	27.077	5.513	271	27.381	5.75	265
Siblings	1.182	0.387	274	1.161	0.368	267
Marital Status	0.873	0.334	275	0.293	0.164	267
Wealth index	0.293	0.164	267	0.309	0.174	275
Age in month	97.117	3.983	275	97.697	4.417	267

ratio of the orthodox and non-Orthodox who are overlapped with the fasting period in utero are almost balanced. In like manner, the gender ratio of the sample is also balanced (there are 890 girls and 993 boys). Additionally, 623 of the females are Orthodox and 83% of them are exposed to fasting while out of 718 male Orthodox children 84% them are exposed to fasting (see Table 3). And also among 542 non-Orthodox there are 267 female and 275 male children and 86% and 87% of them are overlapped with the fasting period respectively.

Table 4: Summary Statistics of Gender Specific Orthodox Christian Children

	Female			Male		
	Mean	Std.Dev.	N	Mean	Std. Dev.	N
Exposed	0.836	0.37	623	0.845	0.362	718
non-Exposed	0.164	0.37	623	0.155	0.362	718
Month Zero	0.136	0.344	623	0.139	0.346	718
First Trimester	0.225	0.418	623	0.259	0.438	718
Second Trimester	0.419	0.494	623	0.391	0.488	718
Third Trimester	0.056	0.23	623	0.056	0.23	718
PPVT	67.92	37.636	615	68.72	36.684	703
EGRA	3.558	2.184	689	3.485	2.272	595
Mother's Education	3.107	3.865	615	3.256	4.043	711
Month of Birth	6.674	3.376	718	6.674	3.376	718
Mother's Age	27.446	6.751	603	27.698	6.616	695
Siblings	1.247	0.432	623	1.225	0.418	717
Marital Status	1.27	0.655	623	1.269	0.686	718
Age in months	97.313	4	622	97.7	3.961	717

Turning to the different levels of the gestation, as we can see in the summary statistics table Month zero (conceived during fasting), First, Second, and Third Trimester represent 14%, 25%,40% and 5% of the sample size and the remaining 12% of the samples are belongs to those who are certainly non-exposed to fasting. When we closely look into the gestation levels the second trimester is larger than the others and the sample size of Orthodox Children who fall to the third trimester are relatively smaller. However, the distribution Orthodox and non-Orthodox to the exposure of fasting during the time in utero are almost evenly distributed as it is presented in Table 2 and 3.

Turning to the control variables, the followings are measured during the first round survey when the child was between 6-18 months, such as; gender, the month of birth, mother's age, a binary indicator if the child has a sibling and a binary indicator of the mother if she is married. The following variables are measured on the third round survey when the child was taking the cognitive test: school distance, mother years of education, and gross income of the family. The summary statistics of the control variables, as we can see the in Tables, the study considers the following variables in order to control for the individual characteristics, age of the child in months, gender, mother's education, age of the mother, if the mother is married and gross income of the household. On average the index child has sibling in every household. And also on average mothers achieve 3 grade and mother's education stands for minimum 0 and maximum 15 the highest grade they achieve

Wealth index is a household level variable measuring the well-being of the household in the range between zero and one. It is a composite variable made up of three important components: housing quality, consumer durables, and services accessibility (see Woldehanna (2011) for details about the construction of the wealth index). Value of the wealth index close to one is an indication that the household is wealthier.The average wealth index is 0.33 and the maximum and the minimum stands for 0.86 and 0.007.

5 Empirical Strategy

The main objective of this study is to investigate the effect of fetal malnutrition on cognitive development of the children using an innovative identification strategy, exposure to the "Great Easter Fasting", assuming some Orthodox Christian mothers in Ethiopia might have fasted during pregnancy. However, estimating the fetal malnutrition on children cognitive development may face two potential econometric challenges. The first one is the fetal malnutrition may not be random with respect to the cognitive test performance. Therefore, implementing the right strategy to deal with the endogeneity would help us from obtaining biased estimates. To deal with this problem I exploit the coincidence of the Easter fasting with the period of pregnancy as a natural experiment. So that, I can compare the cognitive test outcome of children who were in utero during the months of fasting with those who were not, assuming that some Orthodox women might have fasted during Easter fasting while they were pregnant with the child in question. That means, I actually do not observe if the Orthodox mothers have fasted or not, instead, this thesis follow an intent to treat effect (ITT). By using ITT, I am implicitly assuming Orthodox Christian mothers who decide to fast are different from those who does not in both observable and non-observable ways (Almond et al., 2011). And this approach is expected to produce a lower (conservative) bound of the true effect even though the actual fasting rate is believed to be higher. The second challenge is the potential seasonality on the cognitive development of the children. For example, Currie and Schwandt (2013) show that children conceived in the month of May are more likely to be premature since gestation length for these children coincides with a higher influenza prevalence in January and February when these babies are nearing full term. Children conceived during summer may have different cognitive development than children conceived during another season. Therefore, failing to account such problems may give us bias estimate. To deal with this problem the study employ the sample of non-Orthodox children in a difference in difference strategy.

Considering non-Orthodox as a control and Orthodox as a treatment group this study employ a difference-in-differences strategy to account for the impact of seasonality on cognitive development. The main assumption is any effect on the cognitive test score of non-Orthodox children should be due to seasonality since coincidence of Easter fasting should not matter for them. In a regression framework, the difference-in-difference specification is as follows;

$$Y_i = \alpha_0 + \alpha_1 Orthodox_i + \beta_0 Conceived\_during\_Fasting_i * Orthodox_i + \Sigma_{j=1}^{3} \beta_j Trimester_{ij} * Orthodox_i$$
$$+ \alpha_2 X_i * Orthodox_i + \mu_0 Conceived\_during\_Fasting_i + \Sigma_{j=1}^{3} \mu_j Trimester_{ij} + \alpha_3 X_i + \epsilon_i$$

where Y represents either of PPVT or EGRA cognitive development tests for child i. The four treatment variables are "Conceived during Fasting" (Month 0) which is a binary indicator for whether child i was conceived during the months of fasting or not. And the rest three treatment variables, Trimester_{i1}, Trimester_{i2} and Trimester_{i3} are also binary indicators for whether the beginning of the fasting coincided with the 1st, 2nd, or 3rd trimester of pregnancy of the mother of child i, respectively. The omitted category includes those who were certainly not exposed to fasting. The vector X represents the series of control variables such as age of the child, mother's age and mother's age squared, binary indicators for month of birth and siblings, a binary indicators of mother's marital status, mother's education, and gross income of the household. All of these variables are interacted with the *Orthodox* indicator. Finally, this thesis also control for region fixed effects to account for difference that might be correlated with the socio-economic, cultural and religious characteristics. In equation (1), $\beta_0 - \beta_3$, are the difference-in-difference estimates which represent the impact on the test scores of those Orthodox who are exposed to fasting during a particular trimester in utero compared to Orthodoxes with no fetal exposure to fasting, relative to any effect that might exist for non-orthodox children due to seasonality.

6 Findings and Discussions

I start the discussion by estimate the Difference-in-difference specification without the control variables. This estimate is based on those who are Orthodox and were in utero and who were not in utero during the Easter fasting, relative to the non-Orthodox children.

The first two columns in Table 5 shows the estimation result of both test scores: PPVT and EGRA without the control variables and column (3) and (4) with the control variables. As we can see in column (1) Orthodox children who are exposed to fasting in their first trimester scored 0.2 lower standardized score on their PPVT test than their non-Orthodox counterparts. The result is significant at a 1 percent level. Though it is barely significant, children who are also exposed in their second trimester also scored 0.13 lower standardized score on their PPVT test. Other than, the result I find for the first and second trimester of PPVT test score, none of them are statistically significant. One explanation for these null effects could be due to the sample size of the data. Compared to other related works on *Ramadan*, the sample is relatively smaller. This may potentially hide the true effect of being Orthodox and exposed to fasting during pregnancy period.

In Table 5 column (3) and (4) I estimate the difference-in-difference equation (1) controlling important factors that can potentially affect the child's cognitive development and could make the mean of the error term different from zero. In addition, I also include region and month dummy fixed effects. The result is presented for both outcome measures, estimates for binary indicator representing conception during fasting and three dummy variables exposed in one of the three trimesters of pregnancy. As can be seen in column (3) and (4) of Table 5, the PPVT test result shows a significant negative effect for those who are exposed to fasting in their first and second trimester and the results are larger in magnitude and much precise compared to the previous columns. In addition, in this estimation, I find a negative and significant effect on children who are exposed to fasting during the first trimester on their EGRA test as well. However, the result is very small and weak.

Turning to the series of control variables presented in Table 5, most of them show a consistent result in both outcome variables estimation cases; for instance, in both cases Mother's education positively affects the child's performance on both outcome measures and they are significant at a 1 percent level, Mother's age square has also the same effect. On the other hand, gender difference and having siblings have shown a negative effect on the test performance of both PPVT and EGRA tests. Moreover, wealth contributed positively to the PPVT test performance of the Orthodox children while mother's being married has no effect on the children test score.

This implies the effect of exposure to fasting in utero is larger in the first three months of the pregnancy and this is consistent with the hypothetical prediction of most related literature. However, except the effect of exposure to the first trimester on PPVT test, the other effects are still not precise and strong. An alternative explanation could be exposure to fasting in utero on the test scores might be heterogeneous along various characteristics of Orthodox children. For example, differences in gender, age, and family socoeconomic background. At least there is an effect in one of the gestation levels so it is good to see if there is variation in gender and socioeconomic status and try to figure out the true effect of exposure to fasting on child cognitive development.[3]

Table 6 show estimates of the effect of fetal malnutrition on cognitive development of girls and boys of Orthodox children. The Table shows the estimate of the female and male for both outcome variables. The result indicates that the effect strong and the estimates are also much precise in this estimation compared to Table 5. For instance, in column (1) Tabel 5, the first and second trimester effects persists for PPVT test score in Table 6 as well. Specifically, the second trimester in utero exposure to the fasting is associated with 0.21 score reduction in PPVT test score among Orthodox girls and it is significant at 5 percent level. Moreover, there is also a 0.46 standardized score reduction on those who are exposed in their first trimester, which is higher in magnitude than for both the full sample with and without controls estimates. Furthermore, unlike the full sample estimate, I also obtain a negative first and third trimester effect for EGRA test score among Orthodox girls. In the previous case, the effect was shown only on the first trimester and it was significant but weak. The estimate for males for both PPVT and EGRA test shows much smaller effect in magnitude, estimated without much precession and non significant for all indicators and the signs are also non consistent with all cases.

[3]For instance,Jones and Crawford (2006) and Guryan et al. (2008) shows how exposure to fasting is differently affects female and male students.

Table 5: Difference-in Difference Full Sample Estimate of the Effect of Fetal Exposure to Fasting on Test Scores of Orthodox Children

	(1) PPVT W/O Controls	(2) EGRA W/0 Controls	(3) PPVT with Controls	(4) EGRA with controls
Orthod	0.194***	-0.039	0.519	2.467*
	(0.060)	(0.082)	(0.775)	(1.258)
Month Zero*	0.023	-0.027	-0.005	0.038
	(0.057)	(0.063)	(0.064)	(0.088)
First Trimester*	-0.200***	-0.044	-0.240***	-0.097*
	(0.075)	(0.114)	(0.066)	(0.054)
Second Trimester*	-0.136*	0.022	-0.103**	0.142
	(0.075)	(0.101)	(0.043)	(0.101)
Third Trimester*	-0.118	-0.066	-0.004	-0.211
	(0.138)	(0.199)	(0.118)	(0.206)
Sex*			-0.049***	-0.063***
			(0.014)	(0.021)
Married*			0.094	0.075
			(0.096)	(0.129)
Mum's Age*			-0.030	-0.078
			(0.027)	(0.056)
Mum'sAgeSq*			-0.011***	-0.061***
			(0.001)	(0.001)
Mum's Edu*			0.044***	0.032***
			(0.012)	(0.010)
Age in month*			-0.011**	-0.014**
			(0.006)	(0.007)
Wealth*			0.159***	0.104**
			(0.040)	(0.052)
Sibling*			-0.152**	-0.206**
			(0.068)	(0.089)
MonthZero	0.072	0.047	-0.110	0.023
	(0.049)	(0.058)	(0.082)	(0.108)
FirstTrimester	0.277***	-0.051	0.061	-0.127
	(0.065)	(0.102)	(0.101)	(0.150)
SecoodTrimester	0.237***	0.031	0.010	-0.099
	(0.065)	(0.089)	(0.088)	(0.131)
ThirdTrimester	0.334***	0.023	-0.030	-0.062
	(0.122)	(0.185)	(0.132)	(0.219)
Sex			0.002	0.078
			(0.035)	(0.064)
Married			-0.126	-0.047
			(0.089)	(0.122)
Mum's Age			0.024	0.095*
			(0.023)	(0.053)
Mum's Age Sq			-0.021	-0.032*
			(0.017)	(0.019)
Mum's Edu			0.030***	0.013**
			(0.006)	(0.06)
Age in Mon			0.019***	0.019**
			(0.006)	(0.008)
Wealth			0.263***	0.242**
			(0.035)	(0.099)
Sibling			0.144**	0.238***
			(0.056)	(0.077)
_cons	3.805***	1.168***	2.398***	-2.035*
	(0.053)	(0.073)	(0.716)	(1.173)
N	1855	1430	1793	1375
RegionFE			yes	yes
MonthdummyFE			yes	yes

Robust standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Trimesters* is an interaction between Orthodox and the trimesters ($\beta_0 - \beta_3$, the DID estimates)
X* is also an interaction (X*Orthodox)

Table 6: Difference-in Difference Estimate of the Effect of Fetal Exposure to Fasting on Test Scores of Female and Male Orthodox Children

	(1) Female PPVT	(2) Male PPVT	(3) Female EGRA	(4) Male EGRA
Orthodox	-1.043	1.979	2.830	1.675
	(1.114)	(1.217)	(1.894)	(1.766)
Month Zero*	-0.046	0.042	0.012	0.088
	(0.091)	(0.091)	(0.131)	(0.126)
First Trimester*	-0.459***	-0.052	-0.181**	-0.146
	(0.095)	(0.096)	(0.082)	(0.149)
Second Trimester*	-0.214**	-0.012	-0.026	0.196
	(0.090)	(0.090)	(0.147)	(0.143)
Third Trimester*	-0.092	0.093	-0.170**	0.406
	(0.145)	(0.182)	(0.086)	(0.255)
Married*	0.070	0.072	0.078	-0.031
	(0.126)	(0.138)	(0.154)	(0.201)
Sibling *	-0.194**	-0.145	-0.129	-0.295***
	(0.095)	(0.096)	(0.131)	(0.112)
Mum's Age*	-0.020	-0.066	-0.121	0.008
	(0.037)	(0.046)	(0.078)	(0.074)
Mum's Age Square*	0.000	0.001	0.002	-0.000
	(0.001)	(0.001)	(0.001)	(0.001)
Mum's Education*	0.033***	0.022**	0.023***	0.009
	(0.010)	(0.010)	(0.005)	(0.013)
Age in Month*	0.016*	-0.012	-0.015	-0.014
	(0.009)	(0.009)	(0.015)	(0.012)
Wealth*	0.105*	0.211***	0.213***	0.074***
	(0.054)	(0.058)	(0.033)	(0.017)
MonthZero	-0.098	-0.097	0.093	-0.116
	(0.128)	(0.114)	(0.143)	(0.180)
FirstTrimester	0.139	-0.023	-0.026	-0.152
	(0.151)	(0.145)	(0.211)	(0.224)
SecondTrimester	0.088	-0.030	0.059	-0.248
	(0.132)	(0.124)	(0.178)	(0.209)
ThirdTrimester	-0.022	-0.081	-0.034	-0.301
	(0.165)	(0.206)	(0.301)	(0.286)
Married	-0.044	-0.165	-0.102	0.113
	(0.114)	(0.130)	(0.144)	(0.190)
Sibling	0.153**	0.182**	0.207*	0.281***
	(0.076)	(0.082)	(0.115)	(0.092)
Mum's Age	-0.001	0.080*	0.145**	0.000
	(0.032)	(0.041)	(0.073)	(0.071)
Mum's Age Square	0.000	-0.001*	-0.002*	0.000
	(0.001)	(0.001)	(0.001)	(0.001)
Mum's Education	0.033***	0.024***	0.003	0.034***
	(0.008)	(0.009)	(0.014)	(0.012)
Age in Mon	0.011	0.027***	0.025	0.016*
	(0.009)	(0.009)	(0.015)	(0.008)
Wealth	0.214***	0.311***	0.343***	0.071
	(0.046)	(0.052)	(0.131)	(0.143)
_cons	3.268***	0.846	-3.117	-0.702
	(1.030)	(1.259)	(1.926)	(1.580)
N	851	942	742	633
$RegionFE$	Yes	yes	Yes	Yes
$MonthdummyFE$	Yes	Yes	yes	yes

Robust standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Trimesters* is an interaction between Orthodox and the trimesters ($\beta_0 - \beta_3$, the DID estimates)
X* is also an interaction (X*Orthodox)

Table 7: Difference-in Difference Estimate of the Effect of Fetal Exposure to Fasting on Test Scores of Low-SES Orthodox Children

	(1) Full Sample PPVT	(2) Full Sample EGRA	(3) Female PPVT	(4) Male PPVT	(5) Female EGRA	(6) Male EGRA
Orthodx	0.287	2.151	-0.945	0.827	2.496	0.275
	(1.110)	(2.246)	(1.629)	(1.969)	(3.526)	(2.971)
Month Zero*	0.031	-0.009	0.033	0.037	0.046	-0.059
	(0.082)	(0.109)	(0.111)	(0.131)	(0.139)	(0.175)
First Trimester*	-0.196**	-0.082**	-0.405***	0.105	-0.176**	-0.267
	(0.098)	(0.039)	(0.138)	(0.147)	(0.088)	(0.282)
Second Trimester*	-0.057	0.046	-0.172	0.103	-0.124	0.070
	(0.095)	(0.158)	(0.134)	(0.141)	(0.137)	(0.212)
Third Trimester*	-0.080*	0.091	-0.338***	0.186	-0.080	-0.012
	(0.046)	(0.265)	(0.110)	(0.288)	(0.139)	(0.333)
Sex*	-0.050***	-0.034***				
	(0.016)	(0.003)				
Married*	-0.022	0.203	0.030	-0.008	0.343	0.087
	(0.174)	(0.204)	(0.169)	(0.361)	(0.244)	(0.272)
Sibling*	-0.148**	-0.206**	-0.077**	-0.247**	-0.281**	-0.055
	(0.120)	(0.104)	(0.035)	(0.123)	(0.124)	(0.048)
Mum's Age*	-0.016	-0.016	-0.025	0.017	-0.200	0.149
	(0.038)	(0.089)	(0.054)	(0.070)	(0.132)	(0.138)
Mum's Age Square*	0.000	0.000	0.000	-0.000	0.004	-0.003
	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.003)
Mum's Education*	0.027***	0.065***	0.027***	0.023***	0.040***	0.099***
	(0.008)	(0.039)	(0.013)	(0.007)	(0.006)	(0.006)
Age in Month*	0.003	0.016	0.016	0.009	0.004	0.017
	(0.009)	(0.017)	(0.013)	(0.014)	(0.026)	(0.018)
Wealth*	0.102**	0.117	0.061	0.159**	-0.028	0.329*
	(0.049)	(0.151)	(0.063)	(0.077)	(0.199)	(0.187)
MonthZero	0.041	0.013	0.036	0.077	-0.029	0.047
	(0.065)	(0.092)	(0.087)	(0.105)	(0.119)	(0.148)
FirstTrimester	0.185**	-0.076	0.260***	0.111	0.044	0.051
	(0.074)	(0.181)	(0.096)	(0.118)	(0.256)	(0.263)
SecondTrimester	0.087	0.020	0.140	0.034	0.155	0.033
	(0.076)	(0.142)	(0.106)	(0.114)	(0.205)	(0.196)
ThirdTrimester	0.078	-0.134	0.062	0.059	0.047	-0.263
	(0.137)	(0.235)	(0.136)	(0.235)	(0.327)	(0.277)
Sex	0.009	0.022				
	(0.050)	(0.109)				
Married	-0.126	-0.231	-0.011	-0.295	-0.419*	-0.034
	(0.162)	(0.190)	(0.137)	(0.352)	(0.217)	(0.250)
Siblings	0.152*	0.307*	0.091	0.241*	0.267	0.311*
	(0.086)	(0.160)	(0.111)	(0.133)	(0.289)	(0.178)
Mum's Age	0.047	0.053	0.036	0.039	0.230*	-0.092
	(0.029)	(0.082)	(0.038)	(0.062)	(0.123)	(0.127)
Mum's Age Square	-0.001	-0.001	-0.001	-0.000	-0.004*	0.002
	(0.000)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)
Mum's Education	0.034**	0.046	0.038**	0.023	0.027	0.068
	(0.014)	(0.036)	(0.018)	(0.023)	(0.042)	(0.062)
Age in Month	0.020***	0.013	0.019**	0.022*	-0.004	0.014
	(0.006)	(0.016)	(0.008)	(0.012)	(0.025)	(0.015)
Wealth	0.187***	0.111	0.132***	0.244***	0.280	-0.146
	(0.039)	(0.146)	(0.048)	(0.065)	(0.195)	(0.173)
_cons	1.277	-1.085	1.373	1.257	-1.439	0.113
	(0.831)	(2.057)	(1.037)	(1.749)	(3.322)	(2.616)
N	808	541	394	414	289	252
RegionFE	Yes	yes	Yes	Yes	Yes	Yes
MonthdummyFE	Yes	Yes	yes	yes	Yes	Yes

Robust standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Trimesters* is an interaction between Orthodox and the trimesters ($\beta_0 - \beta_3$, the DID estimates)
X* is also an interaction (X*Orthodox)

Finally , I run the difference-in-difference estimate based on social economic status (SES). The social-economic status is defined based on the household employment and mother's education level. Children with mother's primary education not completed and household head unemployed classified as low social economic status. Based on this definition There are 534 Orthodox and 312 non-Orthodox children who are classified as low-SES in the sample. The study was unable to define low-SES better than this, given the available data (see for example, a study by Greve et al. (2015)[4]).

In Table 7 the estimate of low-SES are not indeed different from the previous two tables in a pattern, however, the effects are more precise, strong and the magnitudes are also larger. To begin with the full sample estimates, in column (1) and (2) it shows Orthodox Christian children who are from low-SES and exposed to fasting during different levels of gestation period performed significantly lower on both PPVT and EGRA tests. For example, Orthodox Christian children who are exposed to fasting in the third trimester scored 0.08 lower on PPVT test than their non-Orthodox counterparts. Moreover, Orthodox Christian children who are exposed to fasting during the first trimester gestation period scored 0.19 and 0.08 lower standardized score than the non-orthodox children respectively. Statistically these results are significant at a 5 level.

Moving to gender specific low-SES estimate presented in column (3-6) of Table 7 shows the PPVT and EGRA test scores consecutively, in which female children from low-SES performances are lower and they are significantly affected by their cognitive development test score than their male Orthodox children counterparts. For instance, in column(3) the test result is associated with 0.4 and 0.3 lower standardized score for children exposed during first and third trimester respectively on the PPVT cognitive test. Moreover, female Orthodox Christian children from low-SES who were exposed to fasting during first trimester in utero scored 0.17 lower standardized score in the EGRA test and the result is significant. However, the male counterpart performance in both tests has shown almost no effect with very small magnitude and non-consistent sign.

We find more significant values on the last estimation than the previous two. This may imply the effect of exposure to fasting during pregnancy is more pronounced on children who are from the low socio-economic background than the others. This may be due to the inability of the family to compensate the exposed children afterwards. Moreover, the exposure to fasting affects females than male children; and the effect is higher particularly when they are from low-SES socio-economic background.

[4]in this study the authors define, students coming from low-SES are defined as with mother that had no work and an education less than grade nine when the student was at age 15 and was taking the exam.

Robustness Check: Placebo Test

To examine the identification strategy, I conducted a ”placebo” test by taking a non-Orthodox Christian children whose mothers pregnancy period overlapped with the fasting period as a treatment group and the others who are non-Orthodox and their time in utero certainly non overlapped with the fasting period as a control group. Out of the total of 543 non-Orthodox Christian children in the data there are 160 in first, 214 in second and 20 in the third trimester whose their pregnancy period overlapped with the fasting season. From non-Orthodox there are 78 children whose pregnancy period started during the fasting and 70 children their pregnancy ”certainly not overlapped” with the fasting season. I run the same specification using the certainly non-exposed group as a control and the others as a treatment. If I find “effect” on the treatment group, given that we know they are non-Orthodox and they do not observe the Easter fasting I would be concerned. Any such placebo effect might suggest the identification strategy is not good enough and it does not address the problem of seasonality properly.

As we can see the estimate result in Table 8()presented in the appendix section), column (1) and (2) shows only the four dummy indicators of the different gestation level without the control variables and column (3) and (4) shows the estimate with the control variables. The estimate results show almost all coefficients are not different from zero, it is only one effect. out of all gestation level indicator for both outcome measures there is only one significant result at 10 percent level. I also try to estimate for non-low SES, based on the definition that household head is employed and child with their mother primary education completed. Since there are very few observation we couldn’t define high-SES based on their income status. And as we can see the estimate result in Appendix 2, I find no effect except the only one in column (6) the male result for month zero (conceived during fasting) for EGRA test shows positive and barely significant at 10 percent level. Arguably, this coould be due to the control group size which is small and there could also be data anomaly. Further, I find no evidence that shows there is a systematic pattern in the effects on Orthodox Christian children that are in any way an artifact of seasonality.

7 Conclusion

The main objective of this paper is to provide causal evidence on the effect of fetal exposure to malnutrition on the cognitive development of Orthodox Christian children. To this end, I use Young-lives survey data from Ethiopia and employ difference-in-difference empirical framework. The outcome variables the study uses are the standardized test scores of Peabody Picture Vocabulary Test (PPVT) and Early Grade Reading Assessment (EGRA) taken by children at the age of between 7 and 8.

The results show that fetal exposure to fasting has a negative and significant effect on the cognitive development of Orthodox Christian children, especially children exposed in their first trimester are more vulnerable than the other two trimesters. Moreover, the study shows girls are relatively more victims than their counterparts boys. The result of this study further reveals that the negative effect is more exacerbate on Orthodox Christian children who are from low social socio-economic background and female. This result implies milder forms of malnutrition due to exposure to fasting, besides lowering cognitive development of children it may also complicate the effort of policymakers in narrowing down the economic inequality between high and low SES groups of the society.

Finally, though the study focuses on specific religion group (Orthodox Christian) religious activity and its sequential negative effect, the results obtained from the study are relevant for all religion groups and societies across the world. Fasting due to religious faith, meal skipping, dieting and inadequate nutrition and care during pregnancy are some of the reasons for fetal insults that could potentially occur in all corners of the world regardless of their development status. However, the intervention activities and the total amount of fund that has been put in place to tackle these problems have been very insignificant both in national and international level, unlike the total expenditure and fund that has been disbursed to avert severe situations after extreme natural disasters like drought and famine. The finding of this study indicates that intervention activities would be effective if they are at earliest stage at possible. Interventions that focuses on low-income pregnant women and all prenatal investments would have strong social and economic long-term positive effects in individuals life in particular and the societal and national level in general. For future research, I recommend, other researchers to investigate the reasons behind the strong negative effect of fetal malnutrition on girls than boys. It requires, further study to know the reason if it is biological, economical or behavioural (family response after shock). I believe, knowing the reasons would bring vital information for policymakers intervention decision and for future investigation in the topic.

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Appendix

Table 8: Placebo Test: Difference-in Difference Estimate vs Estimate of Fetal Exposure to Fasting on Test Scores of non- Orthodox Children

	(1) PPVT W/O Controls	(2) EGRA W/O Controls	(3) Full Sample PPVT	(4) Full Sample EGRA
MonthZero	-0.025	-0.052	0.230*	0.257
	(0.091)	(0.139)	(0.119)	(0.168)
FirstTrimester	0.226	0.100	0.015	0.361
	(0.277)	(0.112)	(0.136)	(0.292)
SecondTrimester	0.185	0.018	0.175	0.251
	(0.177)	(0.100)	(0.125)	(0.184)
ThirdTrimester	0.282	0.026	0.279	0.363
	(0.229)	(0.191)	(0.178)	(0.304)
Sex			0.005	0.081
			(0.035)	(0.065)
Married			-0.084	-0.041
			(0.092)	(0.134)
Mum's Age			0.019	0.073
			(0.023)	(0.051)
Mum's Age Square			-0.000	-0.001
			(0.000)	(0.001)
Mum's Education			0.027***	0.011
			(0.006)	(0.010)
Age in Month			0.022***	0.019**
			(0.006)	(0.007)
Wealth			0.251***	0.228**
			(0.036)	(0.105)
Sibling			0.111**	0.174**
			(0.056)	(0.083)
_cons	3.856***	1.217***	2.326***	-1.459
	(0.067)	(0.085)	(0.729)	(1.125)
N	537	213	527	206
$RegionFE$			yes	yes
$MonthdummyFE$			yes	yes

Robust standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 9: placebo:Difference-in Difference Estimate of the Effect of Fetal Exposure to Fasting on Test Scores of non Low-SES Orthodox Children

	(1) Full Sample PPVT	(2) Full Sample EGRA	(3) Female PPVT	(4) Male PPVT	(5) Female EGRA	(6) Male EGRA
MonthZero	0.337	0.417	0.234	0.663	0.932	0.438*
	(0.277)	(0.402)	(0.233)	(0.463)	(0.597)	(0.230)
FirstTrimester	0.081	0.207	0.126	0.435	0.609	0.108
	(0.195)	(0.351)	(0.148)	(0.326)	(0.486)	(0.589)
SecondTrimester	0.366	0.160	0.192	0.818	0.161	0.102
	(0.283)	(0.311)	(0.211)	(0.646)	(0.471)	(0.597)
ThirdTrimester	0.350	0.249	0.350	0.714	0.599	0.000
	(0.240)	(0.520)	(0.216)	(0.540)	(0.670)	(.)
Sex	0.041	0.029				
	(0.045)	(0.122)				
Married	-0.033	-0.339	0.182	-0.185	-0.590	-0.101
	(0.139)	(0.303)	(0.141)	(0.299)	(0.353)	(0.422)
Siblings	0.063	0.241	-0.031	0.197*	0.467	0.077
	(0.075)	(0.184)	(0.091)	(0.115)	(0.323)	(0.169)
Mum's Age	0.012	0.025	0.001	0.006	0.251	-0.034
	(0.027)	(0.087)	(0.031)	(0.066)	(0.212)	(0.108)
Mum's Age square	-0.000	-0.000	-0.000	0.000	-0.005	0.001
	(0.000)	(0.002)	(0.000)	(0.001)	(0.004)	(0.002)
Mum's Education	0.020	0.042	0.021	0.008	0.045	0.011
	(0.013)	(0.038)	(0.016)	(0.020)	(0.060)	(0.054)
Mum's Age	0.017**	0.017	0.014*	0.024	0.006	0.010
	(0.007)	(0.010)	(0.007)	(0.020)	(0.028)	(0.009)
Wealth	0.224***	0.111	0.157***	0.277***	0.459	-0.114
	(0.043)	(0.170)	(0.051)	(0.070)	(0.468)	(0.236)
_cons	3.114***	-0.493	3.369***	2.958	-2.237	1.017
	(0.874)	(1.861)	(0.947)	(2.215)	(4.055)	(2.262)
N	305	91	162	143	45	46
RegionFE			yes	yes		
MonthdummyFE			yes	yes		

Robust standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$