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Life-long Effects of Prenatal Malnutrition
Evidence from Gestation during Ramadan

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Tesis de Maestría en Economía

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Efectos de largo plazo de la desnutrición prenatal
Evidencia de la gestación durante el Ramadán

Abstract

La evidencia empírica muestra que la desnutrición prenatal no sólo tiene impactos en los en la niñez y la adolescencia, sino que también en su salud, desempeño académico y en el mercado laboral en la edad adulta. La mayor parte de la evidencia se ha centrado en la salud más que en los resultados educativos y del mercado laboral, y se ha basado principalmente en experimentos naturales, que tienden a correlacionarse con otros eventos. En este documento, se utiliza la exposición al ayuno de Ramadán en Nigeria para medir los efectos de la desnutrición prenatal en la salud, la educación y los resultados del mercado laboral a lo largo del ciclo de vida de los varones. Dado que las fechas de Ramadán están determinadas por el calendario lunar y varían cada año, la exposición al ayuno durante el embarazo está determinada exógenamente, es posible evaluar los efectos de la desnutrición prenatal a corto y largo plazo. Este trabajo comprende que los choques y las intervenciones posteriores pueden interactuar de manera compleja. Por lo tanto, este documento toma en cuenta los vínculos entre los resultados de la salud, la educación y el mercado laboral en diferentes etapas de la vida. Los impactos tempranos sobre la salud (puntuaciones de peso y talla al nacer) son negativos y estadísticamente significativos, así como los efectos sobre la repetición escolar y los salarios. Sin embargo, la exposición durante diferentes períodos de gestación adquiere relevancia para la repetición escolar y los salarios, lo que sugiere interacciones más complejas entre los choques y las intervenciones posteriores.

Palabras clave: Ramadan, desnutrición, peso al nacer, educación, salarios, ingreso

Life-long Effects of Prenatal Malnutrition
Evidence from Gestation during Ramadan[1]

Abstract

Empirical evidence shows that prenatal malnutrition not only has impacts on kids' childhood and adolescent outcomes, but it also has long-term effects on those children's adult health and academic and labor market performance. This has strong implications on countries' human capital development. Most evidence has been focused on health rather than educational and labor market outcomes, and has relied mostly on natural experiments, such as famines, wars and pandemics, which tend to be correlated with other shocks. In this paper, we take advantage of Nigerian exposure to Ramadan's fasting in order to measure the effects of prenatal malnutrition on health, education and labor market outcomes over individuals' life cycle. Given that Ramadan's dates are determined by the lunar calendar and vary each year, the exposure to fasting during pregnancy is exogenously determined by Ramadan's and pregnancy dates. The dataset allows to track male individuals over different life stages to evaluate the effects of prenatal malnutrition in the short and long-run. This work understands that the shocks and later interventions may interact in complex ways. As a result, the purpose of this paper is account for links between health, educational and labor market outcomes. The early impacts on health (birth weight and height scores), are negative and statistically significant, as well as the effects on school repetition and wages. However, exposure during different gestation periods take relevance for school repetition and wages, suggesting more complex interactions between shocks and later interventions.

Keywords: Ramadan, Fasting, Birth Weight, Height-for-Age Z-Score, Education, Wage, Income.

JEL classification: I12, J16, O15, O17, Z12

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1 Introduction

There is an established consensus in the economics literature that early events in life, such as pre-natal shocks affect well-being in the long-run (Doyle et al., 2009). Moreover, evidence shows that even relatively mild pre-natal shocks caused by nutritional disorders (including disease and stress), environmental conditions (pollution and weather shocks), and the effect of substances such as alcohol and tobacco, can have substantial negative impacts (Almond, Currie and Duque, 2018).

Regarding these nutrition shocks, economists have expanded evidence for the fetal origins hypothesis (FOH) which establishes that maternal malnutrition forces the fetus to allocate its scarce nutritional resources to its most crucial organs, especially its brain, as a protection mechanism (Godfrey Barker, 2001). Such strategy costs the growth of other organs, and depending on the length and the timing of the nutritional shortage, posterior damages could vary. The core insight of FOH is that the consequences of the nutritional shock appear in adulthood, specially causing coronary heart disease, diabetics (Van Ewijk, 2011), and kidney problems. Also, it could cause disability (Almond and Mazumder, 2011).

Early studies relied on natural experiments as wars and famines to evaluate the effects of pre-natal malnutrition on health and socio-economic outcomes. However, these events tend to be correlated with other shocks and they are mostly unpredictable and unsystematic. As a result, it is hard to separate the effects of nutritional shocks from other sources of distress which can also affect the outcome of interest. At the same time, it is difficult to determine the exact timing of the pre-natal exposure, implying additional identification challenges.

As oppose to natural experiments provided by wars or famines, exposure to Ramadan's fasting can be considered a controllable nutrition-related shock. During the lunar month of Ramadan, mature Muslims are supposed to fast during daylight hours. While pregnant Muslim are not necessarily required to fast, they usually follow the same tradition as the

rest of the community, but most important, pregnancy awareness comes about a month after conception. Thus, early pregnancy exposure to Ramadan is similar to random assignment process. Apart from this, the dietary disruptions within the household brought on by Ramadan can also have effects on the fetus, even if the pregnant mother does not fast. Given the predictability of Ramadan, understanding the aspects of the effects of exposure to it has immense implications for Muslims' health and well-bring, but also, it provide relevant insights to understand other nutritional shocks.

As mentioned before, in terms of the empirical strategy Ramadan's fasting provides a better framework than other natural experiments such as famines, natural disasters, and epidemics, where it is difficult to define the precise timeline of the event and the duration of the shock. In addition, it is easier to identify the population exposed to the shock (assign to treatment). Ramadan effects are less confounded with the impact of other shocks, while in the case of war and famines, there are usually other forms of stress and disorders.

To summarise the positive aspects of this empirical strategy to evaluate the effects of prenatal maternal malnutrition, Ramadan provides a better natural experiment than famines, natural disasters or epidemics because: 1) it allows for the identification of the time frame of the event, 2) there is a clear cut for the treated population, 3) it is easier to identify treated and control groups among Muslims and 4) the nutritional shock tend to be less correlated with other causes of distress. Furthermore, given that Ramadan's dates are determined by the lunar calendar, the exact dates of the holiday vary each year: they move forward by roughly 11 days. In this setting, the exposure to fasting during pregnancy will be exogenously determine by Ramadan's and pregnancy dates. Therefore, it allows for the provision of causal evidence for the impacts of Ramadan on different outcomes, under the assumption that pregnancies are not timed relative to Ramadan along unobserved determinants of health, educational and labor market outcomes.

Regarding the previous literature, specifically in the studies of Ramadan, the effect of prenatal maternal malnutrition on health outcomes has been vastly examined, but there

is not much evidence on the impacts on labor market. Besides, questions about the channels between pre-natal malnutrition shocks and labor market effects are still unanswered. In theory, there are two possible channels for this effect: cognitive and physical. Hindered cognitive abilities can be revealed by its negative effects on educational outcomes. Alternatively, or in combination with the cognitive channel, hampered physical abilities in the earliest stages of the life can lead to less fortunate labor market outcomes.

This paper uses exposure to Ramadan to measure the effect of prenatal maternal malnutrition on educational and labor market outcomes of male Muslims in Nigeria. It also provides evidence for the health effects on early development and childhood, which might be indicative of physical damages, using both birth weight and height. Additionally, to account for cognitive impacts, it relies on educational outcomes, using repetition at school. Finally, for the labor market outcomes, Ramadan's impacts are evaluated on wages.

The Ramadan literature, except for Majid (2012), has usually been focused on a specific outcome or specific life-stage. When multiple outcomes are studied, as in Almond and Mazumder (2011), data of different countries is used. Only Majid (2012, 2019) considers several outcomes over the life-cycle for the same socio-cultural background (Indonesia). Similar to Majid (2012, 2019) this work examines different outcomes in the same socio-cultural setting (Nigeria). However, this paper enhances the literature by incorporating new health and educational outcomes. Furthermore, while Majid (2012) and famine and epidemic studies only evaluate the cognitive channel, this work also investigates the physical path by studying the effect on height.

The Nigerian data perfectly suits the purposes of this work and provides advantages over other studies: Muslim and Non-Muslim populations are similar in number in comparison to Indonesia (Majid, 2012), therefore it allows for more credible robustness tests.

The work is organized as follows: Section 2 provides a literature review, Section 3 describes the datasets and empirical strategy, Section 4 shows the results and Section 5 concludes.

2 Lasting effects of Ramadan´s exposure in-utero

Ramadan is the ninth month of the Islamic calendar and coincides with the period in which the Prophet Muhammad first received revelations. Therefore, this month is considered sacred, and fasting during that time is one of the Five Pillars of Islam—basic acts that are considered a duty for all Muslims. The fasting includes abstention from food and drink, as well as smoking and sex, between dawn and sunset during the entire month. Although the elderly and pregnant women are not fully obliged to follow with this tradition, in practice they usually do it as the rest of Muslims.

Ramadan has provided a better framework to analyze nutritional shocks during pregnancy than those provided by natural experiments such as wars and famines (Chen and Zhou, 2007; Meng and Qian, 2009; Jurges, 2011; Neelsen and Stratmann, 2011; Scholte et al., 2012;). On the one hand, it involves a relatively big sample, since roughly three-quarters of the world's 1.6 billion Muslims spent some portion of the in-utero period during Ramadan. On other hand, it has advantages in terms of the empirical strategy: it allows to identify the time frame in which individuals are exposed to fasting, there is a clear cut for the treated population, the distinction between treated and control groups is clear, and the nutritional shock is less confounded with other factors (for example, famines and wars are associated with distress and generalized unrest which also could affect infant´s early development).

Almond and Mazumder (2011) are the first economists who studied in-utero-Ramadan's shock using a dataset from the United States - Michigan Natality Files-. They found that exposure results in lower birth weight and also reduces the number of male births, which means that the probability of female's birth increases among the exposed mothers (women with Arab ancestors) in comparison to non-exposed ones (non-exposed women with Arab ancestors) and non-Arabs . In similar comparisons, using census data from Iraq and Uganda, they trace long-term health consequences of exposure to Ramadan and find stronger impacts for the individuals who were exposed in the first or second trimester

of gestation.

Similarly, using the Indonesian Family Life Surveys from 2000, Van Ewijk (2011) shows that individuals who were exposed to Ramadan fasting have poorer general health than others. In addition, and in line with medical research findings - he shows that the probability of reporting symptoms that indicate coronary heart disease and type 2 diabetes increase among the elderly as a consequence of Ramadan exposure. In parallel, Karimi (2013) provides evidence for a new measure of health development during childhood, using the Demographic Health Surveys for 37 different countries. His work focuses on the effect of in-utero exposure to Ramadan on children's height, a measure that has been used in medical sciences to assess children's growth evolution (Haile, 2016). He shows that exposure to fasting during Ramadan has statistically significant and negative effects on the height-for-age Z-scores indicators. At the same time, Kunto and Mandemakers (2019), incorporate weight and body-mass-index measures for children and adolescents in Indonesia and find similar results.

Besides health outcomes, Majid (2012) studies the effect of in-utero exposure to Ramadan on several other outcomes in Indonesia. He uses two rounds of the Indonesian Family Life Surveys and finds statistically significant and negative effects of in-utero exposure to Ramadan on birth weight, used as an early development indicator. Additionally, he finds that some cognitive development outcomes, such as children's scores in math and Raven's colored progressive matrices, are also negatively affected by Ramadan's fasting. Finally, he included the impact on labor market outcomes, such as adults' work hours and job category. The author concludes that the cognitive development outcomes are one of the reasons for their job market barriers.

As for the effects of Ramadan´s fasting on educational outcomes, Almond, Mazumder, and van Ewijk (2015) use English register data and find that Pakistani and Bangladeshi students exposed to Ramdan's test scores are significantly lower at age seven than those of not exposed students. Regarding labor market outcomes, Schultz-Nielsen, Tekin and Greve (2016) take advantage of Denmark Administrative Data to investigate the impact

of in-utero exposure to Ramadan on labor market outcomes of only adult Muslim males, including employment status, annual salary, hourly wage rate, and hours of work. Their findings indicate that potential exposure to nutritional disruptions during fetal development might result in poor labor market outcomes later in life, specifically, during the 7th month of gestation. Impacts include a lower likelihood of employment, a lower salary, and reduced labor supply, but not necessarily a lower wage rate.

Although significant research has shown the link between early nutritional shocks and long term outcomes, there is still a gap in the literature noted by Almond, Currie, and Duque (2018). They agree that relatively mild shocks can have substantial negative impacts , but the effects are often heterogeneous due to the interaction among the early shocks, child endowments and later interventions, which depend on parents' motivations to compensate for the shocks and also on their budget constraints. Those shocks, investments, and interventions can interact in complex ways, which need to be understood in order to think about better policy interventions.

This paper extends the scope of Majid (2012) and trace the effect of in-utero exposure to Ramadan on a more complete set of variables. It also attempts to show plausible discrepancies between early development and long-term effects to highlight the interactions between pre-natal shocks and later interventions. For this purpose, this paper contemplates the short-term effects of Ramadan's fasting on birth weight and childhood height using the height-for-age Z-score, reflecting early development and childhood outcomes, respectively. In addition, the results are considered as first-stage impacts that might affect future development. For mid-term effects, this work also focus on the probability of repeating a grade at school to account for learning difficulties. Finally, to assess long-term effects on the labor market outcomes, it considers the impact on wages.

3 Data and Empirical Strategy

3.1 Data

3.1.1 MEASURE DHS Samples for Birth and Childhood Information

This paper uses indicators from the Demographic and Health Survey (DHS) of Nigeria from the MEASURE DHS project to determine the effects of Ramadan's fasting on early childhood development. This survey provide a specific section for children, called "Children's Recode" which has information on mother's nutrition and health care during pregnancy, children's birth information, both mother's and children's nutrition and health care indicators after children's birth date, mothers' and children's anthropometrics, and socio-economic characteristics of the corresponding households. As a result, it is possible to link birth dates from this dataset to Ramadan's dates and explore our outcomes of interest for infants and children.

The analysis is based on Nigeria's 2003 and 2008 DHS, despite having access to the four waves of the DHS survey (1990, 1999, 2003 and 2008). Given that the 1990´s and 1999´s do not include some of the crucial control variables such as mother's height, parents' age, parents' education. The work relies on 60% of observations from the "Children's Recode" for which exact birth dates, outcome and crucial control variables were available.

In Table 1, includes summary statistics for outcome variables (children's weight at birth and children's height-for-age standard deviations), treatment variables of interest (days and hours of exposure to Ramadan during the whole gestation and during trimesters of gestation), and control variables. It is worth noticing that, negative average height-for-age Z-scores for all four groups of children means that the height of Nigerian children is less than that for the reference population. Differences among Muslim and non-Muslim, invalidates studies in which comparisons are made between these two groups. This also supports our identification strategy in which comparisons are made within treated and non-treated male Muslims. Additional summary statistics are included in Table 2.

3.1.2 Data for School Age and Adulthood Information

To assess the impacts of prenatal malnutrition on educational and labor market outcomes, this work relies on the second wave of the General Household Survey (GHS) of Nigeria fielded by the National Bureau of Statistics (NBS) in 2012-2013. The GHS-Panel is the result of a partnership that the NBS has established with the Federal Ministry of Agriculture and Rural Development (FMARD), the National Food Reserve Agency (NFRA), the Bill and Melinda Gates Foundation (BMGF), and the World Bank (WB). The ability to follow the same households over time makes the GHS-Panel a new and powerful tool for studying and understanding income generating activities and socio-economic outcomes in Nigeria. The GHS-Panel is the first panel survey to be carried out by NBS. The GHS survey is a cross-sectional survey of 22,000 households carried out periodically throughout the country, but there are also 5,000 households which are part of the panel dataset.

3.1.3 Identification Strategy

Given that Ramadan's dates are determined by the lunar calendar, the exact dates of the holiday vary each year: they move forward by roughly 11 days. In this setting, the exposure to fasting during pregnancy will be exogenously determine by Ramadan's and pregnancy dates. Therefore, the identifying assumption is that pregnancies are not timed relative to Ramadan along unobserved determinants of health, educational and labor market outcomes.

In this regard, we present evidence that parental observable characteristics are not systematically related to the timing of conception relative to Ramadan's dates. It implies that parents' s characteristics among those whose have children exposed to Ramadan fasting during pregnancy, do not differ from those whose children were not exposed. Table 1 shows parent's characteristics, including mother's and father's height, their age at birth and their years of education among both groups. In addition, it implies that parents' characteristics are not correlated to Ramadan's or birth dates.

The methodological approach is based on Almond, D. and B. Mazumder (2011). It

differentiates from previous studies which compared fasting mothers to non-fasting ones at a given point in time and assumes that the fasting decision was exogenous. Instead, we compared the births over the years where Ramadan overlaps with pregnancy to those where it does not and estimate the reduce form effect of Ramadan's timing. Thus, we estimate an intention to treat effect (ITT) without relying on the fasting decision of the mothers. This approach allows to explore differences of exposure to fasting during Ramadan by distinctive months of gestation. As a result, the control group are Muslims whose early postnatal period overlaps with Ramadan and therefore were not exposed to fasting while they were in utero.

3.2 Exposure to Ramadan

The model takes advantage of differences in Nigerian's exposure to Ramadan's fasting using hours of exposure. Given that Ramadan's dates are determined by the lunar calendar, the exact dates change every year. Therefore, the total hours of exposure depend on the season in which the holiday takes place. For instance, when Ramadan occurs during the summer, the exposure is greater as daylight hours are longer than during the winter. At the same time, the exact number of hours of exposure depends on the date of birth relative to Ramadan´s dates. Therefore, different individuals would be impacted by Ramadan fasting over different number of hours.

To construct the exposure, we rely on the start an end dates of Ramadan along every year in the twentieth century and follow Almond, D. and B. Mazumder (2011) definitions. Our first measure, it is called full exposure and takes the value 1 if the child was exposed during the whole month of Ramadan. The measure of partial exposure indicates that pre-natal exposure was less than the whole Ramadan period. Finally, the last measure utilizes the number of daylight hours in each day as an indicator of the Ramadan fasting length. This indicator is constructed as a ratio in which the numerator is the number of daylight hours over a period of 30 days that overlaps with Ramadan and the denominator is the maximum number of daylight hours over a 30-day period over the entire sample

period.

3.3 Econometric Model

$$Y_i = \alpha_j + \beta_k Exp + \theta_i month_i + \gamma_i year_i + X_i + e_{ijk}$$

where,

Y_i is the outcome of interest of individual i (For early development outcomes: birth weight; for childhood outcomes: height (Z-scores); for educational outcomes: if never repeated school, and finally, for long-term effects in the labor market: wages(ln);

β_k is the coefficient for the exposure variable which represents the impact of Ramadan´s exposure on the outcome of interest;

θ_i is the month of birth fixed effect;

γ_i is year of birth fixed effect;

$X_i$is the vector of controls;

To evaluate the effects on early child development, we look on birth weight as done by Almond and Mazumder (2011) and Majid (2012). To identify the impact on childhood development, we and the physical channels of the effect, this work explores the impacts on children's height, using the "height-for-age Z-score"(HAZ). This measure summarizes the distance between the actual height of a child from the median height of the children of their age. This is the standard indicator of the health and nutritional status of populations of children (1-7), can be used in health programs to monitor health and nutritional performance of individual children (4, 5, 8) and allows to evaluate children's growth (Haile, 2016). Besides using the standard health indicators, and to account for the cognitive effects of pre-natal malnutrition: this work evaluated school repetition among male Muslims between 6-12 years. Additionally, labor market outcomes include just wages.

4 Results

4.1 Early Development Impact's

Immediate effects of prenatal malnutrition are explore using birth weight. Overall effects are presented in Table 3. Evidence shows that exposure to Ramadan on the birth weight of male Muslim children, is negative and statistically significant. To be more specific, an hour of exposure to Ramadan during gestation period reduces Muslim boys' birth weight by 1.33 grams. With 11 hours of daylight and a full 30-day exposure, this translates to about 440 grams lower birth weight for compare to non-Muslim boys (although this group is not used as control group non-treated.

The effects of exposure at different episodes of gestation are shown in Table 4. For Muslim boys the effect of exposure in all trimesters is significant, but larger in the first and second ones. As it is revealed by the results, the negative effect of exposure to Ramadan on Nigerian Muslim boys is alarming. The range of the magnitude of the effect, which is beyond 200 and 400 grams if exposed during the first trimester and second trimester, respectively, is considerably larger than Almond and Mazumder (2011)'s finding for children with Arab ancestors, which is about 40 grams.

In addition, these results are consistent using a falsification test: applying a the exposure measure to the Non-Muslim male population we do not find any effect of Ramadan's fasting on birth weight.

4.2 Childhood Health's Effects

The results for height are presented in Table 5. Similar to birth weight, the effect on height is negative and statistically significant for Muslim boys. To be more specific, an hour of exposure to Ramadan during gestation period reduces Muslim boys' height-for-age Z-score 0.000448 standard deviations. Table 6 presents the effect of exposure on height at trimesters of gestation. The effect in the first trimester is negative and significant. It is worth noticing that the effect on height is only significant for the first trimester while the

effect on birth weight is statistically significant for all periods. Therefore, suggesting that the measures are indicative of the development of different features and that posterior interactions may counteract the negative effects of pre-natal malnutrition.

Similarly, these results are consistent using a falsification test: applying a the exposure measure to the Non-Muslim male population we do not find any effect of Ramadan's fasting on height.

4.3 Educational Performance and Cognitive Indicator

When we look at plausible effects of prenatal malnutrition on educational performance and cognitive abilities: the overall effect seems to increase repetition at school age for the male Muslim population between 6 and 12 years old (for which education is mandatory) (Table 7). We compare the effects of the exposure during each trimester of the gestation period and found evidence that the effect could be led by the exposure during the first trimester. Even more, when we differentiate the impact of Ramadan's exposure in month of gestation, our estimations are still negative and statistically significant for the month of the conception and the two consecutive months. Results are comparable using either the index or the hours of exposure. Additionally, these results are consistent with evidence of exposure to Ramadan in early childhood during the first trimester. However, exposure during the second and the third trimester cannot explain the educational outcome, suggesting that effects during childhood only persist if the malnutrition shock happens in the early stages of gestation.

Results are robust to falsification tests, it means that 'exposure' to Ramadan Muslims before the conception has no effect on educational outcomes. In the tables, it is presented as exposure to Ramadan during the previous month of conception. Therefore, it provides evidence to support results for the real exposure to the malnutrition shock and not as a special feature for male Muslims.

Additionally, these results are consistent when looking at educational outcomes of Non-Muslims. We estimate the days and hours which overlaps with Ramadan for this group to

simulate the exposure to fasting during Ramadan. Therefore, we use this procedure as a falsification test. However, there is no impact on repetition at school for the Non-Muslim population, meaning that the evidence supports the impact of Ramadan fasting on school repetition on the treated population.

However, it is worth noticing that not experiencing school repetition, can be an indicator of other factors not necessarily related to school performance but still related to cognitive ability such as social and interactive skills. Even, it is possible that schools follow a policy of minimum school repetition, resulting in repetition rates affected by school decision instead of children's performance. This alternative explanations of the repetition outcomes does not affect out estimations of the partial effect but they are reflected in the low R-squared of the model.

4.4 Long-term Effects: Labor Market Outcomes

To account for plausible long-term effects of prenatal malnutrition on labor market's outcomes this work considers wages of the male Muslim population. In terms of wages, the evidence of the overall effect of exposure to fasting during Ramadan, as a proxy of prenatal malnutrition indicates a negative impact on wages. The results are consistent among different exposure specification, using the index (full and partial exposure) and hours of exposure. However, the effects are statistically significant for the third trimester, and not for the other ones.

The statistically significant effects for the third trimester are consistent with the evidence of Ramadan´s exposure on birth weight. Meaning that long term impact on the labor market outcomes (wages) are consistent with short term impacts on early development. However, the evidence of physical effects, measured using height during childhood can not support the hyphotesis of the physical channel of the impact of the pre-natal nutrition shock over wages. Similarly, school repetition is not supporting the effect on wages (looking at exposure by trimester). Therefore, it seems that channels connecting the short term outcomes and the long term ones in the labor market are much more complex than

those we attempt to show in this work.

Results are robust to falsification tests, it means that 'exposure' to Ramadan Muslims before the conception has no effect on wages. In the tables, it is presented as exposure to Ramadan during the previous month of conception. Therefore, it provides evidence to support results for the real exposure to the malnutrition shock. Also, other robustness checks support the effects of the exposure of Ramadan on wages. Conducting a false experiment, which means assigning hours of exposure to Ramadan to non-Muslim males suggest that exposure to Ramadan has no effect on this population. As a result, even without enough proof for the channels connecting short term outcomes with the ones in the labor market the model is robust to the falsification test.

5 Conclusions

Overall effects of Ramadan fasting as a proxy of pre-natal malnutrition are negative and statistically significative. When we look at the effects by trimester of exposure, the labor market effects are consistent with health in early childhood measured using birth weight. However, they are not consistent with the effects on height during childhood. This suggests, that the physical channel of effects of Ramadan on labor market outcomes is not fully robust. In addition, looking at the effects of Ramadan on school repetition we can not provide enough evidence for cognitive channel due to discrepancies in effects trimester of exposure. However, all effects are consistent with early impacts of the prenatal malnutrition shock. As a result, additional analysis in needed to understand the interactions between the shock and the effect in the long-term. One of the reasons of these discrepancies might be that later interventions in individuals life have compensating effects for some of the negative effects. Therefore, next steps will attempt to incorporate additional analysis to this work. However, the results are consider a lower bound of the effects of the malnutrition shock provided by Ramadan because it is not possible to observe fasting mothers and non fasting ones. Therefore, the results are the intention to treat estimations of pre-natal malnutrition shock during Ramadan fasting exposure.

6 Further analysis

This project recognise the limitations of restricting the analysis to male individuals, therefore the same analysis in going to be conducted for women in a new version of this work. However, their participation in the labor market is quite different from that of male Muslims in Nigeria and this may imply that effects are not relevant enough. In terms of the transmission channels of the pre-natal shock and middle and long term outcomes. This work recognise that later interventions may counteract the early impact of fasting, therefore other outcomes will be included. In addtion, as Almond, Currie, and Duque (2018) noted middle term impacts still bring lots of unanswered questions. Thus, the next steps will try to include additional observations from the Nigerian Panel Dataset and explore a new methodological approach.

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8 Tables

Table 1: Summary Statistics (A)

	Muslim Boys	Muslim Girls	Non-Muslim Boys	Non-Muslim Girls
Height-for-Age Z-score	-1.77	-1.60	-1.18	-0.93
	2.02	2.05	1.79	1.81
Birth Weight (kg)	3.24	3.10	3.39	3.28
	0.73	0.69	0.72	0.74
Hours of Exposure during the Gestation	287	290	284	282
	128	125	132	134
Hours of Exposure during the 3rd Trimester of Gestation	70	75	88	85
	130	133	142	141
Hours of Exposure during the 2nd Trimester of Gestation	107	107	97	96
	151	150	147	146
Hours of Exposure during the 1st Trimester of Gestation	110	109	99	101
	152	151	148	149
Days of Exposure during the Gestation	24	25	24	24
	11	11	11	11
Days of Exposure during the 3rd Trimester of Gestation	6	6	7	7
	11	11	12	12
Days of Exposure during the 2nd Trimester of Gestation	9	9	8	8
	13	13	12	12
Days of Exposure during the 1st Trimester of Gestation	9	9	8	8
	13	13	12	12
% URBAN	27	28	33	33
	-	-	-	-
Mother's Height	157	157	159	159
	7	7	7	7
Mother's Age at Birth	27	27	28	28
	7	7	6	6
Mother's Years of Education	2.3	2.3	7.3	7.2
	4.1	4.1	4.7	4.8
Father's Age at Birth	38	38	38	37
	10	10	10	10
Father's Years of Education	4.0	4.1	8.6	8.5
	5.5	5.5	4.9	4.9
Number of Observations	6,596	6,520	5,581	5,343

Table 2: Summary Statistics (B)

	Muslim	Muslim Boys	Muslim Girls	Non-Muslim	Non-Muslim Boys	Non-Muslim Girls
Height-for-Age Z-score	-1.68	-1.77	-1.60	-1.06	-1.18	-0.93
	2.04	2.02	2.05	1.81	1.79	1.81
Birth Weight (kg)	3.17	3.24	3.10	3.33	3.39	3.28
	0.71	0.73	0.69	0.73	0.72	0.74
Hours of Exposure during the Gestation	289	287	290	283	284	282
	126	128	125	133	132	134
Hours of Exposure during the 3rd Trimeter of Gestation	72	70	75	86	88	85
	132	130	133	141	142	141
Hours of Exposure during the 2nd Trimeter of Gestation	107	107	107	96	97	96
	150	151	150	147	147	146
Hours of Exposure during the 1st Trimeter of Gestation	110	110	109	100	99	101
	151	152	151	149	148	149
Days of Exposure during the Gestation	24.4	24.3	24.5	23.7	23.8	23.6
	10.7	10.8	10.6	11.1	11.0	11.2
Days of Exposure during the 3rd Trimeter of Gestation	6.1	5.9	6.3	7.2	7.4	7.1
	11.1	11.0	11.3	11.9	11.9	11.8
Days of Exposure during the 2nd Trimeter of Gestation	9.0	9.1	9.0	8.1	8.1	8.0
	12.7	12.7	12.7	12.3	12.4	12.3
Days of Exposure during the 1st Trimeter of Gestation	9.3	9.3	9.2	8.4	8.3	8.5
	12.8	12.8	12.8	12.5	12.4	12.5
% URBAN	27.5	27.5	27.5	32.8	32.8	32.7
	-	-	-	-	-	-
Mother's Height	157.4	157.3	157.4	158.8	158.7	158.8
	7.0	7.0	7.0	7.0	7.0	7.0
Mother's Age at Birth	26.8	26.8	26.9	28.4	28.4	28.4
	7.1	7.1	7.1	6.4	6.4	6.4
Mother's Years of Education	2.3	2.3	2.3	7.3	7.3	7.2
	4.1	4.1	4.1	4.7	4.7	4.8
Father's Age at Birth	38.1	38.1	38.2	37.4	37.5	37.4
	10.2	10.2	10.1	9.7	9.7	9.7
Father's Years of Education	4.1	4.0	4.1	8.6	8.6	8.5
	5.5	5.5	5.5	4.9	4.9	4.9
Number of Observations	13,116	6,596	6,520	10,924	5,581	5,343

Table 3: Table 3: Hours of exposure on birth weight

	Birth Weight
Hours of exposure during gestation	-0.00133***
	(0.000422)
Age FE	Yes
Birth year FE	Yes
Birth month FE	Yes
Gender FE	Male
Islam FE	Yes
Urban / Rural FE	Yes
State FE	Yes
Twin FE	Yes
Birth Order	Yes
Mother's Height	Yes
Mother's Age at Birth	Yes
Mother's Education FE	Yes
Father's Age at Birth	Yes
Father's Education FE	Yes
Wealth FE	Yes
Observations	2,041
R-squared	0.128

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4: Hours of exposure on birth weight by trimester

	Weight
Hours of exposure in 1st trimester	-0.00141***
	(0.000498)
Hours of exposure in 2nd trimester	-0.00142**
	(0.000573)
Hours of exposure in 3rd trimester	-0.00123**
	(0.000535)
Age FE	Yes
Birth year FE	Yes
Birth month FE	Yes
Gender FE	Male
Islam FE	Yes
Urban / Rural FE	Yes
State FE	Yes
Twin FE	Yes
Birth Order	Yes
Mother's Height	Yes
Mother's Age at Birth	Yes
Mother's Education FE	Yes
Father's Age at Birth	Yes
Father's Education FE	Yes
Wealth FE	Yes
Observations	2,041
R-squared	0.129

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 5: Effect on Height

	Height
Hours of exposure during gestation	-0.000448*
	(0.000181)
Age FE	Yes
Birth year FE	Yes
Birth month FE	Yes
Gender FE	Male
Islam FE	Yes
Urban / Rural FE	Yes
State FE	Yes
Twin FE	Yes
Birth Order	Yes
Mother's Height	Yes
Mother's Age at Birth	Yes
Mother's Education FE	Yes
Father's Age at Birth	Yes
Father's Education FE	Yes
Wealth FE	Yes
Observations	9,705
R-squared	0.180

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 6: Effect on Weight by Trimester

	Height
Hours of exposure in 1st trimester	-0.000573*
	(0.000247)
Hours of exposure in 2nd trimester	-0.000424
	(0.000219)
Hours of exposure in 3rd trimester	-9.48e-06
	(0.000515)
Age FE	Yes
Birth year FE	Yes
Birth month FE	Yes
Gender FE	Male
Islam FE	Yes
Urban / Rural FE	Yes
State FE	Yes
Twin FE	Yes
Birth Order	Yes
Mother's Height	Yes
Mother's Age at Birth	Yes
Mother's Education FE	Yes
Father's Age at Birth	Yes
Father's Education FE	Yes
Wealth FE	Yes
Observations	9,705
R-squared	0.183

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 7: Effect of Ramadan on School Repetition (Muslims): Never repeat

VARIABLES	NR	NR	NR	NR	NR
Expose	-0.0637**				
	(0.0279)				
Full Exposure		-0.0736**			
		(0.0317)			
Partial Exposure		-0.0584**			
		(0.0298)			
Full Exposure in 3th Trimester			-0.0460		
			(0.0375)		
Full Exposure in 2nd Trimester			-0.0397		
			(0.0394)		
Full Exposure in 1st Trimester			-0.0891**		
			(0.0383)		
Hours of total exposure in the Third Trimester				-0.000123	
				(0.000103)	
Hours of total exposure in the second Trimester				-6.42e-06	
				(0.000110)	
Hours of total exposure in the first Trimester				-0.000193*	
				(0.000115)	
Hours of exposure in the month of conception					-0.000341**
					(0.000156)
Hours of exposure in the month before conception					-0.000220
					(0.000161)
Age FE	Yes	Yes	Yes	Yes	Yes
Birth year FE	Yes	Yes	Yes	Yes	Yes
Birth month FE	Yes	Yes	Yes	Yes	Yes
Gender FE	Yes	Yes	Yes	Yes	Yes
Urban / Rural FE	Yes	Yes	Yes	Yes	Yes
Observations	1,390	1,390	1,390	1,390	1,390
R-squared	0.021	0.021	0.023	0.024	0.026

Robust Standard Errors
*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

Table 8: Effect of Ramadan on School Repetition (Non Muslims): Never repeat

VARIABLES	NR	NR	NR	NR	NR
Expose	-0.0319				
	(0.0224)				
Full Exposure		-0.0256			
		(0.0254)			
Partial Exposure		-0.0365			
		(0.0243)			
Full Exposure in 3th Trimester			-0.0165		
			(0.0357)		
Full Exposure in 2nd Trimester			-0.0211		
			(0.0338)		
Full Exposure in 1st Trimester			-0.0305		
			(0.0271)		
Hours of total exposure in the Third Trimester				-2.15e-05	
				(9.17e-05)	
Hours of total exposure in the second Trimester				-2.19e-05	
				(8.78e-05)	
Hours of total exposure in the first Trimester				-4.75e-05	
				(7.19e-05)	
Hours of exposure in the month of conception					-6.07e-05
					(0.000116)
Hours of exposure in the month before conception					1.30e-05
					(0.000111)
Age FE	Yes	Yes	Yes	Yes	Yes
Birth year FE	Yes	Yes	Yes	Yes	Yes
Birth month FE	Yes	Yes	Yes	Yes	Yes
Gender FE	Yes	Yes	Yes	Yes	Yes
Urban / Rural FE	Yes	Yes	Yes	Yes	Yes
Observations	2,124	2,124	2,124	2,124	2,124
R-squared	0.021	0.021	0.021	0.020	0.022

Table 9: Impact of Ramadan on Wages (Muslims): LN(wage)

VARIABLES	Ln(wage)	Ln(wage)	Ln(wage)	Ln(wage)
Expose	-0.358**			
	(0.182)			
Full Exposure		-0.374**		
		(0.185)		
Partial Exposure		-0.297		
		(0.237)		
Full Exposure in 3th Trimester			-0.581**	
			(0.250)	
Full Exposure in 2nd Trimester			-0.253	
			(0.228)	
Full Exposure in 1st Trimester			-0.247	
			(0.226)	
Hours of total exposure in the Third Trimester				-0.00123**
				(0.000601)
Hours of total exposure in the second Trimester				-0.000678
				(0.000547)
Hours of total exposure in the first Trimester				-0.000313
				(0.000542)
Age FE	Yes	Yes	Yes	Yes
Birth year FE	Yes	Yes	Yes	Yes
Birth month FE	Yes	Yes	Yes	Yes
Gender FE	Yes	Yes	Yes	Yes
Urban / Rural FE	Yes	Yes	Yes	Yes
Observations	741	741	741	741
741				
R-squared	0.395	0.395	0.399	0.396

Robust Standard Errors
*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

Table 10: Impact of Ramadan on Wages (Non Muslims): LN(wage)

VARIABLES	Ln(wage)	Ln(wage)	Ln(wage)	Ln(wage)	Ln(wage)
Expose	0.160				
	(0.129)				
Full Exposure		0.136			
		(0.132)			
Partial Exposure		0.240			
		(0.160)			
Full Exposure in 3th Trimester			0.0583		
			(0.158)		
Full Exposure in 2nd Trimester			0.352		
			(0.163)		
Full Exposure in 1st Trimester			0.141		
			(0.157)		
Hours of total exposure in the Third Trimester				-3.81e-05	
				(0.000375)	
Hours of total exposure in the second Trimester				0.000324	
				(0.000383)	
Hours of total exposure in the first Trimester				8.03e-05	
				(0.000377)	
Hours of exposure in the month of conception					-0.000191
					(0.000674)
Hours of exposure in the month before conception					0.000857
					(0.000647)
Age FE	Yes	Yes	Yes	Yes	Yes
Birth year FE	Yes	Yes	Yes	Yes	Yes
Birth month FE	Yes	Yes	Yes	Yes	Yes
Gender FE	Yes	Yes	Yes	Yes	Yes
Urban / Rural FE	Yes	Yes	Yes	Yes	Yes
Observations	1,688	1,688	1,688	1,688	1,688
R-squared	0.143	0.144	0.147	0.143	0.146

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1