Does Ramadan Exposure In Utero Affect Long-term Labor Market Behavior? Evidence From Indonesia

By Muhammad Farhan Majid

Oct 15, 2012

ABSTRACT

This paper utilizes the Islamic holy month of Ramadan, a period of religious fasting, as a natural experiment to identify the effects of in utero nutrition on the labor market behavior of children in Indonesia when they become adults. Approximately seventy five percent of all pregnancies overlap with Ramadan, suggesting that in 2010 alone, more than 1.2 billion Muslims globally and 155 million Muslims in Indonesia were potentially exposed to their mother's fasting. In contrast to previous research, this paper uses household and biological sibling fixed effects for sub-samples of adults, to control for any bias associated with the selective timing of pregnancies as well as to control for time invariant differences across families in rates of compliance (fasting) during Ramadan. In this sense, this study estimates average treatment effects, rather than intent to treatment effects, for sub-samples of household members. Using the Indonesian Family Life Survey (IFLS), the results show that those exposed work 4.5% fewer hours and are 3.2% more likely to be self-employed, with average treatment effects for sub-samples even larger. Moreover, by making use of novel religiosity data from the latest wave of the IFLS, this study shows that these effects are strongest in religious families. No effects are found on non-Muslims. When suggestive channels are explored, results show that children aged 7-15 score 5.9% lower on Raven's Colored Progressive Matrices assessment and 7.8% lower on math test scores. These estimates generally increase in magnitude when biological sibling fixed effects are used. Exploiting the panel feature of the IFLS, this paper further identifies increased probability of child labor and fewer hours of study during elementary school as two other deeper behavioral channels. In addition, those exposed report lower birth weight, which indicates that these effects are indeed driven by in utero effects. When days of potential exposure during pregnancy are explored, 6 to 18 days of exposure seems to be a critical window during which the marginal effects of fasting are maximized, after which the effects are stabilized.

"The most valuable of all capital is that invested in human beings; and of that capital the most precious part is the result of the care and influence of the mother"- Marshall (1890, paragraph VI.IV.11)

1   Introduction and Background

Economists have recently utilized extreme events, such as the 1944 Dutch Famine and the 1918 Spanish Influenza, as natural experiments to test the effects of in utero health shocks on long-term health and productivity indicators (Almond (2006); Chen and Zhou (2007))[1] Although these events provide natural experiments for the identification of causal effects, it is not clear whether the results from these studies can be generalized to other settings that are more susceptible to intervention through public policy (Almond, Mazumder and Ewijk, 2011).[2] In particular, little attention has been paid to the effects of (less severe) norms during pregnancy, some of which have been practiced for centuries and which may be expected to persist in the future.[3]

Moreover, scarce attention has been paid to behavioral adaptations from in utero health shocks. Current evidence, which is rather limited, suggests that short-term changes in productivity may have negligible immediate impact on the allocation of time, but that productivity changes over the long-term may lead to reduced hours worked (Thomas, 2009). However, it is not clear whether health and productivity have a causal effect on hours worked in more general settings (Thomas, 2009). Studies that ignore labor supply effects provide an incomplete picture of the effects of health on labor market outcomes, leading to understatement of the welfare losses associated with negative health shocks. These losses in turn may not be reflected in aggregate measures of economic growth, and may overstate the importance given to the association between health and wage income.[4]

This paper fills this gap in the literature by analyzing the effects of the norm of maternal fasting by Muslim pregnant women (during the Islamic holy month of Ramadan) on their children's labor market behavior, as measured by hours worked as well as by the sector in which the children choose to work when they become adults. In addition, I pay particular attention to indicators of productivity (test scores), investment in schooling inputs (child labor status and hours of study), and birth outcomes (birth weight), as channels

---

[1]Recently the findings related to the 1918 Spanish Influenza have been challenged by Brown and Thomas (2011) who argue that those exposed to the Influenza had lower socio-economic status (SES) than families not exposed, leading to significant reduction in the size and statistical significance of the earlier effects.

[2]Referred to as AME (2011) from now on.

[3]Currie and Vogl (2012) also express concern regarding mortality selection in all these papers. A particularly attractive feature of studying effects of (less severe) norms is that mortality selection may be less of a concern than in natural experiments exploiting extreme events such as famines.

[4]Long-term changes in health may limit the capacity to work, which in turn would lead to lower total earnings. I am implicitly assuming that the welfare losses from the wealth effect will dominate any welfare gains from 'forced leisure', which seems to be a reasonable assumption in the case of Indonesia, a developing country where poverty is widespread. Thomas (2009) also implicitly assumes the same.

that determine the adult labor market outcomes. Current evidence from Muslim majority countries suggests that 70%-90% of pregnant women fasting during some part of their pregnancy (Almond and Mazumder, 2011). And medical theory predicts that fasting can have an "acceleration starvation" type effect on the fetus, which may have long-term effects on health and cognition.

Within the economics literature, Almond and Mazumder (2011) are the first to systematically consider the effects of fasting during pregnancy by Muslim women on their children's outcomes. They find lower birth weights and lower sex ratios in the US, and evidence of learning disabilities in Uganda and Iraq, in addition to negative effects on certain wealth measures. Using Indonesian Family Life Survey data (Wave 3), Ewijk (2011) finds that those exposed to Ramadan have worse general health, lower sex ratios, and symptoms of coronary heart problems and type 2 diabetes in old age. And contemporaneously, in a working paper, AME (2011) use English registry data on Pakistani and Bangladeshi students to estimate lower math and reading test scores for children age seven.

The common identifying assumption in the economics literature is that the timing of pregnancy is exogenous with respect to the timing of Ramadan. Compliance to treatment, i.e., the extent of fasting during pregnancy in Ramadan is unknown. However, since fasting during Ramadan is a Muslim ritual, it is reasonable to assume that compliers to treatment, i.e., pregnant mothers who fast during Ramadan, would be limited to Muslims only. Instead of estimating average treatment effects (ATE), the current literature estimates intent to treatment (ITT) effects by comparing children of those mothers for whom at least a day of Ramadan coincided with at least a part of their pregnancy. In this sense, the current estimates can be understood to be lower bounds.[5]

This paper adds value to the current literature in several ways. The question itself is new and important. This study analyzes the effect of Ramadan observance during pregnancy on labor market behavior (hours worked and sector of work). As mentioned earlier, this adds value to not just the economics of fasting literature, but to the larger literature on health and labor market outcomes. Second, the paper identifies indicators of cognitive ability (test scores) and behavioral changes related to investment in schooling inputs (study hours and child labor) as suggestive channels determining labor market outcomes. Even more fundamentally, it identifies changes in birth weight as a deeper channel through which these effects may be taking place. In my knowledge, this is the first paper which is able to track mechanisms through which an in utero shock manifests itself at each stage of the life cycle using the same data set.

Third, in contrast to Almond and Mazumder (2011) and AME (2011), this paper uses data from Indonesia, a developing country with the largest Muslim population (and a significant non-Muslim minority of 12%). One may expect compliance to fasting to be lower in developed countries since individuals have better health

---

[5]Ewijk (2011) also utilizes biological sibling fixed effects for analyzing the general health of children up to age 18.

facilities and are generally more educated than their counterparts in developing countries. This may imply that the bias in ITT estimates is somewhat less in developing countries than developed countries. The better SES in developed countries may even lead to higher compensatory investments by society so that the true fasting effect may be confounded. Different fertility trends may also exist. Ewijk (2011) also examines Indonesia but that study's focus is exclusively on health measures and is a cross-sectional study using IFLS Wave 3 (carried out in 2000). In contrast, this paper uses the latest Wave 4 (carried out in 2007-2008). Wave 4 is unique, in particular, because it contains new data on religiosity not available in previous rounds.[6] Moreover, this study uses Wave 1 (1993) to identify biological siblings in Wave 4 and to identify the effects on schooling inputs for a sub-sample of adults in Wave 4 when they were children.

Fourth, in contrast to Almond and Mazumder (2011) and AME (2011), this paper uses biological sibling fixed effects model to assess the effects on children's behavioral outcomes and test scores. This controls for not only any unobservables, which may be potentially driving any selective timing of pregnancy, but also controls for the bias associated with any lack of compliance to Ramadan, as long as compliance is time invariant within families. In this sense, this paper's estimates can be thought of as ATE rather than just ITT estimates. This insight alone has been ignored by the literature until now.

In the absence of panel data, it is usually not possible to carry out biological sibling fixed effects for adults who may no longer live in the same households. By utilizing the panel feature of the IFLS, for a sub-sample of adults, this study is also able to carry out sibling fixed effects for adults aged 22 to 28 years to assess effects on their labor supply. This may be of interest not just to economics of fasting literature but to the broader literature of development studies. However, a clean biological sibling fixed effects analysis cannot be carried out for the entire adult population of interest (15-65) because of the lack of longitudinal data over the entire life course. Household fixed effects are estimated for this purpose. Given that the famous study (Almond, 2006) on the long-term effects of the 1918 Spanish Influenza has been challenged by Brown and Thomas (2011) because the treatment group may have lower SES outcomes, it is particularly important to conduct such an exercise. If the main results of this study are robust to household fixed effects, this will provide further confidence in the estimates of this paper.

Fifth, in addition to using non-Muslims as a placebo for falsification, as had been used earlier, I am able to make use of unique questions on religiosity, found in Wave 4 of the IFLS. If the effects of Ramadan are indeed due to the act of religious fasting, one may expect that more religious Muslim families are more likely to have pregnant women who fast than less religious Muslim families. This may make one more confident that the effects are driven by religiosity rather than by other differences across Muslims and non-Muslims.

In addition, by using a continuous measure of exposure (proportion of days of overlap of pregnancy with

---

[6]The sub-sample is a sub-sample in terms of age cohort but not necessarily exactly the same sub-sample.

Ramadan), I am able to carry out non-parametric estimates (without controls) of exposure on labor market behavior. Moreover, unlike Almond and Mazumder (2011), who do not know the exact date of birth for their adult sample, or religion, for their estimates of birth weight effects, and unlike AME (2011), who also do not know the exact religion of the children, this paper, like Ewijk (2011), uses exact date of birth information, along with religion, in all its estimates. This makes the estimates of this study less prone to measurement error than earlier studies.

The results show that fasting during pregnancy by Muslim mothers has a wealth effect measured by 4.5% fewer hours worked, as well as a selection effect which involves a 3.2% increase in the probability of being self-employed. This conclusion is robust to not only household fixed effects, but also to biological sibling fixed effects for a sub-sample of adults. When falsification tests are done on non-Muslims, no such effects are found on the placebo. This gives further confidence that the estimates are not driven by any other behavioral and economic changes that may take place during Ramadan. For example, if changes in the general price level of a basket of goods, shared by Muslims and non-Muslims, were causing such effects, then non-Muslims should register similar effects. Hence, the effects are peculiar to Muslims during Ramadan. Moreover, if religious fasting is driving the Ramadan effect, then we may expect that individuals from more religious Muslim families should register stronger effects. Results support this prediction.

Suggestive channels through which these effects may be taking place are next explored. Mother's fasting lowers not just the Raven's CPM cognitive test scores by 5.9% but also lowers math scores by 7.8% for children aged 7-15. Moreover, these estimates are robust to biological sibling fixed effects.This suggests that mother's fasting lowers the stock of human capital of the children. Next, deeper channels are examined through which the changes in test scores may be taking place. Children are 3.3% more likely to be involved in child labor and study 3.4% fewer hours during elementary school.[7] Thus, behavioral changes related to schooling inputs may be one possible channel through which the tests score effects are taking place, apart from the direct effects on one's cognitive ability from fasting. In fact, as the theoretical framework in the paper clarifies, the behavioral response may it self be a response to the lower returns to schooling for the exposed children. Finally, if effects are being driven by the in utero nutrition shock and not due to some other post-natal shock per se, we may be interested in finding evidence on birth outcomes as well. Although the sample sizes are small and birth weights could be subject to possible measurement errors, results show that those exposed do register lower birth weights by as much as 270 grams.

When non-parametric analysis (without controls) is carried out, results yield qualitatively similar insights as the parametric estimates. The estimates also show that the major impact of fasting seems to occur between

---

[7]The OLS estimate for overall sample is statistically insignificant but, fixed effect estimate for a sub-sample is significant at the 10% level.

six and eighteen days of exposure to fasting. In the first six days, the marginal effects of fasting seem to be strongest, and after eighteen days of exposure, the marginal effects seem to flatten out. This is a useful finding and, if generally true, can help to identify the critical periods when Ramadan exposure during pregnancy is potentially most damaging to the fetus.

The rest of the paper is organized as follows. Section 2 performs a brief literature review from epidemiology and economics literatures on maternal fasting and its effects. Section 3 presents a conceptual framework to interpret the empirical evidence presented in this paper. Section 4 discusses the data used to carry out the analyses. Section 5 presents the empirical methodology. Section 6 presents the results. Section 7 discusses the results. Section 8 discusses the policy implications. Section 9 concludes.

2   Literature Review

2.1   Epidemiological Theory and Evidence

Fasting during pregnancy is expected to have negative effects because excess demand for nutrition by the fetus, if unmet, impedes fetal growth, leading to permanent effects on the body. There are two main hypotheses concerning the effects of fetal health on long-term outcomes. These can be viewed under the umbrella of the fetal origins hypothesis (FOH). The first is described as fetal under-nutrition. According to this view, inadequate prenatal nutrition leads to developmental adaptations that are beneficial for short-term survival but affect the general growth of the fetus (e.g., lower birth weight). This effect takes place despite a short period of nutritional deficiency (Barker, 1997).

Often, such damage does not create problems immediately, but only later in life, as shocks sustained during the life course take their toll. This can lead to effects on affect the kidneys and, increased risk for type 2 diabetes. Type 2 diabetes, in turn, is a key risk factor in the development of coronary heart disease. In fact, low birth weight is itself understood to predict coronary heart disease in adult life. Almond and Mazumder (2011) provide evidence that Ramadan causes lower birth weights in the US. However, lower birth weight captures only part of the changes to the fetal body due to maternal undernutrition (Almond and Mazumder, 2011).

A second prominent hypothesis is that nutritional restrictions hamper the development of a placental enzyme that is required to convert cortisol into inactive cortisone, thereby exposing the fetus to excessive amounts of cortisol (Almond and Mazumder, 2011). It is believed that in utero exposure to glucocorticoids such as cortisol leads to a reprogramming of the hypothalamic pituitary adrenal axis (HPA), which is linked with not only type 2 diabetes, but also high blood pressure and cognitive impairment (Seckl et al. (2007),

Kapoor et al. (2006)). The fact that fasting during Ramadan is shown to be correlated with high cortisol levels (Dikensoy et al., 2009) suggests that the damage to the development of certain placental enyzmes may indeed play an important role.

Within epidemiology, Metzger et al. (1982) were one of the very first to document the high level of ketones, free fatty acids and low glucose levels in pregnant women compared to non-pregnant women after 12 hours of nighttime fasting. Two years later, Meis, Rose and Swain (1984) showed that daytime fasting for eight hours leads to symptoms that are as severe as those reported in Metzger et al. (1982). Both studies emphasized the necessity for pregnant women to eat during the daytime.

Thereafter, several studies have shown that 'accelerated starvation' caused by fasting during pregnancy is correlated with the malfunctioning of certain cognitive functions (Rizzo et al., (1991)). A sizable literature in epidemiology studies the impact of Ramadan fasting, in particular (see Almond and Mazumder (2011) for a more detailed summary of this literature). Recently, Dikensoy et al. (2009) reported that Ramadan fasting is associated with increases in cortisol levels during pregnancy. This finding is of interest because cortisol is a stress hormone understood to potentially 'program' health in adulthood (Kapoor et al., 2006).

Many studies give evidence that pregnant women in Ramadan do indeed reach low levels of blood glucose and high levels of ketones. Arab (2004) found that 31% of pregnant women in Iran had ketonuria, whereas 61% had hypoglycemia before breaking their fast. In the UK and West Africa, Prentice et al. (1983) and Malhotra et al. (1989) measured unambiguous signs of accelerated starvation in Ramadan among pregnant women who were fasting.

Several studies of maternal fasting during Ramadan have found adverse effects on fetal health indicators. Mirghani et al. (2004) found evidence of reduced fetal breathing, where measures of fetal breathing were taken both before and after fasting on the same day. DiPietro et al. (2007) found a strong association between variation in fetal heart rate in utero and mental and psychomotor development and language ability during early childhood. The above are only few of the many studies. Most evidence points towards strong first-stage effects of exposure to Ramadan fasting among pregnant women and its effect on the health and nutrition of the mother (and the fetus).

Existing studies of the effects of fasting on birth outcomes have relied on comparisons between mothers who reported fasting with those who did not. One of most commonly cited study on the effects of Ramadan on birth weight, conducted a retrospective analysis of 13,351 babies born at full term from 1964-1984 in Birmingham, England (Cross et al.,1990). Cross et al. (1990) found a higher frequency of low birth weight among fasters during the second trimester of pregnancy, although there were no significant effects on mean birth weight. Malhotra et al. (1989) and Mirghani and Hamud (2006) found no effects on birth weight and APGAR (Appearance, Pulse, Grimace, Activity, and Respiration) scores, even though they detected

substantial biochemical changes. In the same study, Mirghani and Hamud (2006) find that there is a higher incidence of gestational diabetes mellitus (GDM), induced labor, higher cesarean section rates as well as higher admission to the special care baby unit (SCBU) among the fasting group versus the control group.

Azizi et al. (2004) is the only well-known study in epidemiology that studies the long-term impact of fasting on human capital outcomes. They find no significant effect of maternal fasting behavior, during the third trimester of pregnancy, on the intelligence quotients (IQs) of school-age children.

There are a number of problems inherent in most of these empirical studies in epidemiology. These include small sample sizes, estimation of effects in a given trimester instead of a comprehensive study of the entire pregnancy period. More seriously, most of these studies have attempted to evaluate the average treatment effects of Ramadan by comparing outcomes for those who actually fasted and those who did not, under the assumption that the decision to fast is exogenous. Although some of these studies control for variables like mother's pre-pregnancy body mass index (BMI), the list is not exhaustive. For example, a number of these studies do not control for smoking behavior, father's education, diversity in ethnic backgrounds or varying levels of community health facilities available to different mothers, which may lead to different fasting behaviors on the part of fasting mothers. In fact, few of these studies are experimental/quasi-experimental, relying on simple OLS regressions with limited controls.

2.2   Evidence From Economics

Within economics, Almond and Mazumder (2011) are the first to systematically consider the effects of fasting during pregnancy by Muslim women on their children's long-term outcomes. Using data from Michigan, they first show that the health of newborns is negatively affected by in utero exposure to Ramadan. Using Ugandan data, they next look at long-term effects of exposure on the probabilities of having disabilities as an adult. They find that Muslims who were conceived during Ramadan had higher probabilities of having vision, hearing and mental or learning disabilities as adults. They also find an effect on the sex ratio (a lower share of males) which reflects adverse pre-birth environment.

Ewijk (2011) uses Indonesian Family Life Survey data (Wave 3) to study long-term effects of Ramadan on health measures. The paper shows that people who were exposed to Ramadan fasting during their mother's pregnancy have a poorer general health and are sick more often than people who were not exposed. This effect is especially pronounced among older people, who when exposed also report health problems more often that are indicative of coronary heart problems and type 2 diabetes. The exposed are smaller in body size and weigh less. In addition, the sex ratio is also lower, corroborating the findings of Almond and Mazumder (2011).

Contemporaneously, AME (2011) find that children of age seven exposed to Ramadan have lower math and reading test scores. English registry data is used for the study and, Pakistani and Bangladeshi ancestry is used as a proxy for the Muslim religion.

It is important to highlight the common methodology of these three papers. Instead of estimating ATE, they estimate ITT effects by comparing children of those mothers for whom at least some part of Ramadan coincided with some part of their pregnancy. The identification assumption is that the timing of the pregnancy is exogenous with respect to the timing of Ramadan. Who actually fasted is unknown. All we know is that non-Muslim mothers cannot be in the pool of the potential treatment group and that the actual group of mothers who fasted will be among the Muslim population. In this sense their estimates can be understood to be lower bounds.[8]

However, their identifying assumption is questionable. There are a host of social factors that not only determine whether a given Muslim pregnant women may fast, but also how her family(community) tries to remedy for any subsequent negative effects on the exposed child(ren) via intra-household (intra-communal) reallocations of resources. For example, mothers from educated families may attempt to selectively time their births to avoid any overlap between pregnancy and Ramadan. Or, more health clinics may be devoted to areas where there is a greater concentration of Muslim women fasting because in such areas there is greater incidence of low child birth. By including household fixed effects, such household level factors can be controlled for.

Moreover, it is not clear if the Ramadan effects are indeed driven solely by religious fasting (as medial theory predicts) or by some other factor not directly related to religiosity. For example, prices of basic food items may hike during Ramadan. Changes in eating behavior after sunset(*iftaar*), which involves eating greasy, oily and generally unhealthy foods, may be causing the real harm rather than calorie restriction during fasting. Sleeping patterns may also change. People may also work less during Ramadan due to fatigue. All these factors may confound the Ramadan effect from the fasting effect. However, if I compare religious and less religious Muslims and find effects mostly on religious groups, it its very likely that the Ramadan effects are due to some factor linked with religiosity amongst Muslims. This will make the assumption that the Ramadan effects are being driven by fasting much more tenable than what one can assume from earlier studies.

The next section presents a conceptual framework to understand the empirical evidence presented in this paper.

---

[8]AME (2011) utilize a differences-in-differences strategy between potentially Muslim children and non-Muslims to isolate any seasonal variations that may be biasing these estimates, which involve just ten cohorts. The differences-in-differences approach however yields similar results to the OLS approach, as no effects are found on non-Muslims.

3 Economic Theory

This section presents a conceptual framework in which to understand the reduced form empirical estimates that will be shown in the later sections of this paper. The framework incorporates aspects of the standard static health-over-life course approach, as summarized in Strauss and Thomas (2007), with static aspects of the technology of skill formation, as exemplified in Heckman (2007) in a Roy economy (as in Pitt et al. (forthcoming), Rosensweig and Zhang (2012) and Vogl (2012)). I show that an early health shock can lead to not just a wealth effect (from changes in the labor supply, for example) but that there is also a selection effect (as people with lower skills sort into less skill-intensive sectors). These changes are made possible because the early life shock affects production of skills. The production of human capital, in turn, is potentially affected by not just changes in endowments of cognitive ability because of the early life shock, but by behavioral responses to the early life shock during childhood.

Parents are assumed to make key health decisions for children, whereas an adult is assumed to make his or her own decisions. It is important to distinguish skill outcomes, such as general health and test scores, from health inputs such as birth weight, and health behaviors such as hours of schooling and incidence of child labor.

Assume there is a static skill production function for an individual:

$$S = S(N, S_o, A, B_S, D, \mu, \epsilon_S), \tag{1}$$

where S represents measured skill outcomes, such as test scores, in my case (and general health as in Ewijk (2011)). These depend on health behaviors, N, which are choices under the control of the individual making the choices. These include, for example, time allocated into production of schooling. The technology of skill formation may possibly evolve over the life cycle, varying by age and, with other social and demographic characteristics, A, such as sex. The technology is also likely to be a function of family background, which affects health, B_S, such as parental religiosity. The production technology may also depend upon environmental and communal factors, D, such as the disease environment, whether there are health clinics in the community and the average religiosity in the community. Finally, μ is assumed to be negative, and represents the in utero health insult , while ϵ_S represents unobserved factors (error term). It is assumed that the partial derivatives of S, with respect to inputs N, S_o, A, B_S, D, μ, are all positive.

Behavioral choices play a major role in my conceptual framework. Assume that an individual's welfare is increasing in the personal consumption of purchased commodities, C (or in the parent's consumption, if they are the decision makers) and decreasing in the labor supply, L_j in sector j. j is ordered such that the higher the j, the more skill-intensive the sector, so that, *ceteris paribus*, more skill-intensive sectors are preferred.

Moreover, Utility, U, is assumed to be increasing in skill outputs, S, as well as in observed characteristics, A, family background, B_U, and unobserved characteristics, ϵ_U :

$$U = U(C, L_j, S, A, B_U, \epsilon_U). \tag{2}$$

Choices are constrained by budget constraints, time constraints, labor supply and sectoral choice functions, in addition to the technology of skill formation (2). Suppose that the individual earns wage, w, for each unit of labor supplied in sector j and that asset or non-labor income is V. The budget constraint is:

$$P_c C^* + P_n N^C = w_j L_j + V. \tag{3}$$

As in Strauss and Thomas (2007), consumption, C, is divided into two parts: consumption that is not related to the formation of skills, C*, with prices P_c, and purchased inputs for human capital production, N^C, with prices P_n. Time constraint is given by :

$$N^T + L + E = T, \tag{4}$$

where T, the total time endowment, can be used for the production of skills, N^T, leisure, E, and labor supply, L. The choices of labor supply and sector of work, will be affected by an in utero shock through the shock's effect on skill formation. But the in utero shock may also have effects through other unmeasured routes, which is captured by μ. All other unobservables are captured by the error term ϵ_L, in the case of labor supply, and ϵ_j, in the case of sector choice. Note that j is ordered such that higher skills are associated with a higher j, so that those with lower skills work in a lower sector (lower values of j) compared to those working in a higher sector (more skill-intensive sector). It is assumed that the partial derivatives of labor supply and sector choice, with respect to inputs $S, A, B., D, \mu$, are all positive.

$$L_j = L(S, A, B_L, D, \mu, \epsilon_L), \tag{5}$$

$$j = j(S, A, B_j, D, \mu, \epsilon_j), \tag{6}$$

$$Max_{(j,L,N)} U(C, L_j, S, A, B_U, D), \tag{7}$$

subject to (1),(3) and (4) , (5) and (6) above.

The above static maximization problem without uncertainty is sufficient to generate some key theoretical

11

predictions of this paper. The negative in utero health shock due to maternal fasting during Ramadan, will lead to a lower labor supply and a selection effect into a less skill-intensive sector. This will take place as mother's fasting lowers the child's stock of human capital (measured by lower test scores) and also possibly through other unmeasured ways. Human capital, in turn, is affected by not just changes in initial health stocks (as measured by birth weight) but also by changes in behavior (such as reduced schooling and more child labor). Reduced schooling, in turn, is a result of exposure to Ramadan, which lowers cognitive ability and, which in turn lowers productivity of schooling in all sectors - as is usually assumed in the literature on the returns to schooling (see Card (2001)). Other than causing reduced schooling time, lower cognitive ability may also lead exposed individuals to sort into sectors that have lower returns to cognitive ability.

At the same time, the framework suggests that the above predictions may be biased by parental characteristics. When parents make decisions for children, parental characteristics may be important. Those who invest more in unexposed children's schooling may be those who also encourage their children to be involved in skilled occupations and who encourage hard work, leading to more labor supply. The next sections will explore the data and, empirical strategy. to test some of the key predictions of the model.

4   Data

The data for this study comes from the Indonesian Family Life Survey (IFLS) consisting of four waves carried out during1993, 1997, 2000 and 2007 (also known as IFLS1, IFLS2, IFLS3 and, IFLS 4, respectively). IFLS collected a great amount of information at the individual, household and community level on a large collection of economic, health and social indicators. Sampling took place at the household level. Great care was taken to assure representativeness of the sample for the reference population. IFLS covers 13 of the (then) 26 provinces of Indonesia, which, in total, represent 83% of the Indonesian population. The analysis in this paper uses the IFLS4. But data from other waves such as IFLS1, carried out 15 years earlier, is also used.

One of the most appealing characteristics of the IFLS is its low attrition rates, comparing favorably even against longitudinal data sets in developed countries. In IFLS4, the re-contact rate was as high as 90.6% of the IFLS 1 households. Another feature of the data set, which is conducive to my study, is that around 88% of the sample population is Muslim, which gives me a large enough sample size to compare siblings and household members in Muslim families. This also implies a significant minority (12%), which leaves sufficient room for any falsification tests on the non-Muslim population. One should find no Ramadan effect for non-Muslim pregnant women because they are not supposed to be fasting during Ramadan. Although my study is primarily cross-sectional, focusing on the fourth wave, it also uses data from IFLS1 to link early childhood outcomes with adult outcomes in IFLS4. This is a particularly unique feature of this paper,

made possible because of the unique longitudinal feature of the IFLS, which has followed people over a15 year period. Very few developing countries, and almost none of the Muslim majority countries, have such a comprehensive data set.

I follow closely Almond and Mazumder (2011) and Ewijk (2011), in defining the exposure to Ramadan variable (see their papers for details on the construction of the exposure variable). However, my analysis differs from these earlier studies in two ways. First, I use the proportion of days that Ramadan overlaps with pregnancy to obtain a continuous measure of exposure. Although Almond and Mazumder (2011) use a similar measure, Ewijk (2011) does not. And unlike either papers, this study carries out a non-parametric estimation of exposure on the main variables of interest. This feature is particularly appealing because it allows one to explore the critical number of days of exposure it takes for the Ramadan effect to peak. Second, for regression analysis, I focus on those who are potentially exposed for a whole month rather than those who were exposed to Ramadan for a few days only.

To estimate exposure, using self-reported exact date of birth, this paper determines the number of days before an individual's date of birth the last Ramadan fell, restricting the sample to those Muslims born between 1942 and 1993 (15-65 years of age in 2007-2008).[9] Assuming that the average pregnancy lasted for 266 days, I calculate the conception date from the date of birth. If Ramadan starts and ends any time between an individual's date of birth and their estimated conception date, then they are potentially exposed to Ramadan fasting for a whole month. But, if Ramadan started and ended before the individual's conception date, they could not possibly be exposed to their mother's fasting during Ramadan. Days of exposure can be determined by calculating the number of days Ramadan overlapped with the period between conception and birth. Proportion of days of exposure is calculated by dividing days of exposure by 29 days (assumed average length of Ramadan).

One may be concerned that if pregnancy lasted longer than 9 months then those who were actually exposed may be declared not exposed, leading to an additional downward bias in the estimates. Since Kieler et al. (1995) document that very few pregnancies last more than three weeks beyond the average nine months, following Ewijk (2011), this study also controls for all those who were conceived within three weeks after the end of Ramadan.[10]

---

[9]The start and end dates of Ramadan were taken from www.phys.uu.nl/ vgent/islam/ummalqura.htm and (before 14 March,1937) www.al-islam.com/eng. When other websites were explored, only very minor discrepancies in dates were found. It may also be noted, that, in many areas of the Muslim world, the start and end of Ramadan is determined by moon sightings which may cause small noise in the estimates of this paper.

[10]Ewijk (2011) explains: " If their mothers pregnancies lasted longer than average, their classification as not being exposed would be erroneous, which would create a relatively large amount of noise. Pregnancies lasting three weeks beyond term or more are rare (see for e.g. Kieler et al., 1995), so 21 days is a safe margin. Actually, this bandwidth is longer than necessary for just this purpose: taking it this long also ensures that almost all children are placed into this category who were conceived in the festive days following Ramadan, who may differ from children conceived at other time points."

4.1 Descriptive Statistics

Table 1 reports selected summary statistics for Muslims and non-Muslims, by exposure. Exposure is a dummy for whether the individual was potentially exposed to a full month of Ramadan in utero. First, outcomes for adults (15-65) in Wave 4 are examined. Labor market outcomes include log of hours worked in a normal week at the primary job (Log Hours), self-employment status (Self-employed) and labor force participation (Work). The average of log hours for the sample of Muslims aged 15-65, is 3.61 (approx. 36 hours). Muslims who are exposed work fewer hours compared to those Muslims not exposed and this difference is larger among non-Muslims.

Overall, mean labor force participation is 69% with a standard deviation of 0.464, with the effect of exposure on participation being similar across exposure for Muslims. Interestingly, mean labor force participation is lower among Muslims compared to non-Muslims. On average, 30.5 % of the sample is self-employed, with a standard deviation of 0.460. Muslims who are exposed are more likely to be self-employed. This is in stark contrast to non-Muslims, who are more likely to be self-employed when not exposed to Ramadan.

One of the unique features of the IFLS Wave 4 is that for the first time it asks detailed questions about religiosity. Average religiosity among families is rather high in Indonesia with a mean of 2.796 (on a scale of one to four, where four is the highest value possible) and a standard deviation of 0.463. Interestingly, non-Muslims report even higher levels of religiosity than Muslims families, on average.

The overall sample is representative of males and females with a 1:1 sex ratio. And among those exposed, there are fewer men. Given that men are known to be more responsive to nutritional deficits in utero, this is consistent with the findings in Almond and Mazumder (2011) and Ewijk (2011), who find that males are more likely to die from Ramadan exposure.

The average age in the adult sample (15-65) is 33.16 years with a standard deviation of 12.59. Muslims who are exposed are slightly older (33.08 compared to 32.82 years), though this trend is the opposite in non-Muslims where exposed are younger. To account for age differences, controls for age and its quadratic term are added in the main regression estimates.

Next, data on test scores are used to estimate effects on cognition for children aged 7-15. Test scores include Raven's Colored Progressive Matrices (CPM) questions and a set of mathematics test questions. The Raven's CPM assessment is often used as a measure of general intelligence, and is recognized as the best available measure of Spearman's general intelligence factor "g" (Kaplan and Saccuzzo,1997). The test evaluates an individual's ability to recognize patterns through identification of the missing elements that best match the incomplete patterns.

The mean for the total scores is 69.6%, that of the CPM or cognitive test is 75% and for the math tests

is 58.5%. The means for all the tests are lower for exposed Muslims, whereas for exposed non-Muslims the cognitive and total scores are actually higher. This gives one confidence in the identification strategy employed.

Next, summary statistics from Wave 1 are presented. IFLS asks questions about birth weights of infants (0-5 years old) in the pregnancy history module. A combination of certificates, birth records from physicians and, family records were primarily used as sources of birth information. Data from Wave 1 are used since those aged 0-5 in 1993 would be around 15-20 years old in 2007-2008. This allows me to estimate the birth weight effects for a sub-cohort of adults in Wave 4. The mean birth weight is 3123 grams with a standard deviation of 573 grams. On average, Indonesian Muslims and non-Muslims, are well above the 2500 gram low birth weight threshold. Non-Muslim children, in fact, have higher mean birth weights than Muslims infants. Moreover, exposed individuals have lower mean birth weight.

Lastly, a sample of children aged 6-14 in Wave 1 is examined. These children would be about 21-29 years old in Wave 4. This allows me to assess the effects on certain early childhood indicators for a sub-sample of adults in the labor market in Wave 4. In particular, the effects on investments in schooling inputs (hours studied during elementary school and child labor status) are explored. The mean hours studied for the sample under consideration is 4.23 hours (log 1.451) during a normal day. Again, those exposed study fewer hours and non-Muslims have higher averages than Muslims. When child labor participation is examined, 1.7% of children report being involved in child labor. Those exposed are more likely to be involved in child labor. But despite studying more hours than Muslim children, non-Muslims are more than twice as likely to be involved in child labor. This is consistent with the summary statistics in Wave 4 where non-Muslim adults are more likely to participate in the labor force than Muslims.

5   Empirical Methodology

5.1   Identification of the Ramadan Effect

Ideally, one would like to compare outcomes for children of mothers who fasted during Ramadan, to the counterfactual outcomes for children if their mothers did not fast during Ramadan to estimate the average treatment effects on the treated. However, no such randomized control trial (RCT) exists. In much of the epidemiology literature, outcomes for children of mothers who actually fasted are compared to those who did not fast. The main concern here is that the decision to fast may be endogenous. For example, less educated and more religious mothers may be more likely to fast. Another approach to this problem has been proposed by Almond and Mazumder (2011) who compare outcomes for children whose mothers were

potentially exposed to Ramadan during pregnancy with those whose mothers were not exposed. In this way, concerns about omitted variables bias in the epidemiology literature can be addressed.

However, two major concerns still remain. First, this method assumes that mothers do not selectively time their pregnancy. Furthermore, it actually identifies the Ramadan effect rather than the fasting during Ramadan effect.[11]

A third approach may be to compare biological siblings who were potentially exposed to their mother's fasting during pregnancy versus those who were not. This method improves upon both the first (medical literature approach) and the Almond and Mazumder (2011) approach. By controlling for all time-invariant unobservables, one is able to control for certain factors which may be driving any timing of pregnancy, hence improving upon the Almond and Mazumder (2011) approach. Moreover, all those time-invariant unobserved factors that may be driving the wedge between actual and potential exposure will be controlled for (hence improving upon both the epidemiology literature approach and the Almond and Mazumder (2011) approach). Although Ewijk (2011) adopts this approach, that paper includes mother fixed effects only for a general health measure of children aged 1-18.[12]

However, most countries do not have longitudinal data that follow biological siblings from childhood well into their adult life and old age. Although sibling fixed effects are useful to identify variables, which identify the short-term to medium-term effect, given current data limitations, it may not be even feasible to apply this approach on adult populations. In this regard, a fourth approach involving household fixed effects may be particularly useful. All those time-invariant unobservables that are common between mothers and the households in which they live will be controlled for so that this may be a close approximation to the sibling fixed effect approach. This is the first paper in the economics of fasting literature to do so.

A fifth approach is to show differential effects for individuals whose mothers are more likely to have actually fasted, while at the same time using the Almond and Mazumder (2011) method. Religiosity can be thought of as a predictor of actual fasting behavior.[13] I demonstrate the usefulness of this approach by showing that households with higher religiosity have stronger effects. Religiosity is not even measured in

---

[11]The two may be different, for example, because prices of basic food items may be higher during Ramadan,which may partly explain these results. In fact, it is also important to note a key potential difference in developing versus developed countries where Muslims are in a minority. In developed countries with minority Muslim populations, there may be little general equilibrium effects on food prices during Ramadan. Food price inflation may be less of a concern so, the Ramadan effect may be closer to the fasting effect. However, selective timing of pregnancy may be a more serious concern in developed countries, as family panning is more prevalent. In developing countries, selective timing of pregnancy around Ramadan may be even unheard of, as Ewijk (2011) argues is the case in Indonesia.

[12]It may be noteworthy that Ewijk (2011) does not carry out mother fixed effects for any other estimates. Not even for analyzing effects on the adult population for which the author finds the strongest effects. Moreover, that paper motivates fixed effects as a way to address selective timing of pregnancy, which, as this paper has pointed out, may not be a major concern in developing countries that lack basic family planning. Although Indonesia has made many strides in family planning, it is still not comparable to the US or UK in this regard. The author does not, for example, motivate the use of fixed effects as an approximation of the ATE compared to the downward biased ITT estimates.

[13]IFLS4 does not ask questions on fasting, but does ask questions on another major pillar of Islam: the five daily prayers. I find that the subjective religiosity measure I use is highly correlated with number of times one prays in a day, suggesting that this may be a good predictor of actual fasting behavior as well.

most data sets, and the data (IFLS4) I use are particularly unique in this regard.

Indeed one of the distinctive features of this paper is that, other than the epidemiology literature approach, which uses data on actual compliance to fasting, this study applies all the last four approaches mentioned above to achieve confidence in the robustness of the estimates. The following section will layout the OLS and fixed effect regression equations.

5.2   Econometric Equations

The traditional OLS formulation is shown in (8) as follows:

$$Y_{if} = \alpha + \beta_1 exposure_{if} + \beta_2 age_{if} + \beta_3 age^2_{if} + \beta_4 male_{if} + \sum_{m=1}^{11} \gamma_m month_{mif} + FC_f + U_{if}, \qquad (8)$$

where Y_{if} is the set of human development outcomes of interest for individual i belonging to family f. $Exposure_{if}$ is a dummy for potential exposure to Ramadan for a full month in utero. age_{if} is age measured in days. γ_m denotes the coefficients for the calendar month of birth fixed effects. [14] In order to control for any communal and social factors that may bias the estimates of exposure to Ramadan, one can carry out a family fixed effects study. I assume that family/community level covariates, remain constant over time, and so, can drop out the fixed effect FC by differencing across t_1 and t_2, the date of births of members of the family 'f'.

$$\Delta Y_{[t_1,t_2]} = \alpha + \beta_{1*} exposure_{[t_1,t_2]} + \beta_{2*}\Delta age_{[t_1,t_2]} + \beta_{3*}\Delta age^2_{[t_1,t_2]} + \beta_{4*}\Delta male_{[t_1,t_2]} + \sum_{m=1}^{11} \gamma_{m*}\Delta month_{[mt_1,mt_2]} + \Delta V_{[t_1,t_2]}.$$
$$(9)$$

This method compares family members who were exposed to Ramadan compared to those who were not, under the identifying assumption that timing of birth and timing of Ramadan is exogenous and fixed effects are time-invariant.

---

[14]For some specifications, I explored an alternate set of controls for Ramadan month fixed effects. The estimates did not change much

6 Results

6.1 Non-parametric Estimates

Potential fasting during pregnancy by Muslim women is inversely related to their children's adult labor market outcomes. These estimates are strongest for those from more religious families, suggesting that the actual act of fasting may be driving these results. Three sets of figures summarize this relationship. The sample is restricted to those not conceived in the three weeks after Ramadan ends. No other controls are added and a pure relationship between potential exposure to Ramadan and outcomes of interest is explored.

Figure 1 examines the non-linear relationship between proportion of days of potential in utero exposure to mother's fasting and hours worked at a primary job, as well as for self-employment status, for an overall sample of individuals 15-65 years old. Exposure to Ramadan reduces hours worked and increases the likelihood of being self-employed, which can be interpreted as a low skill sector. It is interesting to note that the gradient of these curves peaks in the interval of 0.2-0.6, which corresponds to roughly 6 to 18 days of exposure to Ramadan. The marginal negative effect of exposure is almost zero after one is exposed for about 18 days of Ramadan and is increasing most in the interval up to 6 days of Ramadan exposure in utero.

Figure 2 and Figure 3 explore effects on hours worked and self-employment status by average religiosity in the families where the individuals reside. Both figures show that the effects are strongest for those coming from more religious families, though the standard errors for the less religious are much larger. It is worth noting that those from more religious families have fewer average hours worked and are more likely to be self-employed, on average, than those from less religious families.

6.2 Estimates with Controls

Subsequent analyses will use a dummy for full potential exposure to Ramadan, as compared to the non-parametric analysis where a continuous variable was used. First, the effects are rather linear, particularly for those exposed for more than 18 days of Ramadan. Second, most individuals have been exposed for a full Ramadan in utero as opposed to partial exposure. Last, the interpretation of results, in linear regression estimates, is cleaner for full exposure to Ramadan in utero.

Table 2 shows a summary of some key estimates of this paper from OLS regressions by religion. For Muslims, those exposed work fewer hours and are more likely to sort into the self-employment sector as adults. As children, their cognitive ability is hampered, which is reflected in lower math and Raven's CPM scores. Furthermore, when they are born they register lower birth weights. When falsification tests are done on non-Muslims, these effects vanish which gives strong evidence in support of the basic hypothesis.

Fasting during pregnancy not only effects children's earliest heath indicators, but their cognition as well, which later is correlated with lower labor supply and sorting into self-employment rather than into the wage work sectors.

Table 3 shows estimates for log hours worked in a normal week and self-employment status using both OLS and household fixed effect approaches for Muslim adults aged 15-65 in 2007. The first column shows OLS, the second, OLS restricted and the third, household fixed effect estimates for each of the variables. In terms of rows, the first row shows point estimates from comparisons of those potentially exposed to a full month of Ramadan to those not potentially exposed to Ramadan at all, during any part of the pregnancy. This is followed by rows for each trimester, where 'Exp. 1st Tri.' stands for an exposure dummy for the overlap of the first trimester with Ramadan, and so on.

Those exposed work 4.5% fewer hours in a normal week at their primary jobs. When sample is restricted to households with three or more family members, the estimates surge to 8.8%, eventually more than doubling to 10% when fixed effects are applied. When these effects are explored by trimester, I find that although OLS estimates predict the first trimester to have the strongest effects, restricted OLS shows that the third trimester has the highest impact. When fixed effects are applied, the statistical significance of all of the trimester point estimates drops, though in terms of magnitude, the third trimester shows strongest effects.

Similarly, those exposed are 3.2% more likely to be self employed. When the sample is restricted to households with three or more family members, the estimates surge to 7.9%, eventually stabilizing to 7.8% when fixed effects are applied. When these effects are explored by trimester, I find that although OLS estimates predict the first and second trimesters to be equally harmful, restricted OLS estimates show the second trimester as marginally more harmful, followed by the third trimester. When fixed effects are applied, the statistical significance of all of the trimester point estimates drops, though in terms of magnitude third trimester remains the most affected.

Next, falsification tests are carried out in Table 4, on non-Muslims in Indonesia. Although sample sizes are much smaller, I do not find similar negative effects for non-Muslims. If anything, some of the estimates show the opposite. Could it be that there are some spill-over effects so that non-Muslims exposed to Ramadan benefit from the more skilled wage-paying jobs where exposed Muslims no longer have the comparative advantage? In any case, the results are reassuring. For example, an argument could be made that it is the high food prices of basic commodities during Ramadan that may be driving these results. But if that is the case, it may be expected to impact Muslims and non-Muslims alike. The fact that non-Muslims do not register negative effects makes such an alternate hypothesis less appealing in favor of the fasting hypothesis.

One of the appealing features of the IFLS is that it is a panel study that has followed individuals for 15 years, between 1993 and 2007. I take advantage of this longitudinal feature of the IFLS, by identifying

biological siblings of adults aged 19-29 (19-26 in the case of self-employment results) in 2007 from their Wave 1 files when they were about 5-14, living most likely together with their parents. Although sample sizes are small, if one does find qualitatively similar results, it will be reassuring. Table 3 shows that is indeed the case. Exposed Muslims work fewer hours than their biological siblings and these effects are concentrated in the second and third trimesters, according to the fixed effect analysis. Non-Muslims - though of an even smaller sample size-register no such effects. Similarly, the estimates for self-employment are robust, with the second trimester effects standing out.

The analysis, thus far, uses alternate identification strategies, to argue that in utero Ramadan exposure negatively affects Muslims and not non-Muslims, in terms of their labor supply and sector of work (self-employment). However, the estimates are based on potential in utero exposure to Ramadan and, there is no concrete measure of actual fasting behavior. Given the lack of questions about fasting behavior for most people in the IFLS, I take advantage of a unique feature of Wave 4 of the IFLS, which asks questions about religiosity. A self-reported measure of religiosity, which asks people to rate their religiosity from none to very religious, is used. If individuals from families who are the most religious have the largest effects, then this will provide further confidence that indeed it is fasting behavior during Ramadan, rather than some other factor not related to religiosity, which is driving the results.

I redo my analysis in Table 3, for the religious and less religious households. When estimates from Table 6 (religious households sample) are compared to Table 7 (less religious households sample), one finds that the largest and most statistically significant effects are found in the religious sample. In terms of trimester analysis, the first and the second trimester seem to be most impacted when OLS estimates are used, but the second and the third trimester appear to be the most impacted (yet again) when OLS restricted and fixed effect estimates are used.

6.3   Suggestive Pathways

What are the possible channels through which labor supply and probability of self-employment are being affected? Table 8 shows estimates for test scores for children aged 7-14 in IFLS 4. Test scores include both Raven's cognitive test scores and math scores. The scores are in percentage terms. In contrast to Table 1 where household fixed effects were shown, biological sibling fixed effects are estimated in this sample. Those children who were potentially exposed score 5.9% lower in their cognitive scores, 7.8% lower in math scores, so that total scores are 7.1% lower. Restricted OLS estimates for the biological siblings sample and fixed effect estimates are even larger, though broadly similar. All these estimates are statistically significant at 1% level, after bootstrapping the standard errors.

20

In terms of the trimester effects, this paper finds that both fixed effects and OLS estimates are strongest in the third trimester for cognitive scores, but for math scores, the first and third trimesters are the strongest for the fixed effect analysis. A similar conclusion is reached when analyzing total scores, where the strongest effects seem to be in the first followed by the third trimester, although most of the trimester estimates continue to be statistically insignificant when fixed effects are used.

As strong as these test score estimates are, it is not clear if the adults, who were 15 years and older in 2007, did indeed have lower schooling outcomes as children. AME (2011) point out that that one of the gaps in the literature is the inability to link early childhood insults with long-term measures for the same cohort. To fill this gap in the literature, I exploit the panel feature of the IFLS and examine different measures of schooling inputs. Those who were aged 7-14 in 1993 would be 22-29 in 2007. We have already seen that this age group did have lower labor supply and are more likely to be self employed. I now provide some evidence that children of a similar age group, but not necessarily exactly the same individuals, do indeed have worse schooling outcomes. Table 7 shows estimates for hours spent studying during elementary school and for child labor status.[15]

Returning to Table 9, those exposed in the second and third trimesters spent 4.3% and 14.3% fewer hours studying during elementary school, respectively. In the restricted OLS model, third trimester effects continue to exist at 14%. In sibling fixed effect estimates, those exposed study 10% fewer hours during elementary schooling, with the strongest effects in the third trimester followed by the first trimester.

Next, effects of exposure on child labor status are explored. Child labor is often perceived to be a negative outcome, and those with lower human capital may be more likely to engage in it. I find evidence that indeed this is the case, as those exposed are about 2.3% to 3.9% more likely to be involved in child labor, with the effects strongest in the first trimester followed by the third trimester. Although, the sibling fixed effects estimates are not statistically significant for child labor, they do have the right (positive) sign, similar to the OLS estimates.

I have so far presented evidence that schooling and cognitive outcomes are being affected by Ramadan exposure and these may indeed be possible channels through which the labor supply and self-employment status are being affected. Now this paper will explore whether those who were age 15-20 in 2007 (age 0-5 in 1993) have lower reported birth weights. If I do find evidence of this, it will give me all the more confidence about the deeper channels through which the labor effects may be taking place, as predicted by the fetal origins hypothesis. Table 10 shows OLS estimates for birth weight effects. Those exposed weigh about 270 grams lower, with those in the second and third trimester having the strongest effects.

---

[15]In addition, I explored effects on the age of starting schooling, age of quitting schooling, whether attended school last year, grade progression and whether child failed grade. Although the OLS effects for most of the categories had the right signs, and were also statistically significant in many cases, the fixed effect estimates were not statistically significant.

7   Discussion

The results show that fasting during pregnancy by Muslim mothers has a wealth effect, measured by fewer hours worked, as well as a selection effect, with those exposed choosing the self-employment sector rather than the more skill-intensive wage work sector.[16] This conclusion is robust to not only household fixed effects, but also to biological sibling fixed effects for a sub-sample of adults. Any other explanation would have to be not only specific to different household members, but for a sub-sample, sibling specific. The fixed effect models give us confidence that the selective timing of pregnancies is unlikely to explain these effects. Selective timing of pregnancy is also an unlikely explanation since, in many developing countries, parents may not plan pregnancies. Moreover, Ewijk (2011) and Almond and Mazumder (2011) provide evidence against any selective timing based on observables. What can then explain the downward bias of OLS relative to fixed effects estimates? An obvious candidate is compliance to fasting. To the extent that compliance is time invariant within households, then fixed effects estimates can control for the downward bias associated with lack of compliance in OLS estimates. In this sense the fixed effects estimates may be thought of as ATE.[17]

Although this paper identifies the Ramadan effect, it is not clear whether religious fasting is driving these results. For example, prices of basic food items may hike during Ramadan. Or, a change in eating behavior after sunset(*iftaar*), which involves eating greasy, oily and generally unhealthy foods may be causing the real harm rather than calorie restriction during fasting. Changes in sleep patterns may also occur. People may also work less during Ramadan due to fatigue. All these factors may confound the Ramadan effect from the fasting effect. Falsification tests on non-Muslims are carried out to check the viability of some of these alternate hypotheses. If the Ramadan effect is driven primarily by changes in prices, the price changes should also affect non-Muslims. The fact that this study does not find any similar effects on non-Muslims is comforting.

It may be that Muslims consume a different basket of goods during Ramadan feast times than non-Muslims. In this case, comparisons between Muslims and non-Muslims may hide the fact that the price increase is only in the greasy, oily and unhealthy products consumed by Muslims during Ramadan. If this change in the basket of commodities (for which prices have also risen) is causing the Ramadan effect, then *a priori* one may not expect more religious families to necessarily eat more of these goods than less religious families, in the absence of fasting. If I do not find similar effects on less religious families, then following the

---

[16]In IFLS, I find that self-employed workers have lower years of schooling.

[17]There is empirical evidence that many pregnant Muslims fast for at least a few days during Ramadan. For example, a study in Singapore of 181 Muslim women found that 70% percent fasted at least a day during pregnancy (Joosoph et al., 2004)). In a study conducted in Sanaa City, Yemen, more than 90% percent fasted over 20 days. In general estimates of compliance to fasting among pregnant women vary between 70%-90% (Makki, 2002; See Almond and Mazumder (2011) for a more detailed survey.)

logic of the alternate hypothesis, it must be the case that religious Muslims are more likely to eat expensive unhealthy food than less religious Muslims. This will be a weaker assumption than one assumed by the earlier literature. In fact, if anything, we may expect less religious Muslims to also eat the same food items even if they are not fasting, because fasting may have spillover effects on non-fasting Muslims too. In this case, one may find effects on less religious Muslims as well– if it is this non-fasting-related eating behavior that is explaining the effect. My results show that effects are strongest on Muslims from religious households compared to less religious ones, which casts doubts on this alternate hypothesis.

In general, comparisons between religious and less religious Muslims find effects mostly on religious groups. It its very likely that the Ramadan effects are due to some factor linked with religiosity amongst Muslims. This will make the assumption that the Ramadan effects are being driven by fasting much more tenable compared to earlier studies. That said, one cannot completely rule out other channels in addition to religious fasting. For example, religious mothers are be more likely to perform extra rituals and suffer from more sleep deprivation. But the same rituals may also relieve mental stress. Any positive effects associated with habits of religious Muslims may imply that the effects of fasting itself are biased downwards, whereas sleep deprivation may imply that the estimates are biased upwards.[18]

When suggestive channels through which these effects may be taking place are examined, evidence shows that mother's fasting lowers not just the Raven's CPM cognitive test scores but also the math scores, for children aged 7-15. Moreover, these estimates are robust to biological sibling fixed effects. This suggests that mother's fasting lowers the stock of human capital of the children. Although AME (2011) study test scores, their sample is restricted to those of age 7 only and they use school registry data rather than Raven's CPM, which is considered the gold standard of measuring Spearman's general intelligence factor "g" (Kaplan and Saccuzzo, 1997). Moreover, this paper is able to apply biological sibling fixed effects, which AME (2011) do not.

When the deeper channels through which the changes in test scores may be taking place are analyzed, results show that exposed children are more likely to be involved in child labor and study fewer hours during elementary school. Thus behavioral changes related to schooling inputs may be one possible channel through which the tests score effects are taking place, apart from the direct effects on one's cognitive ability from fasting (as predicted by medical theory). In fact, as the theoretical framework in the paper clarifies, the behavioral response may itself be a response to the lower returns to schooling for the exposed children. The finding of an effect of maternal fasting on child labor is unique, and provides new evidence that lower health and cognition has causal effects on the incidence of child labor. Moreover, child labor itself may accentuate

---

[18]Future work may want to investigate this concern in greater detail, by disentangling the effect of religious fasting from any other factor, associated with religiosity but not related to undernutrition, from fasting per se.

the initial health shock leading to further cognitive and health effects, as measured by lower test scores and general health (Ewijk, 2011). Similarly, not much is understood about how in utero health shocks can affect schooling behavior. The fact that this paper is able to carry out biological sibling fixed effects for these estimates and find qualitatively similar results gives further confidence in the estimates.

Finally, if the effects are really due to the in utero nutrition shock and not due to some other post-natal shock per se, one may be interested in finding evidence on birth outcomes as well. Although the sample sizes are small and birth weights could be fraught with possible measurement errors, I do find evidence that indeed those exposed do register lower birth weights. The fact that estimates of this study are qualitatively similar to the results found in Almond and Mazumder (2011) is reassuring.

When non-parametric analysis (without controls) is carried out, the results are qualitatively similar to my parametric estimates. However, the estimates show that the major long-term harm to the fetus occurs between 6 and 18 days of exposure to maternal fasting. In the first six days, the marginal effects of fasting are strongest and after 18 days of exposure the marginal effects flatten out. This is an interesting find by itself, for it helps to identify an estimated interval within which additional fasting is most damaging to the fetus. Any policy intervention aimed at creating awareness about the effects of fasting will find such an estimate helpful, as it suggests that even if mothers do not fast for the full month but only for about 18 days, their children can experience effect sizes similar to those fully exposed.

7.1   Effects By Trimester For Salient Outcomes

Almond and Mazumder (2011) summarize select human and animal studies on the effects of nutritional disruption (including fasting) by gestational stage. There is significant heterogeneity of effects for any given outcome and different periods of gestation matter differently for different outcomes. In the case of birth weight, effects vary depending upon the channel and sample. For example, when fasting leads to low blood glucose levels it leads to low birth weight in the third trimester, or low birth weight may occur towards the end of the second trimester due to factors associated with a shorter gestation. Almond and Mazumder (2011) found the strongest effects on birth weights in the first trimester, which is consistent with studies emphasizing changes in HPA axis and exposure to ketones as channels. This paper's finding, that fasting leads to lower birth weight in all trimesters but is strongest (and statistically significant) in the second and third trimesters, is broadly consistent with the literature. Scholl et al. (2001) find that nutritional disruptions early in the third trimester leads to lower birth weights possibly through lowered blood glucose levels.

Most common long-term effects on cognitive function occur in the first trimester, though effects in the

third trimester are also found. AME (2011) find effects on test scores primarily in the first trimester in the UK. This paper finds that the strongest (and statistically significant) effects on math test scores are in the first trimester, when siblings fixed effects are used. This is also consistent with the findings of Rizzo et al.(1991), who ascribe low blood glucose levels as a mechanism through which cognitive functioning is impaired in the first trimester. The effects for Raven's CPM measurement, though statistically insignificant for all trimesters, are strongest for the third, followed by the first, trimester. Mirghani et al. (2005) argues that Ramadan fasting affects cognitive function, through changes in fetal heart rate, in the third trimester. This may suggest that changes in Raven's CPM scores may be taking place through changes in fetal heart rates.

For labor supply, the OLS estimates for the full sample show that the first two trimesters are the most critical. However, when the sample is restricted (OLS restricted) to those families with three or more family members, the OLS estimates suggest that the second and third trimesters are more important. When effects are analyzed for the religious sub-sample, the same conclusion holds. Similar to labor hours worked, self-employment full-sample effects are strongest in the first and second trimesters as well and are robust to the religious sub-sample. However, when the sample (OLS restricted) is restricted to families with three or more members, the effects across trimesters become more homogenous, though still marginally highest in the second and third trimesters. The labor supply and self-employment estimates suggest that the first two trimesters are particularly sensitive periods, though there is heterogeneity by sample so that when large enough families are analyzed the last two trimesters become more sensitive.

Together these results suggest that fasting during pregnancy, through perhaps lowering blood glucose levels, effects not just birth weight but cognitive outcomes, leading to effects on labor market behavior.

7.2 Importance of the Magnitude of Some Key Estimates

One way to compare the negative effects of an in utero nutrition shock is to think about the magnitude of improvements in labor market outcomes, which may have happened in the absence of such a negative effect. The hours worked estimates imply that those exposed work 4.5% fewer hours on average in a normal week. Thomas et al.(2006) find that among those treated with 120 mg of iron per week for a year, there was no change in hours worked. Adhvaryu and Nyshadham (2011) study the effects of better quality health care usage on the labor supply outcomes of those who are sick in Tanzania. They find that using higher quality health care has no statistically significant effect on the total hours worked and the sizes of the effects are rather small. Concurrently, Baird et al. (2011) shows that those children given two or three more years of deworming treatment register a 12% increase in hours worked. In contrast, only a month of potential

fasting during pregnancy leads to the 4.5% effect for the overall sample (and this number increases to 10% for households with three or more members for whom fixed effects are added). Given that, in my sample, the mean number of hours worked is close to full time for primary jobs (36 hours from Table 1), a 4.5 % reduction in hours worked is non-trivial. Indeed, as Thomas (2009) points out, there is a big gap in the literature on the labor supply effects of health shocks and my paper is one of the few to provide robust evidence for such effects, as predicted by theory.

Arguably, the strongest evidence is for a change in an individual's work sector, away from wage work to self-employment. Thomas et al. (2002) document the economic impact of the East Asian financial crises in Indonesia. They find very modest changes in total employment rates, but that male employment declined by 3.7% in the wage sector, with a 1.74% increase in the self-employment sector as a result. The estimates of effects of mother's fasting during pregnancy on children's self-employment probabilities (of about 3.2%) is broadly similar, and if anything larger, compared to the labor supply response during the financial crises.

The estimates of the Ramadan effect on test scores are comparable to those found by Cas (2012), who uses the IFLS to identify the effects of the Safe Motherhood program. The author's estimates of cognitive test scores (of 5.12% to 5.49%) are remarkably comparable to this paper's estimates, which are 5.9% to 7.8%. Together, these estimates, which are equivalent to around 0.25 standard deviations of change in (standardized) cognitive test scores, are comparable to the effects of nutritional intervention, as found in the famous Institute of Nutrition of Central America and Panama (INCAP) experimental study in Guatemala. AME (2011) find effects of about 0.6 standard deviations in the UK. However, they do not use the same measures of test scores; their estimates are only for those aged 7, and their estimates may be prone to measurement error as they do not know the exact religion of the child. Moreover, they study a developed country where the society may invest in the less able child to close the inequality gap created across exposure levels, compared to a developing country like Indonesia, where similar investments are not made. If anything, the inequality gap may be reinforced by investments in the more able children for efficiency concerns.

8   Policy Implications

Knowledge regarding the effects of fasting during pregnancy is important not only because of the size of Muslim population affected by it, but also because it highlights potential concerns over any practice that disrupts the timing of nutrition in utero in any society. Around 75% of all pregnancies overlap with Ramadan in any given year, suggesting that in 2010 alone, more than 1.2 billion Muslims globally and 155 million Muslims in Indonesia were potentially exposed to their mother's fasting in utero (Grim and Karim, 2011). This number is more than twice the roughly 500 million directly affected by the 1918 Spanish Influenza and

240 times the roughly 5 million directly affected by the 1944 Dutch Famine, two extreme events that have received much attention.

From a biological perspective, since fasting during pregnancy affects the intrauterine environment similar to other disruptions in the timing of prenatal nutrition, the result of this study may also generalize to non-Muslims (Almond and Mazumder, 2011). Muslims are also not the only religious group to fast. One of the most intriguing aspects about fasting is its almost universal practice since ancient times. Fasting appears to have emerged independently in different societies. Both eastern and western cultures have practiced it (Arbesmann, 1951). The norms of fasting may vary, but the practice of fasting (and/or skipping meals) does persist to this day across most religions and societies. For example, one in every five pregnant women in the US skip their breakfast (Almond and Mazumder, 2011). Many Baha'i may fast during Ala, Christians during Lent, Hindus during festivals such as Durga Puja Navaratri and Karva Chauth, Jains during Paryushan and Jews may fast during Yom Kippur, to name a few. Given how deeply fasting is linked with material consumption, that it has had such a rich historical legacy, and how universally it seems to have been practiced, it is surprising to see the little attention economists have given to this area of study. This research takes an exception to this trend.

Knowledge of the harmful effects of fasting during pregnancy may be useful to policy makers who may want to create appropriate awareness programs and solve any coordination failures between religious, health and economic sectors of the society. Campaigns, for example, may be aimed at creating awareness of the health and economic impacts of fasting not only to families, through the print, electronic and social media, but they may also be targeted at local midwives and doctors as well as imams so that they offer contextualized solutions. It is indeed helpful to know that Islam exempts women from fasting during pregnancy if their health is adversely affected. The local imams can be encouraged to give talks on this topic, such as during Friday *khutbahs*, to create awareness. This may involve, for example, encouraging husbands to take their pregnant wives to the local doctors for regular health checks in general, and during Ramadan in particular. And when negative health effects are clear, imams can encourage delayed fasting, as allowed by Islamic law.

9   Conclusion

This paper examines the effects of fasting during pregnancy by Muslim mothers on their children's adult labor market behavior. Non-parametric analysis reveals that partial exposure in utero to Ramadan, for even 18 days, generates effects similar to those from from full exposure. Moreover, the marginal damage to the fetus, from mother's fasting during Ramadan, peaks during the 6-18 days window.

Parametric estimations with limited controls show that fasting during pregnancy by Muslim mothers has

a wealth effect measured by 4.5% fewer hours worked in a normal week (in their primary jobs) as well as a selection effect, which involves a 3.2% increase in those choosing self-employment sector.[19] This conclusion is robust to not only household fixed effects, but also to biological sibling fixed effects for a sub-sample of adults. If anything, the estimate sizes increase with fixed effects. When falsification tests are done on non-Muslims, no effects are found. Thus, the effects this paper details are peculiar to Muslims during Ramadan. Moreover, if the Ramadan effect is indeed driven by religious fasting, then the religious families should register the strongest effects since they may be the most likely to participate in fasting. Evidence supports this prediction. The effects are strongest in the more religious families than in the less religious families.

To explore the channels through which these labor market effects are taking place, this study examines the effects on test scores. Evidence shows that mothers' fasting lowers not just the Raven's CPM cognitive test scores by 5.9% but also the math scores for children aged 7-15, by 7.8%. Moreover, these estimates are robust to biological sibling fixed effects(in fact they increase). This suggests that mothers' fasting lowers the stock of human capital of the children which in turn may be determining the labor market behavior. Furthermore, this paper explores the deeper channels through which the changes in test scores may be taking place. Evidence shows that children are 3.3% more likely to be involved in child labor (though the estimates decrease to1.6% and become insignificant with fixed effects) and study 3.4% fewer hours during elementary school (estimates grow significant and larger with fixed effects). Thus behavioral changes related to investments in schooling inputs may be one possible channel through which the tests score effects are taking place, apart from the direct effects on one's cognitive ability from fasting (as predicted by epidemiological theory). In fact, as the theoretical framework in this paper clarifies, the behavioral response itself may be a response to the lower returns to schooling for the exposed children. Finally, if the effects we are observing are indeed due to the in utero health shock and not due to some other post-natal shock per se, we may be interested in finding evidence on birth outcomes as well. Although the sample sizes are small and birth weights could be subject to possible measurement errors, I do find evidence that those exposed register lower birth weights of about 270 grams. [20]

In terms of magnitudes, the estimates of this paper on hours worked are of particular interest (to the broader audience), as few studies exist on this topic. Thomas et al. (2006) find that those treated with 120 mg of iron per week for a year had no change in hours worked, and Adhvaryu and Nyshadham (2011) find no effects of better quality health care usage in Tanzania on labor hours worked. Concurrently, Baird et al. (2011) show that those children given two or three more years of deworming treatment register a 12%

---

[19]Self-employment can be thought of as a less skill-intensive sector. In fact, the self-employed have fewer years of schooling than wage workers in the IFLS.

[20]This estimate is in fact larger than the estimate of birth weight effects from the US, found by Almond and Mazumder (2011)

increase in hours worked. In contrast, only a month of potential fasting during pregnancy leads to a 4.5% effect for the overall sample. The effect sizes for self-employment effects are broadly comparable to those from the East Asian financial crises (Thomas et al., 2002). And the estimates of test scores are broadly comparable to those found by Cas (2012), who studies the Safe Motherhood program in Indonesia, as well as to the famous INCAP experimental study in Guatemala.

There is significant heterogeneity of effects by trimester for any given outcome and by outcome. In general, birth weight, Raven's CPM, hours studied in elementary school and labor market behavior are most strongly affected in the second/third trimester, though math test scores are strongest in the first trimester. This is broadly consistent with the medical literature, which suggests that lower blood glucose levels during pregnancy may play a critical role in shaping these effects.

There are important policy implications of this paper. In contrast to the most recent studies on in utero shocks which study the effects of pollution, war, weather and famine, this study identifies the long-term effects of mild behavioral choices made during pregnancy on children, who are more under the control of decision makers such as fathers and mothers. This makes this study unique and of interest to not only policy makers, health practitioners, and imams, but also to fathers and pregnant mothers themselves. Also, in contrast to studies such as Maccini and Yang (2009), which identify effects of rainfall shocks on rural populations, my sample is not restricted to rural or urban regions but rather includes both, making this study of broader interest. In fact, as Muslims reside in developing and developed countries across the globe, the results have much wider significance. The findings on long-term effects on labor market behavior are also of particular interest since they imply that current studies understate the welfare losses associated with negative health shocks. These losses may not be reflected in aggregate measures of economic growth and overstate the importance given to the association between health and wage income (Thomas, 2009).

These findings also imply that interventions such as the Safe Motherhood program in Indonesia, which seek to improve upon quality and/or quantity of midwives in developing countries, may have higher returns than earlier thought. Access to midwives, for example, may lead to more informed health choices, which may contribute to optimal fasting and minimize losses for children from maternal fasting during pregnancy. Furthermore, this also creates room for new and creative interventions which create awareness about the effects of fasting during pregnancy. Media may be used so that health effects of maternal fasting during pregnancy are highlighted. The local imams can be encouraged to give talks on this topic, such as during Friday *khutbahs*, to create awareness. This may involve, for example, encouraging husbands to take their pregnant wives to the local doctors for regular health checks in general ,and during Ramadan, in particular. And when negative health effects are clear, imams can encourage delayed fasting, as allowed by Islamic law.

Future extensions of this paper can exploit panel feature of the IFLS to determine not only effects on the

levels of outcomes, but growth rates as well. One can also explore heterogeneity by mother's age, education and income. Finally, it will be very interesting to disentangle the role parents and society play in mitigating or reinforcing the in utero nutrition shocks.

References

[1] Adhvaryu, A., Nyshadham, A. (2011). Labor supply, schooling, and the returns to healthcare in Tanzania. Working Papers 995, Economic Growth Center, Yale University.

[2] Almond, D. (2006). Is the 1918 influenza pandemic over? Long-term effects of in utero influenza exposure in the post-1940 U.S. population. Journal of Political Economy 114, 672-712.

[3] Almond, D., Mazumder, B. (2011). Health capital and the prenatal environment: The effect of Ramadan observance during pregnancy. American Economic Journal: Applied Economics 3, 56-85.

[4] Almond, D., Mazumder, B., Ewijk, R.V. (2011). Fasting during pregnancy and children's academic performance. NBER Working Papers 17713, National Bureau of Economic Research, Inc.

[5] Arab, M. (2004). Ketonuria and serum glucose of fasting pregnant women at the end of a day in Ramadan. Acta Medica Iranica 42, 209-212.

[6] Arbesmann, R. (1951). Fasting and prophecy in pagan and Christian antiquity. Traditio 7, 1-71.

[7] Azizi, F., Sadeghipour, H., Siahkolah, B., Rezaei-Ghaleh, N. (2004). Intellectual development of children born to mothers who fasted during pregnancy. International Journal of Vitamin and Nutrition Research 74, 374380.

[8] Baird S., Hicks J.H., Kremer M., Miguel, E. (2011). Worms at work: Long-run impacts of child health gains. http://www.cgdev.org/doc/events/KLPS-Labor_2011-05-16-Circulate.pdf.

[9] Barker, D.J.P. (1997). Fetal nutrition and cardiovascular disease in later life. British Medical Bulletin 53, 96-108.

[10] Brown, R.,Thomas, D. (2011). The 1918 influenza pandemic as a natural experiment, revisited. Manuscript, Duke University.

[11] Card, D. (2001). Estimating the return to schooling: Progress on some persistent econometric problems. Econometrica 69,1127-60.

[12] Cas, A. (2012). Early life public health intervention and adolescent cognition: evidence from the safe motherhood program in Indonesia. Mimeo.

[13] Chen, Y., Zhou, L. (2007). The long-term health and economic consequences of 1959-1961 famine in China. Journal of Health Economics 26, 659681.

[14] Currie, J., Vogl, T. (2012). Early life health and adult circumstance in developing countries. NBER Working Papers 18371, National Bureau of Economic Research, Inc.

[15] Dikensoy,E. , Balat, O., Cebesoy, B., Ozkur, A., Cicek,H., Can, G. (2009). The effect of Ramadan fasting on maternal serum lipids, cortisol levels and fetal development. Archives of Gynecology and Obstetrics 279, 119.

[16] DiPietro, J., Costigan, K., Bornstein,M., Hahn, C., Achy-Brou, A. (2007). Fetal heart rate and variability: Stability and prediction to developmental outcomes in early childhood. Child Development 78, 17881798.

[17] Ewijk, R.V. (2011). Long-term health effects on the next generation of Ramadan fasting during pregnancy. Journal of Health Economics.

[18] Grim, B.J., Karim, M.S. (2011). The future of the global Muslim population. Pew Research Center.

[19] Heckman, J.J. (2007). The economics, technology and neuroscience of human capability formation. IZA Discussion Papers 2875, Institute for the Study of Labor (IZA).

[20] Joosoph, J., Abu, J. , Yu, S.L. (2004). A survey of fasting during pregnancy. Singapore Medical Journal 45, 583-586.

[21] Kaplan, R., Saccuzzo, D. (1997). Psychological testing: Principles, applications, and issues, 4th ed., Pacific Grove, CA: Brooks Cole.

[22] Kapoor, A., Dunn,E., Kostaki, A., Andrews, M., Matthews, S.G. (2006). Fetal programming of hypothalamo-pituitary-adrenal function: Prenatal stress and glucocorticoids. Journal of Physiology 572, 3144.

[23] Kieler, H., Axelsson, O., Nilsson, S., Waldenstrm, U. (1995). The length of human pregnancy as calculated by ultrasonographic measurement of the fetal biparietal diameter. Ultrasound in Obstetrics & Gynecology 16, 353-357.

[24] Maccini, S., Yang, D. (2009). Under the weather: Health, schooling, and economic consequences of early-life rainfall. American Economic Review 99, 1006-1026.

[25] Makki, A.M. (2002). Impact of Ramadan fasting on birth weight in 4 hospitals in Sanaa city,Yemen. Saudi Medical Journal 23, 14191420.

[26] Malhotra, A., Scott, P.H., Scott, J., Gee, H., Wharton, B.A. (1989). Metabolic changes in Asian Muslim pregnant mothers observing the Ramadan fast in Britain. British Journal of Nutrition 61, 663-672.

[27] Meis, P. J., Rose, J.C., Swain, M. (1984). Pregnancy alters diurnal variation of plasma glucose concentration. Chronobiology International 1, 145149.

[28] Metzger, B.E., Ravnikas, V., Vileisis, R.A., Norbert, F. (1982). Accelerated starvation and the skipped breakfast in late normal pregnancy. The Lancet 1, 588-592.

[29] Mirghani, H.M., Hamud, O.A. (2006). The effect of maternal diet restriction on pregnancy outcome. American Journal of Perinatology 23, 2124.

[30] Mirghani, H.M., Weerasinghe, D.S.L, Smith, J.R., Ezimokhai, M. (2004). The effect of intermittent maternal fasting on human fetal breathing movements. Journal of Obstetrics and Gynaecology 24, 635-637.

[31] Mirghani, H.M., Weerasinghe, D.S.L, Al-Awar, S., Abdulla, L., Ezimokhai, M. (2005). The effect of intermittent maternal fasting on computerized fetal heart tracing. Journal of Perinatology 25, 90-92.

[32] Pitt, M., Rosenzweig, M.R., Hassan, H. (Forthcoming). Human capital investment and the gender division of labor in a brawn-based economy. American Economic Review.

[33] Prentice, A.M., Prentice, A., Lamb, W.H., Lunn, P.G., Austin, S. (1983). Metabolic consequences of fasting during Ramadan in pregnant and lactating women. Human Nutrition: Clinical Nutrition 37C, 283-294.

[34] Rizzo, T., Metzger, B.E., Burns, W.J., Burns, K. (1991). Correlations between antepartum maternal metabolism and child intelligence. New England Journal of Medicine 325, 911916.

[35] Rosenzweig, M.R., Zhang, J. (2012). Economic growth, comparative advantage, and gender differences in schooling outcomes: Evidence from birthweight differences of chinese twins. Mimeo, Yale University.

[36] Scholl,T.O., Sowers, M., Chen, X., Lenders, C. (2001). Maternal glucose concentration influences fetal growth, gestation and pregnancy complications. American Journal of Epidemiology 154, 514520.

[37] Seckl, J.R. Holmes, M.C. (2007). Mechanisms of disease: Glucocorticoids, their placental metabolism and fetal programming of adult pathophysiology. Nature Clinical Practice Endocrinology & Metabolism 3, 479-488.

[38] Strauss, J., Thomas, D. (2008). Health over the life course. In: Scultz, T.P., Strauss, J. (Eds.), Handbook of Development Economics, Vol. 4. North-Holland, Amsterdam, pp. 3375-3474.

[39] Thomas, D. (2009). The causal effect of health on social and economic prosperity: Methods and findings. Health Economic Growth Framework Paper, HEGPR_07.

[40] Thomas, D., Smith, J.P., Beegle, K., Teruel, G., Frankenberg, E. (2002). Wages, employment and economic shocks: Evidence from Indonesia. Journal of Population Economics 15, 161-193.

[41] Thomas, D., Frankenburg, E., Friedman, J., Habicht, J., Hakimi, M., Ingwersen, N., Jaswadi, Jones, N., McKelvey, C., Pelto, G., Sikoki, B., Seeman,T., Smith, J.P., Sumantri, C., Suriastini, W., Wilopo, S. (2006). Causal effect of health on labor market outcomes: Experimental evidence. California Center for Population Research Working Paper, CCPR-070-06.

Fig 1: Effect of Ramadan Exposure on Hours Worked and Self-employment Status
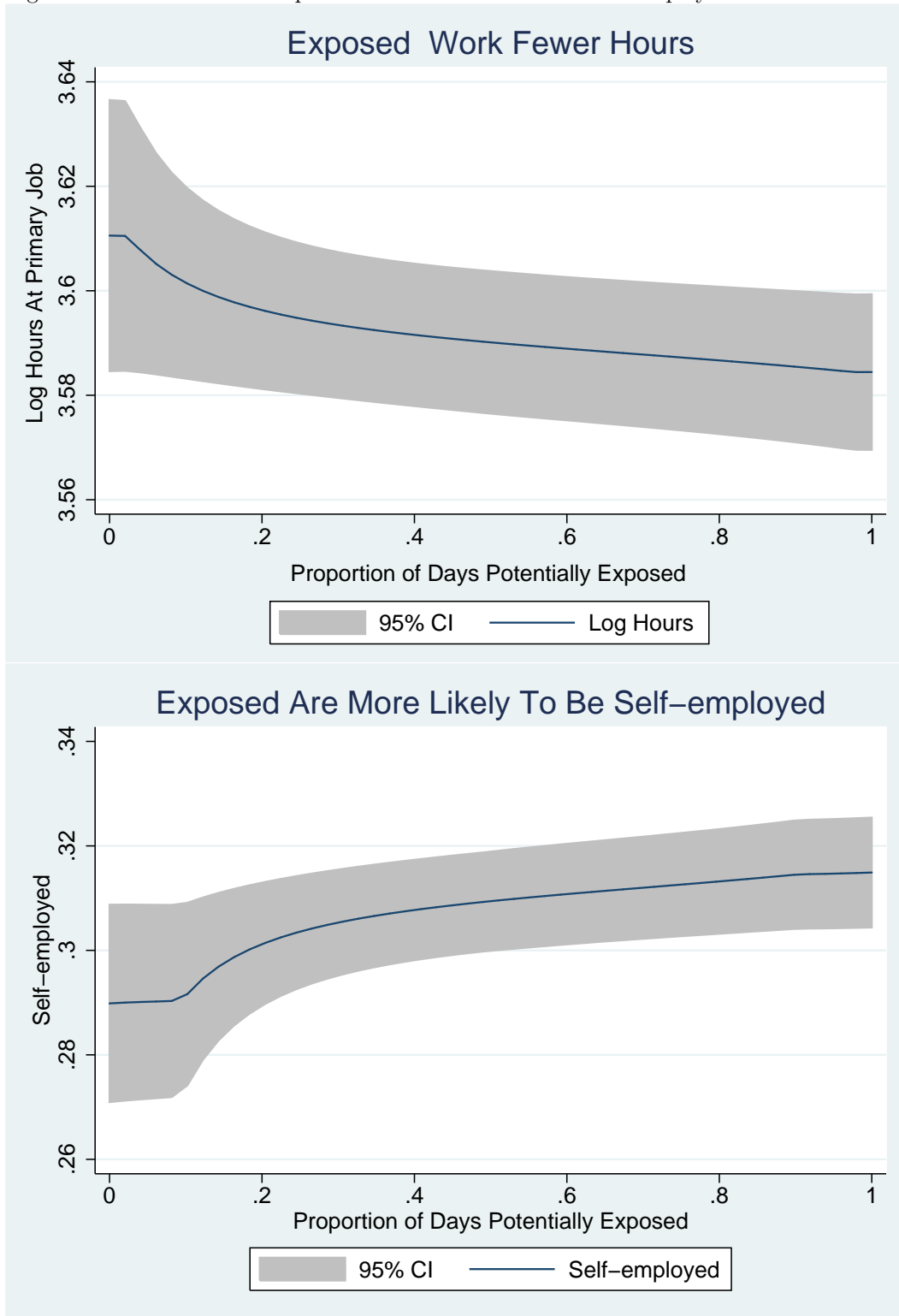
Exposed Work Fewer Hours

Exposed Are More Likely To Be Self-employed

Note: The graphs are local polynomial smooth plots using the Epanechnikov kernel and a bandwidth of 0.405 for Self-employment and 0.436 for Log Hours. The bandwidths were determined using a cross validation technique. Shaded areas represent 95% confidence intervals. Days of potential exposure measures the proportion of days Ramadan overlapped with in utero.

Fig 2: Effect of Ramadan Exposure on Hours Worked By Family Religiosity
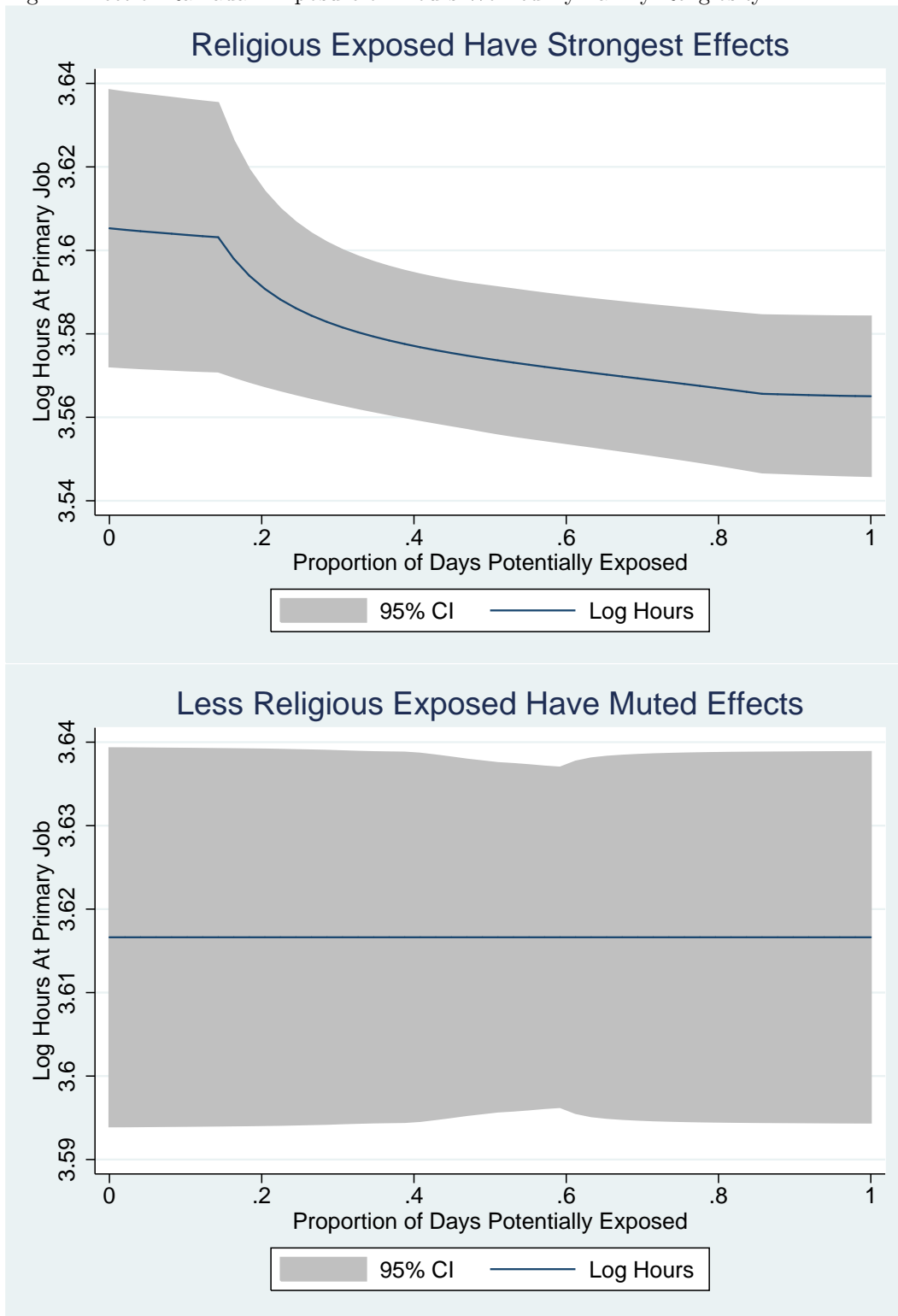
Religious Exposed Have Strongest Effects

Less Religious Exposed Have Muted Effects

Note: The graphs are local polynomial smooth plots using the Epanechnikov kernel and a bandwidth of 0.3829468 for those religious, and 326568.9 for those not so religious. The bandwidths were determined using the cross validation technique. Shaded areas represent 95% confidence intervals. Days of potential exposure measures the proportion of days Ramadan overlapped with in utero.

Fig 3: Effect of Ramadan Exposure on Self-employment By Family Religiosity
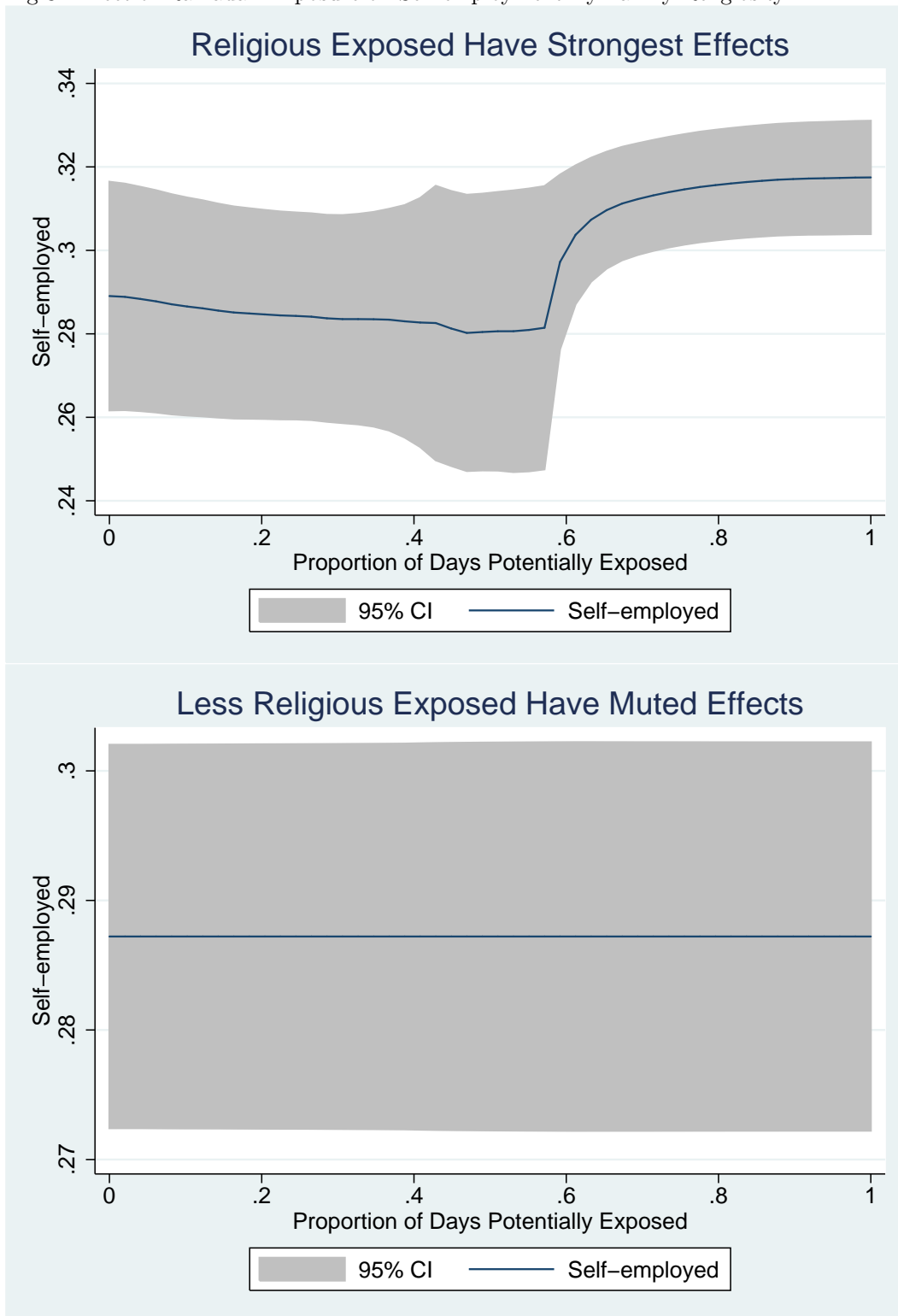
Religious Exposed Have Strongest Effects

Less Religious Exposed Have Muted Effects

Note: The graphs are local polynomial smooth plots using the Epanechnikov kernel and a bandwidth of 0.1917202 for those religious, and 40434.37 for those not so religious. The bandwidths were determined using the cross validation technique. Shaded areas represent 95% confidence intervals. Days of potential exposure measures the proportion of days Ramadan overlapped with in utero.

Table 1: Summary Statistics by Exposure and Religion

	Muslims Exposed	Muslims Not Exposed	Non-Muslims Exposed	Non-Muslims Not Exposed	Total Total
Wave 4 Adults: 15-65 years					
Age	33.08 (12.51)	32.82 (12.25)	34.05 (13.43)	34.94 (13.85)	33.16 (12.59)
Male	0.495 (0.500)	0.518 (0.500)	0.513 (0.500)	0.560 (0.498)	0.500 (0.500)
Religiosity	2.781 (0.464)	2.770 (0.468)	2.940 (0.424)	2.903 (0.474)	2.796 (0.463)
Work	0.679 (0.467)	0.678 (0.467)	0.729 (0.445)	0.820 (0.385)	0.685 (0.464)
Log Hours	3.581 (0.666)	3.631 (0.611)	3.527 (0.696)	3.541 (0.734)	3.582 (0.664)
Self-employed	0.308 (0.462)	0.270 (0.444)	0.309 (0.462)	0.392 (0.490)	0.305 (0.460)
Observations	10207	1630	1223	191	13251
Wave 4 Children: 7-15 years					
Cognitive Scores	0.751 (0.226)	0.761 (0.216)	0.735 (0.247)	0.690 (0.267)	0.750 (0.227)
Math Scores	0.584 (0.263)	0.596 (0.270)	0.578 (0.261)	0.600 (0.217)	0.585 (0.263)
Total Scores	0.697 (0.209)	0.706 (0.201)	0.683 (0.223)	0.662 (0.230)	0.696 (0.210)
Observations	3615	543	390	67	4615
Wave 1 Infants: 0-5 years					
Birth Weight	3.087 (0.550)	3.181 (0.554)	3.126 (0.597)	3.374 (0.584)	3.123 (0.573)
Observations	477	52	339	53	921
Wave 1 Children: 6-14 years					
Hours Studied-Elem.	1.441 (0.263)	1.448 (0.269)	1.497 (0.200)	1.532 (0.154)	1.451 (0.256)
Child Labor	0.0170 (0.129)	0.00673 (0.0819)	0.0242 (0.154)	0.0200 (0.141)	0.0168 (0.128)
Observations	2235	372	432	72	3111

Note: Mean of each variable with standard deviation in parentheses. Sample does not include those conceived less than 21 days after the end of Ramadan.

Table 2: Summary of Key Estimates

	Muslims	Non-Muslims
VARIABLES	Exposed	Exposed
Log Hours	-0.045**	-0.027
	(0.020)	(0.071)
Observations	8,051	1,035
Self-employed	0.032**	-0.089**
	(0.014)	(0.041)
Observations	8,373	1,069
Cognitive Scores	-0.059***	0.083
	(0.018)	(0.054)
Observations	3,514	379
Math Scores	-0.078***	0.036
	(0.023)	(0.048)
Observations	3,521	380
Total Scores	-0.071***	0.062
	(0.017)	(0.044)
Observations	3,521	380
Birth Weight	-0.271*	0.449
	(0.153)	(0.369)
Observations	828	144

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
Robust standard errors are clustered at current household level.
For labor market outcomes, sample is restricted to adults in Wave 4
who were 15-65 years old in 2007. For test scores, sample includes
children aged 7-15 in 2007 from Wave 4. 'Cognitive Scores' are the
Raven's CPM intelligence test scores. All scores are in percentages. For
birth weight, sample is restricted to those 0-5 years old in 1993 (Wave1).
All regressions control for gender, month of birth fixed effects, age and
age squared, where age is defined in days. In addition, I control for all
those estimated to be conceived less than 21 days after the end of
Ramadan. Exposed is a dummy which assumes value 1 if child was
potentially exposed to a full month of Ramadan and 0 otherwise.

Table 3: Estimates From IFLS 4 for Muslims

VARIABLES	OLS	OLS-Rest.	Fixed Effect	OLS	OLS-Rest.	Fixed Effect
	Log Hours	Log Hours	Log Hours	Self-employed	Self-employed	Self-employed
Exposed	-0.045**	-0.088***	-0.103***	0.032**	0.079***	0.078**
	(0.020)	(0.033)	(0.040)	(0.014)	(0.023)	(0.036)
Observations	8,051	2,859	2,859	8,373	2,968	2,968
Exp- 1st Tri.	-0.055**	-0.029	0.024	0.040**	0.072**	0.006
	(0.024)	(0.041)	(0.083)	(0.017)	(0.028)	(0.071)
Observations	3,317	1,154	1,154	3,444	1,202	1,202
Exp- 2nd Tri.	-0.052**	-0.092**	-0.095	0.040**	0.080***	0.034
	(0.025)	(0.042)	(0.069)	(0.017)	(0.029)	(0.056)
Observations	3,211	1,149	1,149	3,320	1,185	1,185
Exp- 3rd Tri.	-0.038	-0.143***	-0.101	0.021	0.077***	0.101
	(0.025)	(0.046)	(0.135)	(0.017)	(0.028)	(0.068)
Observations	3,222	1,076	1,076	3,354	1,118	1,118

Robust standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.
The OLS-restricted and fixed effect estimates are clustered at household level.
'Fixed effects' are household fixed effects which include household head, their spouse,
children and their siblings and siblings-in-law. Sample is restricted to Muslim adults
who were 15-65 years old in 2007. The OLS-restricted limits sample further to those
households with three or more household members. All regressions control for gender,
month of birth fixed effects, age and age squared, where age is defined in days.
In addition, I control for all those estimated to be conceived less than 21 days after the
end of Ramadan. Exposed is a dummy which assumes value 1 if child was potentially
exposed to a full month of Ramadan and 0 otherwise.

Table 4: Estimates From IFLS 4 for Non-Muslims Only

	OLS	OLS-Rest.	Fixed Effect	OLS	OLS-Rest.	Fixed Effect
VARIABLES	Log Hours	Log Hours	Log Hours	Self-employed	Self-employed	Self-employed
Exposed	-0.027	0.087	-0.008	-0.089**	-0.144**	0.000
	(0.068)	(0.116)	(0.154)	(0.042)	(0.067)	(0.101)
Observations	1,035	377	377	1,069	392	392
Exp- 1st Tri.	0.013	0.260**	0.766*	-0.073	-0.157*	-0.161
	(0.078)	(0.125)	(0.446)	(0.051)	(0.086)	(0.377)
Observations	428	162	162	442	170	170
Exp- 2nd Tri.	-0.097	0.008	-0.363	-0.032	-0.084	0.035
	(0.083)	(0.144)	(0.806)	(0.052)	(0.099)	(0.392)
Observations	413	157	157	428	162	162
Exp- 3rd Tri.	-0.006	0.079	0.054	-0.125**	-0.190**	-0.169
	(0.081)	(0.154)	(0.613)	(0.049)	(0.080)	(0.281)
Observations	442	162	162	454	169	169

Robust standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.
The OLS-restricted and fixed effect estimates are clustered at household level.
'Fixed effects' are household fixed effects which include household head, their spouse,
children and their siblings and siblings-in-law. Sample is restricted to Non-Muslim adults
who were 15-65 years old in 2007. The OLS-restricted limits sample further to those
households with three or more household members. All regressions control for gender,
month of birth fixed effects, age and age squared, where age is defined in days.
In addition, I control for all those estimated to be conceived less than 21 days after the
end of Ramadan. Exposed is a dummy which assumes value 1 if child was potentially
exposed to a full month of Ramadan and 0 otherwise.

Table 5: Estimates From Sibling Fixed Effects

	Muslims			Non- Muslims	Muslims			Non-Muslims
	OLS	OLS-Rest.	Fixed Effect	OLS	OLS	OLS-Rest.	Fixed Effect	OLS
VARIABLES	Log Hours	Log Hours	Log Hours	Log Hours	Self-employed	Self-employed	Self-employed	Self-employed
Exposed	-0.159*	-0.333**	-0.434**	-0.039	0.149**	0.140	0.380**	-0.108
	(0.082)	(0.137)	(0.174)	(0.186)	(0.069)	(0.113)	(0.179)	(0.226)
Observations	1,310	530	530	233	1,010	416	416	171
Exposed-1st Tri.	-0.240	-0.560*	0.220	-0.359	0.005	-0.082	-0.900	-0.058
	(0.186)	(0.285)	(1.888)	(0.490)	(0.128)	(0.179)	(1.753)	(0.552)
Observations	523	209	209	98	390	157	157	73
Exposed-2nd Tri.	-0.286*	-0.332*	-0.879	0.155	0.027	-0.003	0.159	-0.684
	(0.168)	(0.183)	(1.365)	(0.363)	(0.037)	(0.060)	(2.285)	(0.565)
Observations	522	217	217	93	405	167	167	63
Exposed-3rd Tri.	-0.168	-0.415*	-0.907	-0.002	0.240**	0.348*	-0.579	-0.023
	(0.140)	(0.248)	(1.227)	(0.343)	(0.117)	(0.200)	(2.851)	(0.085)
Observations	532	215	215	105	403	161	161	73

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The OLS-restricted and fixed effect estimates are clustered at the mother level. 'Fixed effects' are biological sibling fixed effects. Sample for Log Hours is restricted to Muslim adults who were 19-29 years old in 2007, and for Self-employed, 19-26 years old. The OLS-restricted limits sample further to those households with two or more household members. All regressions control for gender, month of birth fixed effects, age and age squared, where age is defined in days. In addition, I control for all those estimated to be conceived less than 21 days after the end of Ramadan. Exposed is a dummy which assumes value 1 if child was potentially exposed to a full month of Ramadan and 0 otherwise.

42

Table 6: Estimates From IFLS 4 for Highly Religious Muslims Only

	OLS	OLS-Rest.	Fixed Effect	OLS	OLS-Rest.	Fixed Effect
VARIABLES	Log Hours	Log Hours	Log Hours	Self-employed	Self-employed	Self-employed
Exposed	-0.054**	-0.131***	-0.133*	0.040**	0.097***	0.119***
	(0.026)	(0.043)	(0.069)	(0.018)	(0.033)	(0.041)
Observations	5,031	1,412	1,412	5,232	1,465	1,465
Exp- 1st Tri.	-0.062**	-0.044	-0.013	0.040*	0.093**	0.067
	(0.031)	(0.058)	(0.143)	(0.022)	(0.041)	(0.084)
Observations	2,019	538	538	2,103	566	566
Exp- 2nd Tri.	-0.061*	-0.142***	-0.258	0.061***	0.094**	0.019
	(0.032)	(0.054)	(0.167)	(0.022)	(0.043)	(0.140)
Observations	2,001	551	551	2,070	568	568
Exp- 3rd Tri.	-0.055*	-0.245***	-0.304**	0.026	0.121***	0.254**
	(0.031)	(0.063)	(0.147)	(0.022)	(0.041)	(0.114)
Observations	2,024	530	530	2,109	551	551

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
The OLS-restricted and fixed effect estimates are clustered at household level.
'Fixed effects' are household fixed effects which include household head, their spouse
children and their siblings and siblings-in-law. Sample is restricted to religious Muslim adults
who were 15-65 years old in 2007. Religious individuals come from families whose mean
corresponds to "Very Religious" or "Religious". The OLS-restricted limits sample further to
those households with three or more household members. All regressions control for gender,
month of birth fixed effects, age and age squared, where age is defined in days. In addition,
I control for all those estimated to be conceived less than 21 days after the end of Ramadan.
Exposed is a dummy which assumes value 1 if child was potentially exposed to a full month
of Ramadan and 0 otherwise.

Table 7: Estimates From IFLS 4 for Less Religious Muslims Only

VARIABLES	OLS Log Hours	OLS-Rest. Log Hours	Fixed Effect Log Hours	OLS Self-employed	OLS-Rest. Self-employed	Fixed Effect Self-employed
Exposed	-0.029	-0.049	-0.073	0.016	0.063**	0.051
	(0.034)	(0.049)	(0.068)	(0.023)	(0.032)	(0.041)
Observations	3,015	1,447	1,447	3,134	1,503	1,503
Exp- 1st Tri.	-0.033	-0.014	0.019	0.033	0.059	-0.014
	(0.039)	(0.056)	(0.124)	(0.027)	(0.039)	(0.084)
Observations	1,294	616	616	1,335	636	636
Exp- 2nd Tri.	-0.028	-0.041	-0.101	0.004	0.072*	0.045
	(0.042)	(0.063)	(0.115)	(0.028)	(0.040)	(0.072)
Observations	1,207	598	598	1,246	617	617
Exp- 3rd Tri.	-0.016	-0.058	-0.041	0.008	0.033	0.018
	(0.042)	(0.065)	(0.177)	(0.028)	(0.039)	(0.093)
Observations	1,194	546	546	1,240	567	567

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
The OLS-restricted and fixed effect estimates are clustered at household level.
'Fixed effects' are household fixed effects which include household head, their spouse
children and their siblings and siblings-in-law. Sample is restricted to less religious Muslim adults
who were 15-65 years old in 2007. Less religious individuals come from families who
self-reported "Somewhat Religious" or "Not Religious" on average. The OLS-restricted
limits sample further to those households with three or more household members.
All regressions control for gender, month of birth fixed effects, age and age squared, where
age is defined in days. In addition, I control for all those estimated to be conceived
less than 21 days after the end of Ramadan. Exposed is a dummy which assumes value 1
if child was potentially exposed to a full month of Ramadan and 0 otherwise.

Table 8: Estimates For Test Scores for Children Aged 8-15

VARIABLES	OLS Cog. Scores	OLS-Rest. Cog. Scores	Fixed Effect Cog. Scores	OLS Math Scores	OLS-Rest. Math Scores	Fixed Effect Math Scores	OLS Total Scores	OLS-Rest. Total Scores	Fixed Effect Total Scores
Exposed	-0.059***	-0.085***	-0.100***	-0.078***	-0.099***	-0.143***	-0.071***	-0.094***	-0.120***
	(0.018)	(0.024)	(0.035)	(0.023)	(0.033)	(0.052)	(0.017)	(0.023)	(0.036)
Observations	3,514	2,084	2,084	3,521	2,087	2,087	3,521	2,087	2,087
Exposed-1st Tri.	-0.027	-0.138**	-0.068	-0.053	-0.122	-0.248*	-0.045	-0.141***	-0.136
	(0.034)	(0.055)	(0.132)	(0.042)	(0.076)	(0.144)	(0.031)	(0.052)	(0.129)
Observations	1,342	790	790	1,364	828	828	1,345	801	801
Exposed-2nd Tri.	-0.000	-0.056	-0.059	-0.032	-0.074*	0.132	-0.014	-0.067*	-0.017
	(0.030)	(0.041)	(0.083)	(0.034)	(0.042)	(0.098)	(0.026)	(0.035)	(0.082)
Observations	1,344	790	790	1,366	828	828	1,348	803	803
Exposed-3rd Tri.	-0.070**	-0.023	-0.163	-0.077*	-0.095*	-0.076	-0.070**	-0.045	-0.128
	(0.032)	(0.042)	(0.192)	(0.040)	(0.053)	(0.217)	(0.030)	(0.040)	(0.167)
Observations	1,344	790	790	1,366	828	828	1,348	803	803

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The OLS-restricted and fixed effect estimates are clustered at the mother level. Standard errors are bootstrapped for fixed effect estimates.'Cog. Scores' are cognitive section of the Raven's test scores. Scores are in percentages. 'Fixed effects' are biological siblings fixed effects. Sample is restricted to Muslim children who were 8-15 year old in 2007. The OLS-restricted limits sample further to those households with two or more household members. All regressions control for gender, month of birth fixed effects, age and age squared, where age is defined in days. In addition, I control for all those estimated to be conceived less than 21 days after the end of Ramadan. Exposed is a dummy which assumes value 1 if child was potentially, exposed to a full month of Ramadan and 0 otherwise.

Table 9: Estimates For Schooling Inputs for Children Aged 7-14 in IFLS1

VARIABLES	OLS Log Hrs. School	OLS-Res. Log Hrs. School	Fixed Effect Log Hrs. School	OLS Child Labor	OLS-Res. Child Labor	Fixed Effect Child Labor
Exposed	-0.034	-0.046	-0.100*	0.033***	0.039***	0.016
	(0.024)	(0.034)	(0.055)	(0.012)	(0.014)	(0.023)
Observations	1,815	941	941	2,164	1,117	1,117
Exposed-1st Tri.	0.046	0.004	-0.144	0.037	0.035	0.130
	(0.048)	(0.066)	(0.262)	(0.029)	(0.044)	(0.307)
Observations	746	382	382	887	446	446
Exposed-2nd Tri.	-0.043**	-0.024	0.196	0.000	0.000	-0.014
	(0.021)	(0.016)	(0.230)	(0.001)	(0.003)	(0.153)
Observations	722	396	396	863	472	472
Exposed-3rd Tri.	-0.145***	-0.139**	-0.255	0.019	0.024	0.027
	(0.040)	(0.059)	(0.227)	(0.022)	(0.018)	(0.083)
Observations	743	390	390	907	474	474

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The OLS-restricted and fixed effect estimates
at the mother level. Standard errors are bootstrapped for fixed effect regressions. 'Log. Hrs School' are hours spent studying
while at elementary school. 'Fixed effects' are biological siblings fixed effects. Sample is restricted to Muslim children aged
15-22 (7-14 in 1993) in 2007. The OLS-restricted limits sample further to those households with two or more
members. All regressions control for gender, month of birth fixed effects, age and age squared, where age
is defined in days. In addition, I control for all those estimated to be conceived less than 21 days after
the end of Ramadan. Exposed is a dummy which assumes value 1 if child was potentially exposed to a full month
of Ramadan and 0 otherwise.

Table 10: Birth Weight Estimates From IFLS 1 for Those Aged 15-20 in IFLS4

VARIABLES	Birth Weight	Birth Weight	Birth Weight	Birth Weight
Exposed	-0.271*			
	(0.153)			
Exposed 1st Tri.		-0.183		
		(0.300)		
Exposed 2nd Tri.			-0.671**	
			(0.335)	
Exposed 3rd Tri.				-0.461***
				(0.174)
Observations	828	290	316	312
R-squared	0.037	0.047	0.049	0.070

Robust standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0$. The table shows OLS estimates for reported birth-weights from Wave 1 of the IFLS. Errors are clustered at household level. Sample is restricted to Muslims who were 0-5 years old in 1993. All regressions control for gender, month of birth fixed effects, age and age squared, where age is defined in days. In addition, I control for all those estimated to be conceived less than 21 days after the end of Ramadan. Exposed is a dummy which assumes value 1 if child was potentially exposed to a full month of Ramadan and 0 otherwise.