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JEL Classification: I15, J13, J24

Keywords: Nutrition Shock, Human Capital, Labor market

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March 2022

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Using Ramadan fasting as a natural experiment, we estimate the long-run impacts of in-utero health and nutrition shocks on adult outcomes. We exploit administrative tax return data comprising the universe of income tax returns filed in Pakistan during 2007–2009. The data allow us to link in-utero Ramadan exposure of individuals with their later life labor market outcomes. We find a robust negative effect of Ramadan exposure on earnings (a lower-bound estimate of around 2–3 percent). The exposed individuals are less likely to be in high-skilled occupations and less likely to be in the top of the income distribution. Using nationally representative survey data we show that our results are unlikely to be driven by selective timing of conception.

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I Introduction

Gaps in children's health, IQ scores, and socio-emotional skills appear early and persist in later life (Cunha & Heckman, 2007). The fetal origins literature traces the roots of these gaps in the health and nutritional environment humans experience before birth, in different pregnancy sub-periods (Gluckman & Hanson, 2004; Almond *et al.*, 2018). Nine months in utero is one of the most critical periods for human skill formation and even mild shocks during this period can leave lasting imprints on future abilities and health trajectories—and thereby the likely path of earnings—of exposed children (Almond & Currie, 2011).

Establishing causal links between in-utero environment and later-life outcomes is not straightforward. For starters, the shocks commonly used to identify these links—nutritional deprivation, disease, stress etc.—are mild and therefore may not leave outwardly visible markers. This measurement problem is accentuated by the fact that outcomes are observed a long time after the shock, when the effects may have been dampened by compensatory parental or societal investment. To overcome this challenge, it is essential that one measures outcomes with precision and has sufficient power to detect even small changes in outcomes across differentially exposed groups. Second, shocks to the in-utero environment are rarely exogenous, being intricately linked with the socioeconomic status of parents and thus the likely path of offspring's earnings. For example, shocks such as famine, disease, and hunger are likely to affect poor families more than the rich. In fact, this identification challenge is related to the measurement challenge in the sense that stronger the shock is more endogenous it is likely to be.

In this paper, we overcome the latter challenge by leveraging a plausibly exogenous shock created by Ramadan fasting. Ramadan is the ninth month of the Islamic calendar, and Muslims fast during this month as a religious obligation, abstaining, among other things, from eating and drinking from sunrise to sunset. Diminished food intake, dehydration, glucose swings, sleep deprivation, and stress resulting from fasting represent an external shock to the maternal environment the developing embryo or fetus experiences for roughly four weeks. We use linked parent-child data from the Pakistan Demographic and Health Survey (DHS) to show that exposure to this shock is uncorrelated with parental observables. Parents do not seem to time pregnancies to avoid or limit their children's in-utero exposure to Ramadan fasting: there is no difference in birth rate across various months of the lunar year

Ramadan follows. Nor is there any difference in the socioeconomic profile of parents of differentially exposed children. We overcome the measurement challenge we note above by using administrative data from Pakistan comprising the universe of income tax returns filed in 2007–2009. Besides reducing measurement error and increasing statistical power, the administrative data allow us to estimate treatment effects on economically relevant labor market outcomes including earnings and occupational choice.

Biomedical literature documents many pathways through which maternal fasting may lead to irreversible physiological changes in the baby. The disruption of glucose—the body's main fuel—sets off the alternative metabolic process of fat burning, which though releases energy can harm the fetus through its toxic byproducts, ketones and fatty acids. These toxins, for example, have been linked to neurological impairment and cognitive deficiency in the exposed children (Hunter & Sadler, 1987; Rizzo *et al.*, 1991). Dietary restrictions of 14–18 hours can push a pregnant woman's body into a biochemical state otherwise seen only in prolonged episodes of starvation (Metzger *et al.*, 1982). The evidence of *accelerated starvation* has been found among pregnant fasting women across the world (Malhotra *et al.*, 1989; Arab & Nasrollahi, 2001). But perhaps even more importantly, these temporary biochemical changes can be misconstrued by the body as representative of the postnatal world, thus wrongly predicting the long-run environment into which the fetus would be delivered. Epigenetic adaptations triggered by these wrong predictions may leave the body with a physiology ill-suited for the postnatal world, thereby hurting the future trajectories of its health and other outcomes (Gluckman & Hanson, 2004). Economic literature, for example, has found that exposed individuals in later life are more likely to be disabled (Almond & Mazumder, 2011), experience heart disease and type-2 diabetes (van Ewijk, 2011), and have lower academic achievement (Almond *et al.*, 2014).

Ramadan, as we note above, follows a lunar calendar. It slowly passes through the Western calendar, advancing by 11 days each year, and hence completing a full cycle in 33 years. We have 66 birth cohorts in our data and therefore can control for birth seasonality—an important confounder in this setup—nonparametrically. Our preferred specification also includes year, month, and place of birth fixed effects. Comparing the outcomes of exposed and unexposed individuals we document four key results. First, in-utero Ramadan exposure has a significant negative effect on earnings. We estimate more than 30 specifications and in each case we can reject the null that Ramadan exposure in any of the pregnancy months has no effect on earnings.

Second, the effect size varies with the pregnancy month of exposure, with individuals exposed in months 3–8 being the worst affected. Earnings of these individuals are 2–3 percent lower than the earnings of the unexposed. Third, exposed individuals are less likely to be employees, less likely to be in high-skilled occupations, more likely to be in low-skilled sectors, and less likely to be in the top of the income distribution. Using nationally representative survey data we show that the occupational choice of exposed individuals likely reflects their lower educational attainment. Finally, we show that the average effect size increases with exposure intensity. Since Ramadan is observed as a religious obligation, exposure is likely to be more intense for more religious families. We construct a measure for the religiousness of a family using the first name of the individual, treating the family as religious if the first name of the individual is Muhammad.

Our estimate is an intention-to-treat effect and therefore has a lower bound interpretation. Surveys of Pakistan pregnant women show that only around one-third of them fast for the *whole* month of Ramadan. The average treatment effect of in-utero Ramadan exposure can therefore be as high as 9 percent of earnings. Since individuals born in 9 out of 12 months of a year are exposed, a back-of-the-envelope calculation shows that Ramadan fasting by pregnant Muslim women lowers output every year by at least $2.4 billion in Pakistan and by $13.8 billion globally. All major religious schools of Islam allow pregnant women to delay Ramadan fasting to a period after pregnancy if they feel fasting could harm them or their baby. Despite this conditional exemption, most pregnant women fast—likely because of misperceptions about religious injunctions or potential harm to the child. Our estimates show that large Pareto gains can be made by targeted interventions educating women about these misperceptions.

We contribute to a rich literature surveyed recently by Almond *et al.* (2018) that examines causal links between prenatal events and adult outcomes. Within this literature, Almond & Mazumder (2011) was the seminal paper that used Ramadan fasting during pregnancy as an exogenous shock to the in-utero environment, examining its effects on outcomes including birth weight, disability, wealth, and sex ratios. Van Ewijk (2011) later showed that Ramadan-exposed individuals were more likely to have poorer general health and were more likely to develop conditions such as coronary heart problems and type 2 diabetes. Almond *et al.* (2014) linked Ramadan exposure to schooling attainment, documenting that the exposed children scored up to 0.08 standard deviation less than the unexposed on the standard math, reading, and writing tests taken at age 7. Similar negative association between prenatal Ramadan exposure and educational attainment was documented by Majid (2015) and Greve *et al.* (2017).[1]

Existing literature has mostly relied on survey data for measuring outcomes. To the extent Ramadan exposure affects cognitive development, recall ability may vary systematically across differentially exposed individuals and can bias the results (Almond *et al.*, 2018). Relatedly, survey data do not afford researchers the power and precision needed in a setting where the treatment is mild and outcomes are measured with a significant time lag. Finally, survey data usually do not record human capital outcomes economists are most interested in. Thus, relative to the existing literature, our comparative advantage is that we can examine the impacts of in-utero Ramadan exposure on economically relevant labor market outcomes including earnings and occupation choice using administrative data that comprises the universe of income tax records for one of the largest Muslim populations in the world. We contribute well-identified estimates of the impacts and present evidence on the likely mechanisms driving them.

The rest of this paper is organized as follows. Section II surveys the literature, documenting the biomedical and economic pathways through which in-utero Ramadan exposure can affect later life outcomes. Section III describes our data and section IV our empirical strategy. We show in section V that our key identification assumption that Ramadan exposure is uncorrelated with parental traits is plausible. Section VI presents our results and section VII concludes.

II In-Utero Ramadan Shock and Later-Life Outcomes

Ramadan is the ninth month of the Islamic calendar.[2] Observing fast (*sawm*) during this month is one of the five pillars of Islam. Fasting involves among other things abstaining from food and drink from sunrise to sunset[3] and is obligatory for every Muslim apart from those who are exempt, such as children, the sick, and the elderly. Pregnant women are not expressly exempt, but they can skip the fast if they fear it would harm them or their baby, in which case they have to make up for it by fasting later

[1]For a more detailed review of this literature please see Table 1 of Almond *et al.* (2018).

[2]The Islamic calendar is a lunar rather than a solar calendar, officially called the "Hijra" calendar. In this paper, we use the terms lunar calendar and Hijra calendar interchangeably.

[3]The most recent Ramadan fast in Pakistan was on May 13, 2021. It was around 15 hours long; it began at 04:24 AM and ended at 7:09 PM.

in the year.[4] Despite this conditional exemption, a majority of Muslim women across the world fast during pregnancy. Table A.XXIV lists 19 studies that estimate the fasting rate in a diverse group of countries. It shows that observance is the norm among pregnant Muslim women, with the fasting rate ranging between 70 and 90 percent in the high-powered studies. Importantly, these studies also highlight widespread misperceptions about the nature of the Ramadan fast and its health impacts. For example, Mubeen *et al.* (2012) report that 88 percent of the surveyed women believe that fasting during pregnancy is obligatory and 59 percent perceive no harm from doing so.

The gestation period is one of the most critical periods in human development. Diurnal fasting during this period can disrupt the supply of nutrients to the fetus. Changed eating and sleeping patterns can stress the maternal environment further, especially through glucose swings, lack of sleep, and mental stress experienced by the mother.[5] Biomedical literature has documented many pathways through which these factors may leave the child with lower cognitive and non-cognitive skills. These pathways have been documented in detail in earlier literature (see Almond & Mazumder, 2011; van Ewijk, 2011). Here we give a brief overview of these pathways.

II.A Biological Mechanisms

A steady supply of glucose in the mother's blood is vital for the healthy development of the child. Dietary restrictions disrupt the supply of glucose, forcing the mother's body to turn toward fat as an alternative fuel. Metabolizing fat releases energy, but its byproducts ketones and fatty acids can be harmful. For example, their in-utero exposure has been linked to neurological impairment among animals and to diminished cognitive ability among humans (Hunter & Sadler, 1987; Rizzo *et al.*, 1991). More generally, studies find that dietary restrictions of only 14–18 hours can push a pregnant woman's body into a biochemical state—measured in terms of metabolic fuels and hormone levels in the blood—otherwise seen only in starvation (Metzger

[4] Encyclopedia of Islam, for example, writes that "The law permits relaxation ... if pregnant or nursing women fear it would be dangerous for them if they should fast" (see "Ṣawm", in: Encyclopedia of Islam, Second Edition, Edited by: P. Bearman, Th. Bianquis, C.E. Bosworth, E. van Donzel, W.P. Heinrichs).

[5] Glucose swings arise from going without food for the whole day and breaking the fast with glucose-heavy food and drinks (dates, for example), which are taken as a social norm (e.g., Arab, 2003). Sleeping patterns are disturbed because breakfast has to be taken before sunrise. Stress arises among other things from the concentration of activity at the end of the day when energy is at its lowest because of food deprivation (e.g., Dikensoy *et al.*, 2008).

et al., 1982). Such *accelerated starvation* can arise when the mother skips breakfast after a night without food, but happens even more rapidly with daytime fasting, as daytime activities stretch the pregnant woman's already high glucose demand even further (Meis *et al.*, 1984). Evidence of accelerated starvation among Ramadan-fasting women has been found in West Africa, the UK, and Iran (Malhotra *et al.*, 1989; Arab & Nasrollahi, 2001).

Biochemical changes in the mother's blood also inform the fetus of the external environment into which it would be delivered. Based on these *postcards* from the future (Paul, 2010), the fetus may reprogram itself, acquiring traits that would give it survival advantage in the predicted future environment (Gluckman & Hanson, 2004). This process, known as predictive adaptive responses (PAR), is shown in Figure I. If the environmental cues turn out to be correct, the reprogrammed traits would maximize the offspring's chance of reaching the reproductive age, but importantly if they turn out to be incorrect, the body's physiology would not be suited for the postnatal environment, hurting its long-term outcomes. For example, in the case of a diminished flow of nutrients from the placenta, the fetus may come to expect a postnatal world with a limited supply of food. It may then reprogram itself accordingly, slowing down metabolism and making other epigenetic adaptations to lower the body's energy needs permanently, thereby gaining a survival advantage in the limited food environment. But if the postnatal world turns out to be one with rich food availability, the reprogrammed traits—higher fat storage, greater insulin resistance, lower muscle mass—would worsen the child's health trajectory, exposing it to higher risks of obesity, hypertension, and heart disease in later life. Fetal programming is a sensitive process, and animal studies have shown that even mild nutritional changes lasting for only a few days can trigger it.[6]

To see how fetal programming can influence the child's cognitive endowment at birth, we need to examine the key stages of neural development in detail. The human brain, like other organs, begins to form in the embryonic stage. This process, however, accelerates in weeks 8–15 of pregnancy when rapid development of the cerebral cortex, called cerebrogenesis, takes place (Otake & Schull, 1998). By the end of this period, the full number of neurons that a normal human possesses gets generated (Dobbing & Sands, 1973). These newly created neurons then migrate from their pro-

[6]In experimental animals, exposure during pregnancy to a single dose of powerful cortisol-like drugs has been found to program the fetus to develop hypertension and insulin resistance after birth, especially if such exposure occurs relatively early in pregnancy (Gluckman & Hanson, 2004).

liferative zones to the neocortex—their functional site. Disturbances to neuronal migration can cause learning disorders and intellectual disabilities (Nyagu *et al.*, 2002). The second critical stage of cerebrogenesis occurs during weeks 16–25. During this stage, accelerated neuronal differentiation and synaptogenesis (creation of synapses) takes place and cerebral architecture begins to develop (Otake & Schull, 1998). The brain also undergoes programmed cell death at this stage, which, if interrupted, can lead to mental illnesses such as schizophrenia (Saugstad, 1998). In the final stage (26+ weeks) the formation of cerebral architecture, cell differentiation, and synaptogenesis continues.

The above highlights the importance of gestation weeks 8–25 in shaping the cognitive ability of the child. During these weeks, a series of timed processes including neurogenesis, neuron migration, and early differentiation occur, which make it a particularly sensitive period for reprogramming modifications (Weinstock, 2008). Many empirical studies find that any adverse external stimuli during this sensitive period, such as exposure to nuclear radiation (Otake & Schull, 1998; Almond *et al.*, 2009), influenza (Almond, 2006; Kelly, 2011), or maternal stress (den Bergh *et al.*, 2005; Persson & Rossin-Slater, 2018), worsen the child's human capital outcomes significantly. The last factor—maternal stress—has also been linked to behavioral and cognitive deficiencies through another channel, reprogramming of the HPA axis (Glover *et al.*, 2010).[7] Fasts of 13 hours or longer have been found to produce increased levels of plasma corticotrophin-releasing hormone (CRH), indicating reprogramming of the HPA axis (Herrmann *et al.*, 2001). Similarly, Ramadan fasting has been linked to elevated levels of cortisol (indicating heightened sensitivity of the HPA axis) during pregnancy (Dikensoy *et al.*, 2008). Reprogramming of the HPA axis reduces the efficiency of glucocorticoid feedback, causing extended HPA responses to stress, which in turn lead to a reduction in hippocampal volume and impaired cognitive ability (Kapoor *et al.*, 2006).

II.B Economic Mechanisms

Biological mechanisms listed above mean that children exposed to Ramadan in-utero may have lower health and skills endowment at birth. Heckman (2007) models two mechanisms through which lower at-birth endowment may have persistent, long-run

[7] The hypothalamic-pituitary-adrenal axis (HPA) is a major neuroendocrine system that controls reaction to stress and regulates many processes such as mood, emotions, and immunity.

impacts on economic outcomes. The model considers human capital investments at various stages of life as inputs to a multistage production function of human capacities where investments at one stage produce capacities at the next. In this dynamic process, the productivity of investments at a stage may depend on the level of capacities in the previous stage. For example, a lower stock of cognitive skills at a stage may diminish the returns to educational investment at the next stage. Capacities may also be cross-fertilizing in the sense that a given dimension of capacity may augment the production of a different dimension. With such *self-productivity*, a higher level of capacities in one stage produces higher levels of capacities in future stages. For example, the stock of cognitive skills at a stage may foster the accumulation of non-cognitive skills at the next stage and vice versa. Together, these two dynamic mechanisms imply that the effects of early-life shocks do not *fade out* but rather remain present throughout the adult life (Almond & Currie, 2011).

Of all the stages in human capacities formation, in-utero is perhaps the most critical. Many studies have shown that even mild shocks during this period can have large effects on later-life outcomes (see Almond *et al.*, 2018 for a recent survey). For example, Almond & Mazumder (2011) show that the overlap of Ramadan fasting with pregnancy lowers the birth weight of affected children. Lower birth weight has in turn been causally linked to lower educational attainment by Currie & Hyson (1999); to lower adult height, IQ, and earnings by Black *et al.* (2007); and to lower cognitive development by Figlio *et al.* (2014). A recurring theme in this literature is that the causal pathways from in-utero shocks to future outcomes run through the educational attainment channel. Almond *et al.* (2014) show that exposure to Ramadan fasting during pregnancy lowers academic achievement at age 7: exposed students perform on average 0.05-0.08 standard deviations worse than unexposed students. A qualitatively similar result was found for in-utero Ramadan exposure by Majid (2015) and Greve *et al.* (2017), influenza exposure by Almond (2006), and nuclear radiation exposure by Almond *et al.* (2009). Other studies link prenatal shocks to later life health and labor market outcomes directly. Individuals with in-utero Ramadan exposure, for example, have been found more likely to be disabled as adults (Almond & Mazumder, 2011) and suffer from poor health, especially heart disease and type-2 diabetes (van Ewijk, 2011).

In-utero shocks commonly exploited in the fetal origins literature are mild. Their effects, however, are measured a long time after birth when these may have been attenuated by compensatory investment processes we outline above. To estimate these effects credibly, it is therefore essential that one measures economically relevant variables with precision. We use administrative data comprising the universe of tax returns filed in Pakistan for our estimates. The data allow us to link current labor market outcomes with past in-utero Ramadan exposure and therefore to estimate the effects of a mild treatment with precision and high statistical power. The use of administrative data is rapidly becoming a norm in this literature, which apart from reducing measurement error helps mitigate the problem of selective attrition from surveys (Almond *et al.*, 2018). Furthermore, we are able to estimate the effect of in-utero Ramadan exposure on earnings of a large Muslim population directly, which to our knowledge has not been done before.

III Data

Our primary data source is the universe of personal income tax returns filed in Pakistan over the period 2007–2009. We measure earnings as the taxable income reported by individuals on these returns. Using unique personal identifiers, we link these returns to the Tax Register, which contains information on individual characteristics such as the date of birth, place of birth, and occupation. We do not observe the religion of a person, but Pakistan is a predominantly Muslim country where more than 97 percent of the population report Islam as their religion (Esposito, 2004).

We restrict our sample to individuals born between 1924 and 1989. These 66 birth cohorts cover two complete cycles of Ramadan's advance through the solar year, allowing us to control for an important confounder in our setup—birth seasonality—nonparametrically. In the data, the birth date of individuals who know their year of birth but not the exact day is coded as the 1st January of the birth year. To avoid any measurement error arising from it, we drop all observation where the reported birth day is the 1st of January. We also drop observations where the date of birth or taxable income is missing. Applying these restrictions leaves us with a sample of nearly one million observations for which we observe both the birth date and earnings.

We combine the birth date with the normal gestation length of 266 days to construct our measures of Ramadan exposure. This strategy is illustrated in Figure II. The left vertical axis shows the conception date, which we calculate as the birth date minus 266. We divide individuals into twelve groups depending on their conception date relative to Ramadan. It is easy to see from the figure that individuals conceived in the month Ramadan began in, indicated by month 0, are partially exposed with the exposure length varying between 1 and 29 days. Compared to them, those in months -2 and -1 are not exposed and those in months 1–8 are fully exposed in the corresponding pregnancy month. Finally, individuals in month 9 were born during Ramadan. Being so, they are also partially exposed with the exposure length varying between 1 and 29 days in the period just before their birth. In some specifications, we use a trimester measure of exposure, classifying individuals exposed in pregnancy months 1–3 in the first trimester, 4–6 in the second, and 7–9 in the third.

Using the normal pregnancy length can create measurement error in our exposure measures if the pregnancy lasts more or less than the normal term. Note, however, that individuals classified in month -2 would be exposed only if the pregnancy term falls in the $(295, 325]$ days interval,[8] which is an extremely unlikely event (Jukic *et al.*, 2013). Our reference category therefore includes *certainly* not exposed individuals only. We have more power than is usually available in such studies and therefore can show results for other months relative to this baseline category of certainly unexposed separately.

In addition to the tax returns, we use data from two other sources. First, to show that parents do not time pregnancies to avoid their overlap with Ramadan, we use the nationally representative Pakistan Demographic and Health Survey (DHS). The survey is part of an international program that collects numbers on fertility, family planning, and maternal health in more than 60 countries. We focus on the *ever-married women* part of the survey, pooling together its three rounds carried out in 1990-1991, 2006-2007, and 2012-2013. The data allow us to link mothers and children and contain information on important mother characteristics such as literacy, education, partner's education, wealth, occupation, and house ownership. The data contain the month and year of birth for all children and the day of birth for a small subset of children (8 percent). Where we do not observe the birth day, we impute it to be the 15th of the birth month and create our Ramadan exposure measures using the strategy described in Figure II. In a robustness check on this strategy, we draw the day of birth at random from a uniform distribution when the day of birth is missing and find similar results. The data cover children born between 1952 and 2013 and therefore have a good overlap with our tax data.

Finally, we also use data from the Pakistan Social and Living Standard Measure-

[8] It is important to emphasize that in this setup premature births cannot be misclassified as "not exposed" (see Figure II). They can, however, be classified as "exposed" even when they are not exposed. However, in such cases we are more likely to misclassify the month of exposure than the trimester and hence our trimester estimates are less likely to be affected by this issue.

ment (PSLM) survey. It is a nationally representative biannual survey, and we access its six rounds carried out between 2004 and 2014. Using the data we document the correlation between educational attainment and occupation choices of Pakistan workers. We use the correlation to explore causal pathways between in-utero Ramadan exposure and earnings.

IV Empirical Strategy

IV.A Specification

To examine the causal link between in-utero Ramadan exposure and later life outcomes, we exploit the plausibly exogenous variation in exposure created by the timing of pregnancy, comparing the unexposed individuals with those exposed in different pregnancy months. Specifically, we estimate the following model

$$y_{igmt} = \sum_{\mu=-1}^{9} \beta_\mu \,.\, \mathbb{1}(em_i = \mu) + \gamma_g + \eta_m + \lambda_t + \varepsilon_{igmt}, \tag{1}$$

where em_i denotes the pregnancy month of Ramadan exposure. We regress the outcome of individual i born in district g, month m, and year t on dummy variables indicating the exposure month (see Figure II for the exact definition of these dummies). We omit the baseline category consisting of *certainly unexposed* individuals, classified in month -2, and include separate dummies for the eleven other months from -1 to 9. The specification includes the district, month, and year of birth fixed effects.

For some of our results we define the Ramadan exposure measure in terms of the in-utero trimester rather than the month. The model we estimate in such cases is the following

$$y_{igmt} = \alpha \,.\, \mathbb{1}\left[em_i \in \{-1, 0\}\right] + \sum_{\tau=1}^{3} \beta_\tau \,.\, \mathbb{1}(et_i = \tau) + \gamma_g + \eta_m + \lambda_t + \epsilon_{igmt}, \tag{2}$$

where et_i represents the exposure trimester. Pregnancy months 1–3 of exposure are included in the first trimester and 4–9 in the next two. Our omitted category is the same as in (1), i.e., *certainly unexposed* individuals corresponding to month -2, and we combine individuals in exposure months -1 and 0 into one category. This category comprises unexposed and partially exposed individuals and we use it as a placebo test on our empirical strategy.

IV.B Identification

Identification in this setup rests on the assumption that the unobserved determinants of earnings and other labor market outcomes are uncorrelated with our Ramadan exposure measures. Operationally, it implies that parents do not systematically choose the timing of pregnancy in terms of the Hijra calendar so that parental composition does not vary with children's prenatal Ramadan exposure. Because individuals in exposure month -1 are unexposed and those in month 0 are partially exposed, both of our models contain built-in placebo tests of the validity of our identification strategy.[9] We supplement these tests with direct evidence from the DHS data showing that our Ramadan exposure measures are indeed uncorrelated with parental characteristics.

Birth seasonality is an important confounder in this setup. Prior work has found that later life outcomes, such as life expectancy (Doblhammer & Vaupel, 2001) and cognitive ability (Crawford *et al.*, 2007), are associated with the season of birth of the child. Because Ramadan follows a lunar calendar, each year it begins roughly 11 days earlier than the previous year. Exploiting its slow passage through the Western calendar, one can disentangle the seasonality effect from the effect of interest using the standard controls, provided that the data cover at least 33 birth cohorts.[10] Our data include 66 birth cohorts, which lets us control for the birth seasonality nonparametrically and credibly.

IV.C Interpretation

We do not observe if mothers of individuals in our sample observed Ramadan fasting while they were pregnant. Our estimates therefore have an intention-to-treat (ITT) interpretation. Surveys of Muslim women, however, routinely find that a majority of them do fast during pregnancy. Table A.XXIV lists 19 such surveys from 11 diverse countries. The two high-powered surveys from Iran and Yemen report fasting rates

[9] If parental composition varies across our Ramadan exposure groups, the coefficients on these month dummies will pick it up.

[10] Ramadan's slow advance through the Western calendar can be seen by comparing the two birth cohorts shown in Figure II.

between 71 and 90 percent (Arab & Nasrollahi, 2001; Makki, 2002). These fasting rates are similar to the ones estimated in Pakistan (see the first three studies in the table). There is only modest variation in the fasting rate over the gestation term. It declines from 77 percent in the first trimester to 72 percent in the second and 65 percent in the third (Arab & Nasrollahi, 2001). Given that the fasting rate is less than 100 percent, our ITT estimates understate the average Ramadan effect in the population, a point we come back to later in the paper. One other noticeable feature of these surveys is that many women are not aware of the optional nature of the Ramadan fast. Nor are they aware of its harmful effects on the child's health. In fact, 67–88 percent of the surveyed women believe fasting is obligatory and 59–79 percent of them perceive no harm from doing so (Joosoph *et al.*, 2004; Mubeen *et al.*, 2012).

V Selective Timing of Conception?

A critical piece of our identification strategy is that the Hijra timing of conception is uncorrelated with the unobserved determinants of the child's later life outcomes. This assumption would be violated if a selected set of parents were able to time pregnancies in such a way as to avoid the pregnancy's overlap with Ramadan. Before presenting evidence on this point, we may emphasize that Ramadan lasts one month only and therefore avoiding its overlap with pregnancies is not practically straightforward: pregnancies initiated in 9 out of 12 months of a year will overlap with Ramadan at some stage. Moreover, because Ramadan follows a lunar calendar, its exact timing depends on the moon sighting and therefore is not perfectly known in advance.[11] Largely for this reason, the Hijra calendar is rarely used in planning decisions either by governments or by households.

We now formally rule out selection in the Hijra timing of conception using the nationally representative DHS data. We begin by looking at the proportion of births by birth month, comparing the Western and Hijra calendars. The Western calendar provides a useful benchmark against which we can compare our Hijra results. Figure III illustrates these results. The birth rate shows a clear seasonal pattern in terms of the Western calendar with births in summer exceeding births in winter by a significant margin. In contrast, no such pattern is visible for the Hijra calendar. The birth rate

[11] A lunar month consists of either 29 or 30 days. In Pakistan, an official body called Central Ruet-e-Hilal Committee meets on the 29th of every lunar month to announce the sighting of the new moon. In case the new moon is not sighted on the 29th, the current lunar month is extended to have 30 days.

is flat over the lunar year: births in each month nearly equal one-twelfth of the total births in the year. For these results, we pool the DHS data from all three survey waves. Figure A.I shows that running the analysis separately on each survey wave produces similar results, showing that fertility patterns have not changed much over time.

No variation in the birth rate does not rule out sorting of parents of different socioeconomic status across Hijra months of conception. To rule out selection along this dimension, we use variables from the DHS data indicating the socioeconomic status of parents to examine whether any of these variables exhibit systematic correlation with the Hijra timing of conception. Again we begin with the Western calendar to provide a benchmark. Tables A.I-A.II show that parental characteristics are indeed correlated with children's Gregorian quarter of birth. We can reject the null that the quarter of birth coefficients are jointly zero at the conventional levels for 18 out of 20 outcomes. No such correlation, however, exists for the Hijra timing of conception (please see Tables I and II). None of the trimester coefficients in Tables I-II are distinguishable from zero at the conventional levels. Nor can we reject the null that the three trimester coefficients are jointly zero for any of the 20 outcomes. It bears emphasizing that our failure to reject does not stem from lack of statistical power. We have a large sample and hence statistical power for this exercise. The insignificant coefficients we obtain are precisely estimated zeros where both the coefficients and their standard errors are trivial. This can be seen more clearly in Figure IV where we display the estimated coefficients and their 95 percent confidence intervals from our exposure month based specifications. We get flat lines with tight confidence intervals around them for all specifications we estimate.

We conduct two robustness tests on our results above. First, Table A.III estimates a multinomial logistic model where we test if parents' education attainment, occupation, and other socioeconomic characteristics predict the Hijra timing of conception of their children. Unsurprisingly, these covariates have no predictive power. This again can be seen more clearly in Figure A.II where we plot the marginal effects from these models. Second, in our baseline specification, when we do not observe the day of birth of an individual we impute it to be the 15th of the birth month.[12] Tables A.IV-A.V follow an alternative strategy. Here we draw the day of birth at random from a uniform distribution when the exact day of birth is missing. The results from these

[12]Note that this issue exists only in the DHS data. We always observe the complete date of birth of individuals in our administrative tax data sample.

alternative specification are indistinguishable from our baseline results in Tables I-II.

Together, the above evidence shows that the Hijra timing of conception is indeed uncorrelated with the preexisting determinants of children's later life outcomes. Note that we are not alone in reaching this conclusion. Before us, evidence consistent with such exogeneity was presented for the Muslim populations of Michigan, Uganda, and Iraq by Almond & Mazumder (2011), Indonesia by van Ewijk (2011), and Britain by Almond *et al.* (2014).

VI Results

We now examine the effects of in-utero Ramadan exposure on earnings and other outcomes using administrative tax return data. We begin by presenting nonparametric evidence and later formalize the results through the regression-based framework.

VI.A Nonparametric Evidence

Figure V illustrates the relationship between earnings and in-utero Ramadan exposure nonparametrically. We divide individuals into 52 groups depending on their week of conception relative to Ramadan. Individuals in groups -12 to -4 are not exposed: they were conceived after Ramadan ended and were born before the start of next Ramadan. Individuals in groups -3 to 0 and 36 to 39 are partially exposed and those in groups 1–36 are fully exposed though in different pregnancy weeks. The figure plots the average earnings of these 52 groups. Since a lunar year is shorter than the solar year by roughly 11 days, week 39 in our sample contains only 1 day and week -12 only 3–4 days. We fit a local-linear kernel on the binned scatter plot to highlight the shape of the earnings-exposure profile.

We find a curious, saucer-shape relationship between exposure and earnings. Average earnings fall monotonically along the horizontal axis, reaching a minimum in week 15. They start rising from this point onward before finishing at virtually the level they begin from. Not only does this relationship hold for average earnings but also for the other moments of the distribution—first quartile, median, and third quartile (see the bottom panel of Figure V). Exposure to Ramadan during pregnancy seems to have long-run effects: exposed individuals—in particular those exposed in the middle period of pregnancy—earn significantly less than the unexposed in their adult life.

Figure VI refines this analysis by conditioning on the month, district, and year of birth. Formally, we estimate a version of equation (1), adding successively each of the three fixed effects into the model. We plot coefficients $\hat{\beta}_\mu$'s along with their 95 percent confidence intervals from these specifications. Conditioning on birth covariates, in particular on the year of birth fixed effects, flattens the earnings-exposure profile considerably. No meaningful difference now exists between the unexposed individuals and those exposed in the early months of pregnancy. In contrast, individuals exposed in the middle period of pregnancy continue to have significantly lower earnings regardless of the controls we use.

VI.B Regression Results

Table III formalizes these results by estimating equation (1). We begin with the most parsimonious specification and successively introduce the month, district, and year of birth fixed effects, permuting among their combination in the next six columns. The sample here includes all three years 2007–2009, and we cluster standard errors at the individual level. We show below that we obtain similar results if we use each year's data separately or use more granular controls for the time and place of birth or replace the year of birth fixed effects with flexible controls for age.

Unsurprisingly, the regression results are consistent with the visual evidence. In-utero Ramadan exposure indeed has a causal effect on later life earnings. Four insights from this analysis are particularly noteworthy. First, the estimated coefficients for the unexposed (month -1) and partially exposed (month 0) groups are indistinguishable from zero.[13] These coefficients, as we note above, are placebo tests built into our models. Their insignificance shows that the Hijra timing of conception does not bear a systematic correlation with earnings, providing another piece of evidence supporting our empirical strategy. Second, we can easily rule out that Ramadan exposure in any of the pregnancy months has no effect on adult life earnings. The null that exposure months dummies are jointly insignificant is rejected with a *p*-value close to zero in all specifications. Third, exposure in pregnancy months 3–8 matters the most. The final specification, which makes the most granular comparison, shows that individuals exposed in these months earn 2–3 percent less on average than the certainly unexposed (our omitted category). Fourth, the coefficient on month 9 is statistically

[13] Recall that individuals grouped in month -1 are unexposed and those in month 0 are partially exposed (please see Figure II on how we construct these groups). The coefficient on the first group is always insignificant and on the second is insignificant in specifications with the cohort fixed effects.

insignificant in all specifications. This is unsurprising given that this group is also partially exposed with exposure length varying between 1 and 29 days (please see Figure II for details). The insignificance may also reflect that by this time of the pregnancy the fetus may already have gained maturity, making any incremental shocks less likely to have strong negative effects.

VI.C Exposure Intensity

Table A.XXIV shows that a majority of Muslim women fast during pregnancy. It means we have a strong first stage in our setup, although we do not observe the fasting rate for our sample directly. The fasting data would have allowed us to go beyond the ITT to estimate the average treatment effect for our population. It would also have allowed us to see if the effect size increases with the fasting rate (the number of days the mother fasts during pregnancy—the exposure intensity). Here we follow an alternative strategy to make progress on the latter point. Since Ramadan fast is observed as a religious obligation, the fasting rate must to a first order depend on how religious an individual's family was at the time they were in utero. We do not observe family religiousness directly but can construct a measure of it using the given name of the individual. Specifically, we define a family as religious if the given name of the individual is Muhammad. We presume that religious mothers are more likely to pick a religious name for their children and are more likely to fast during pregnancy. Because name of the child is chosen at the time of birth, it captures religiousness of the family close to the event of interest—the pregnancy. Bifurcating our sample on the basis of this criterion, we estimate the effect size for the two groups separately. The results, plotted in Figure VII, are consistent with our a priori reasoning.[14] The point estimates for the group with a higher expected fasting rate are invariably larger (more negative), although the difference between the two is not always significant. Since Muhammad is a male name, by construction all females in our sample get included in the low treatment intensity group. To show that our result is not biased by gender gap in earnings, Figure A.III replicates this analysis, restricting the sample to males only. The results from this alternative specification are quite similar (note that our sample is more than 90% male). The positive relationship between exposure intensity and the effect size strengthens our causal story, linking Ramadan exposure during pregnancy

[14]This finding is consistent with a similar result in Majid (2015) showing that the negative effect of in-utero Ramadan exposure is stronger for more religious families.

to earnings in the later life.

VI.D Occupation Choice

We next explore the effect of in-utero Ramadan exposure on occupation choice of individuals. To increase power, we use equation (2) with the trimester measure of exposure for this exercise. We first re-estimate our earnings equation for this specification as a baseline, obtaining similar results (compare Tables IV and III). Table V examines two other outcomes—occupation choice and the likelihood of being a top earner—using this alternative specification. Occupation choice is a binary variable here, indicating if the individual is an employee as opposed to being self-employed. In-utero Ramadan exposure indeed matters for occupation choice: the estimated likelihood of employment is significantly lower for individuals exposed in the first two trimesters of pregnancy (by around 0.7 percentage points or 1.25 percent) than for the unexposed group (the omitted category).[15] We show below that employees in Pakistan on average are more educated and earn substantially more than the self employed. The result thus suggests that the Ramadan-exposed individuals on average have lower human capital and make dominated occupation choice. One other reflection of the lower human capital is that the proportion of top earners falls with Ramadan exposure, especially for those exposed in the second trimester (see the next six columns of the table).

Choosing employment in place of entrepreneurship (self-employment) is commonly associated with having lower ability to bear risk (e.g., Ahn, 2010). However, in developing countries, employment—especially in the public sector—is linked with status and hence on average attracts more able and more educated individuals. To show this point formally for our population, we use the PSLM data where both occupational choice and educational attainment are recorded. Table VI presents the results. We restrict the sample to working individuals who report either employment or self-employment as their primary occupation and regress a dummy for being an employee on an indicator that the individual attains education up to the given level or higher. A strong correlation exists between these two variables. The propensity to be an employee rises sharply as one goes up the education ladder. For example, individuals with an undergraduate degree or higher are 14 percentage points more likely

[15] In a parallel result for Indonesian population, Majid (2015) finds that individuals exposed to Ramadan in utero are more likely to be self-employed.

to be employees than self-employed. The difference in educational attainment in turn shows up in the income people earn. Figure A.IV compares earnings of employees and the self-employed using the tax returns data. The employees' distribution has a thicker right tail and first-order stochastically dominates that of the self-employed other than at the extreme bottom.

Table A.VI explores the effect of Ramadan exposure on occupation choice further. We now exploit the six-digit occupations codes available in the tax data to divide occupations into high- and low-skilled categories. Specifically, occupations requiring specialized knowledge or skills such as finance or accounting are coded as high-skilled, whereas those requiring no specialized knowledge such as wholesale or retail trade are coded as low-skilled. We then estimate our equation (2) with a dummy variable indicating if the individual works in a high-skilled profession as the outcome variable. The results show that Ramadan-exposed individuals are less likely to work in high-skilled professions. In no specification do we fail to reject that Ramadan exposure has no effect on occupation choice. To strengthen this conclusion, in an alternative specification we use a low-skilled dummy as the outcome variable. However, instead of hand-coding occupations as high- or low-skilled, here we use a more data-driven approach, categorizing individuals in the wholesale and retail trade *only* as low-skilled. The results in Table A.VII are consistent with our earlier results, showing that Ramadan-exposed individuals are more likely to be in low-skilled professions.

While we discover a significant impact of Ramadan exposure on occupation choice, it is important to emphasize that the occupation choice alone does not explain the earnings effect we estimate above. Tables A.VIII and A.IX show results from estimating our earnings equations after restricting the sample to employees only. Significant earnings differences exist across exposed and unexposed individuals even within employees. Table A.X repeats this analysis for high-skilled individuals, producing similar results. The key takeaway from the analysis in this section therefore is that Ramadan-exposed individuals likely have lower human capital on average. This lower human capital reflects in their occupation choice as well as in their earnings within occupations.

VI.E Robustness

Our results are robust to important identification and inference concerns. Section V shows that parents do not time pregnancies to avoid or limit Ramadan exposure of their children. Nor does their composition differ significantly across the exposed and unexposed groups. This conclusion is reinforced by the built-in placebo tests contained in our estimating equations. They show that within the unexposed groups, there are no systematic differences in terms of earnings or other outcomes depending upon their Hijra month of conception. We now run more robustness checks. We have so far controlled for birth seasonality using the month of birth fixed effects. Our sample contains 66 birth cohorts and exploiting the richness of our data we can experiment with finer seasonality controls. We can also experiment with more granular spatial controls. Tables A.XI and A.XII do this, showing that our results are not sensitive to these alternative specifications. In a similar vein, Table A.XIII shows insensitivity of our results to replacing the cohort fixed effects with flexible controls for age. The results in the last three columns, where we progressively add age and its higher-order terms into the model, are similar to ones with the cohort fixed effects. Finally, our baseline specification pools data for all three years (2007–2009), clustering standard errors at the individual level. Tables A.XIV–A.XIX show that similar results are obtained if we estimate our models on each year's data separately. We report these year-wise results for both our pregnancy month and trimester measures of exposure.

VI.F Heterogeneity

We explore heterogeneity in the treatment effect along three dimensions. First, the epigenetic mechanisms we discussed in section II.A reprogram the body so that it remains at its prime at least until the reproductive age. As a result, some adverse effects of the PARs, as we note above, are not expected to appear until late in life (Gluckman & Hanson, 2004). In our setup, this means that the negative effect of in-utero Ramadan exposure is likely to be worse among older cohorts, especially if health is an important channel through which the earnings effect mediates. Table A.XX tests this hypothesis. We estimate an augmented version of equation (2), adding interactions of the Ramadan exposure dummies and an indicator that the individual belongs to an older cohort. Various columns of the table look at cohorts aged above 40 to above 65 using our preferred specification that includes all three types of birth fixed effects. The point estimates of the interaction terms are almost always negative, economically meaningful, and increase with age, but these differences are statistically indistinguishable from zero. We therefore cannot rule out that the negative earnings effect of Ramadan exposure is the same for both young and old cohorts.

The length and severity of the Ramadan fast vary across meteorological seasons. Pakistan is located around 2,000 miles north of the equator and, accordingly, its day length does not vary as much over the year as it does in other countries.[16] In contrast to day length, the variation in temperature across summer and winter months is unusually large in Pakistan, with temperature reaching 50°C (or 122°F) in some parts of the country in summer. Fasting during such extreme weather is likely to have more pronounced effects than during other months.[17] Table A.XXI explores heterogeneity along this dimension. We indicate individuals whose in-utero exposure to Ramadan was in months May and June—the two hottest and driest months in the country—with the dummy variable *Ext Weather*. As expected, the coefficients on the interaction terms are negative and meaningful, but as earlier we cannot rule out if they are indistinguishable from zero in our preferred specification.

Parental investment, as we note earlier, can offset the negative effects of prenatal shocks. We do not observe parental income in our data and instead proxy for it using the place of birth of the individual. The dummy *Major City* in Table A.XXII indicates that the individual was born in one of the three richest cities of Pakistan—Karachi, Lahore, and Islamabad. To the extent that parental income is on average higher for this group of individuals, any differential effect could capture the role of parental investment. Clearly, incomes of these individuals are on average higher than others (see the results of the specifications where we do not control for the place of birth fixed effects) and the point estimates of the interaction terms are of the expected sign, but again these differences are statistically insignificant in more granular comparisons.[18]

[16]Pakistan's latitude is 30.3753° N. The day length remains constant at 12 hours at a latitude of 0° and varies between 0 and 24 hours at a latitude of 80°. In Pakistan, the day length varies by around 3–4 hours over the year. For example, in 2021, the day length was 13 hours 41 minutes on the 21st of June and 10 hours 36 minutes on the 21st of December in Karachi (data from the website https://www.timeanddate.com/, retrieved on June 27, 2021).

[17]Note that Ramadan fasting involves abstaining from both food and water from sunrise to sunset. In hot and dry months, abstaining from water and other liquids becomes more important, causing dehydration and other related concerns.

[18]An important caveat here is that these differences could also reflect differences in fasting rate across locations. The positive difference, for example, may reflect that the fasting rate on average is lower in major cities.

VI.G Sex Ratio

One other impact of Ramadan fasting discussed in the literature is that it may skew the sex ratio of exposed children toward females. There are well-described examples of environmentally-determined sex ratios in some species such as the red deer (Gluckman & Hanson, 2004). In general, under stressed nutritional conditions more females are born given that the survival of the species depends on the number of fetuses that can reproduce in later life. This pattern is reversed as conditions improve, with the sex ratio tilting toward males in good times so that an overall balance is maintained. Based on this idea, some biomedical studies suggest that low levels of glucose in the mother's blood around the time of conception may favor the survival of female conceptuses (Larson *et al.*, 2001). This initial difference may get amplified by selective post-birth mortality by sex. The existence of this biological mechanism, called the Trivers-Willard hypothesis, among humans has been validated by some empirical studies (Mathews *et al.*, 2008; Almond & Mazumder, 2011; van Ewijk, 2011) but not by others (Cramer & Lumey, 2010). In Table A.XXIII, we investigate this question using both administrative and DHS data. Given that the uterine environment at time of conception (rather than later in the gestation period) matters most for this outcome, the coefficient of interest now is that on month 0.[19] We estimate equation (1) with and without controls, but in no case is the coefficient significantly different from zero. In fact, Ramadan exposure in any of the prenatal months bears no association with the sex ratio. Again, we emphasize that our estimates are precisely estimated zeros. Given that our datasets are quite large, the standard errors on the estimated coefficients are quite small but, importantly, so are the coefficients, illustrating that differences in sex ratio across the compared groups are trivial. Thus, nutritional stress arising from fasting does not seem to favor conception and survival of a particular sex.

VI.H Mechanisms

The negative effect of Ramadan exposure on earnings can mediate through two channels: the skills channel and the health channel. Causal story under the skills channel

[19] According to the Trivers–Willard hypothesis, when conditions are unfavorable for survival, it is more advantageous for a mother to produce females. Since the sex of the offspring is determined at conception, the usual interpretation of this hypothesis is that the sex ratio adjustment takes place primarily around conception (Mathews *et al.*, 2008). Skewed sex ratios, however, may also arise from selective mortality by sex after birth.

runs as follows. Stressed maternal environment during pregnancy means exposed children are born with lower capacities to produce cognitive and non-cognitive skills. Through the two dynamic processes—complementarity and self-productivity—the lower endowment of capacities continues to stymie skill formation in later stages of development. As a result, exposed children go on to attain less education, make dominated occupational choices, and earn less income. Under the health channel, lower earnings of exposed individuals arise out of their worse health. For example, they may lack the vitality and vigor the unexposed possess and thus come up short in the labor market.

On balance, the evidence we present above favors the skills channel. We show that exposed children indeed make dominated occupational choices. They are significantly less likely to be in high-skilled jobs, requiring professional qualifications. On the other hand, they are more likely to be in retail and wholesale trade, industries with proportionally the most low-skilled jobs. In our population, occupational choice and educational attainment are tightly correlated. The sign and magnitude of these correlations suggest that exposed children are likely to possess significantly less education than the unexposed. One other piece of supporting evidence is the lower proportion of exposed individuals among top earners, which potentially reflects their lower levels of human capital relative to the unexposed in terms of cognitive and noncognitive skills. Finally, our causal story linking exposure and skills is consistent with prior work. For example, Almond *et al.* (2014) find a negative relationship between Ramadan exposure and academic performance among the Pakistani and Bangladeshi heritage children in the UK. A similar negative relationship between in-utero shocks and educational attainment has also been found for other types of shocks, such as exposure to disease and radiation (see section II.B for details).

Prior work has also documented a negative association between Ramadan fasting and later-life health outcomes of exposed children (see van Ewijk, 2011 and Almond & Mazumder, 2011). This health channel linking exposure to earnings is likely to play out the same way as the skills channel in all but one respect. The hallmark of predictive adaptive responses through which temporary shocks to the maternal environment can lead to long-term changes in human physiology is their latency. Because the primary aim of these physiological changes is to prioritize survival of the reprogrammed body until the reproductive age, their harmful health effects remain latent until late in life (Gluckman & Hanson, 2004). Under this mechanism, the reprogrammed body remains at its prime until the reproductive age and then declines rapidly. Our evidence, however, shows that the negative effects of Ramadan exposure are similar for both young and old cohorts. We do not observe a strong decline in human capital outcomes of the exposed individuals at any stage of their working life. It is therefore unlikely that our headline result arises mainly out of the health rather than the skills channel.

VI.I Discussion

We have noted above that our estimate provides a lower bound on the average treatment effect (ATE) of in-utero Ramadan exposure. This is due mainly to two reasons. First, our estimate is an intention-to-treat effect and therefore must be scaled up by the fasting rate to find the ATE. Since the fasting rate is considerably less than 100 percent, the ATE must be considerably higher than our estimate.[20] According to the three surveys from Pakistan we list in Table A.XXIV, around 80 percent of Pakistani pregnant women report fasting for at least one day during Ramadan and around 30–40 percent for the whole month. Assuming that the treatment effect is homogeneous in the population, based on this data the true effect of in-utero Ramadan exposure on earnings could be as high as 9 percent.

Second, survivors of negative fetal events are potentially a selected sample of the population. Because mortality tends to remove worst-affected individuals, the estimates based on survivors' outcomes tend to understate the true ATE (please see Almond & Currie, 2011; Almond, 2006; Bozzoli *et al.*, 2009 for the scarring vs. culling distinction in the fetal shocks literature). Such selection is likely to be stronger in our setting since we measure outcomes using tax data.[21] Intuitively, our data contains individuals who either receive milder shocks or overcome the negative effects through other mitigating circumstances, such as remedial parental investment, so as to not only survive but also become taxpayers. In general, with remedial parental or societal investment the reduced-form effect understates the biological effect (Royer, 2009).

To get some sense of the effect size, we benchmark it against labor market returns

[20] To the extent that the fasting rate can vary across the term of a pregnancy, the difference between our ITT estimate and the ATE could vary across our exposure groups.

[21] The income tax exemption threshold in developing economies is generally large. As a result, only top earners (top 5–10 percentiles) are required to file a tax return. Since our data consist of tax returns, they capture the top end of the income distribution only.

to education. The literature on returns to education estimates that one additional year of education raises labor income in later life by around 10 percent, with estimates typically ranging between 6 and 15 percent (e.g., Oreopoulos, 2006). Given the above discussion, the ATE of in-utero exposure to Ramadan is potentially equivalent to having between one-half and one year less of education.

What is the size of the macro output loss implied by the micro estimates we report? Table IV shows that Individuals born in 9 out of 12 months of a year have lower earnings because of their in-utero Ramadan exposure. Assuming that labor earnings comprise two-thirds of the GDP of the country, our estimates imply an output loss of at least $2.3 billion in Pakistan each year.[22] In 2020, Muslim population in the world was around 1.91 billion.[23] Extrapolating the Pakistani estimates to the global population translates into an annual loss of roughly $13.8 billion. This represents a lower bound on the output loss given that our estimate is a lower bound on the average treatment effect. Ramadan fasting by pregnant Muslim women, as we note above, is not obligatory: all major religious schools of Islam allow delaying the fast to a time after pregnancy. High rates of fasting during pregnancy thus largely reflect misperceptions about religious injunctions and harmful effects of fasting. In principle, therefore, large Pareto gains can be made by reducing these misperceptions through targeted awareness programs. It bears emphasizing, however, that challenging people's cherished beliefs—involving their notions of morality, religion, and identity—is likely to evoke strong emotional responses (Bénabou & Tirole, 2016). To the extent misperceptions about Ramadan fasting are *protected* beliefs, people may be averse to acquiring new information and may not update their priors even when they acquire new information to a degree a rational learner would.

VII Conclusions

We use Ramadan fasting as a natural experiment to estimate the long-run effects of in-utero health and nutrition shocks on labor market outcomes. We show that exposed

[22]This back-of-the-envelope number is based on the following calculation. Using estimates from Table IV, we assume that on average in-utero Ramadan exposure lowers the earnings of exposed individuals by 1.5 percent (a conservative estimate of the average effect of Ramadan exposure in any of the pregnancy trimesters from Table IV). Pakistan has a GDP of roughly US$300 billion. We arrive at the $\$2.3$ billion figure by multiplying $\$300$ billion with 0.67 (labor's share of the GDP) and 0.75 (individuals born in 9 out of 12 months are affected) and 0.015 (the effect size).

[23]See Religious Composition by Country, 2010–2050 by Pew Research Center. We accessed this data on 30th April 2021 from https://tinyurl.com/rz3ucvds.

individuals on average earn significantly less than the unexposed in their adult life. The size of the effect varies with the gestation month of exposure, with individuals exposed in the middle period of pregnancy earning around 2–3 percent less than the unexposed. Exploring the mechanisms underlying the earnings effect, we find that exposed individuals make dominated occupational choices. They are less likely to be employees, less likely to be in high-skilled professions, and more likely to be in low-skilled sectors. For our population, employees are systematically more educated and earn substantially more than the self-employed. Under-representation of exposed individuals in the better-paying occupations as well as among the top-earners of the country suggests they are born with lower capacities to produce cognitive and noncognitive skills. They accordingly attain less education, make dominated occupational choices, and earn significantly less than the unexposed. Finally, we rule out that our results are driven by selective timing of conception. Observed parental characteristics do not change significantly with the Hijra timing of conception. Nor does the birth rate across various months of the lunar year that Ramadan follows. Together, this rules out that a selective group of parents time pregnancies to avoid or limit in-utero Ramadan exposure of their children.

Ramadan fasting is a relatively mild shock, but it affects nearly 1.35 billion people globally. Our back-of-the-envelope calculation shows it causes a yearly output loss of around $2.3 billion in Pakistan and $13.8 billion globally. This suggests that large Pareto gains can be made by making families aware that (1) Ramadan fasting is not obligatory upon pregnant women so that they can postpone it to a later period without violating any religious injunctions, and (2) Ramadan fasting by pregnant mothers can have long-run negative effects on human capital and labor market outcomes of children. Survey evidence shows that a vast majority of women are not aware of these two facts and thus eliminating these misperceptions through targeted interventions could be a cost-effective way to improve outcomes. It is, however, not clear if such misperceptions are a type of *protected* beliefs and hence less amenable to informational interventions. Future work may look at the nature of these misperceptions as well as study other investments that would be most cost effective in terms of improving exposed children's future outcomes.

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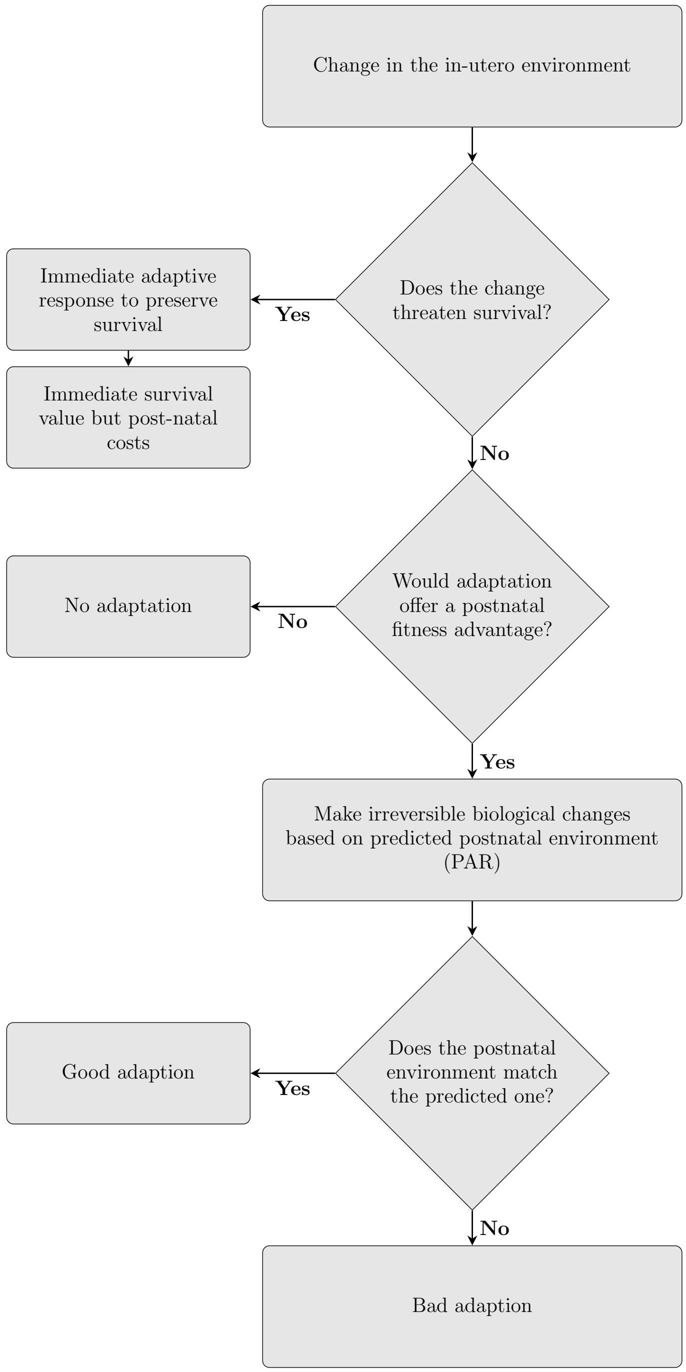
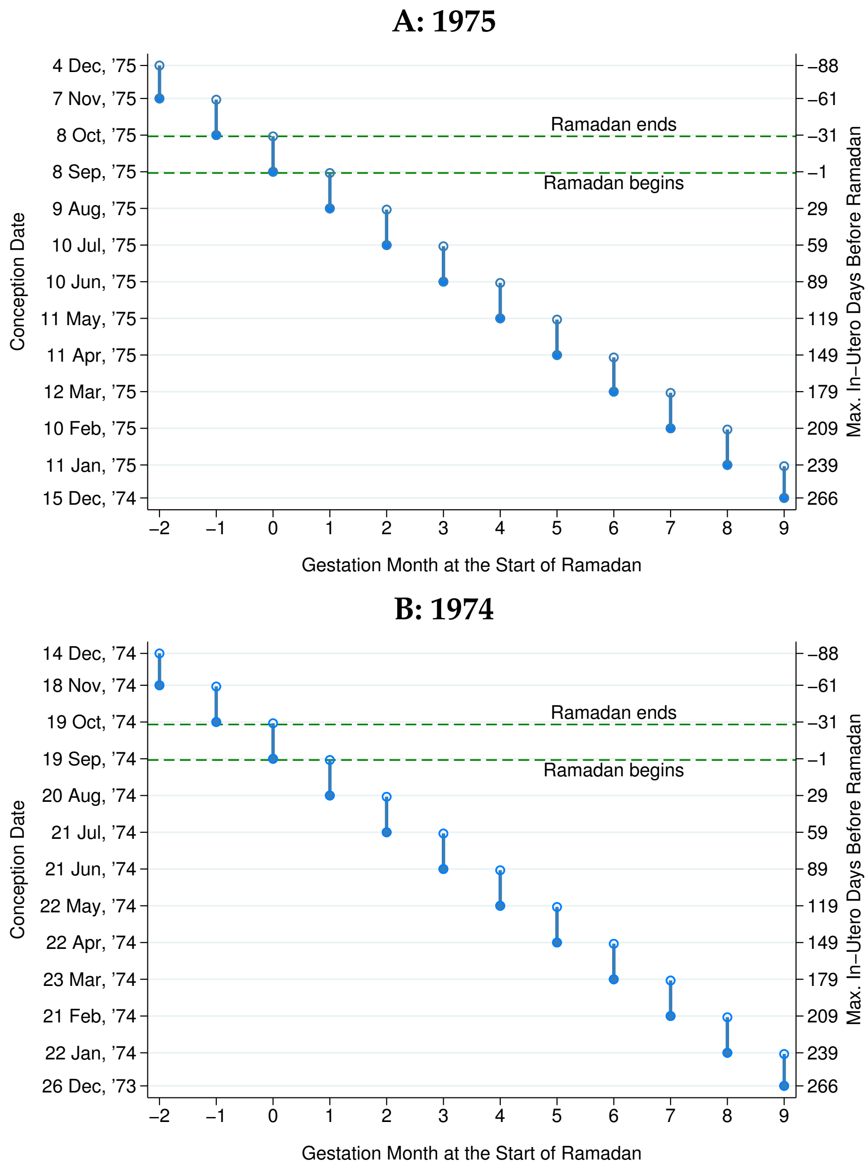
FIGURE I: **PREDICTIVE ADAPTIVE RESPONSES**



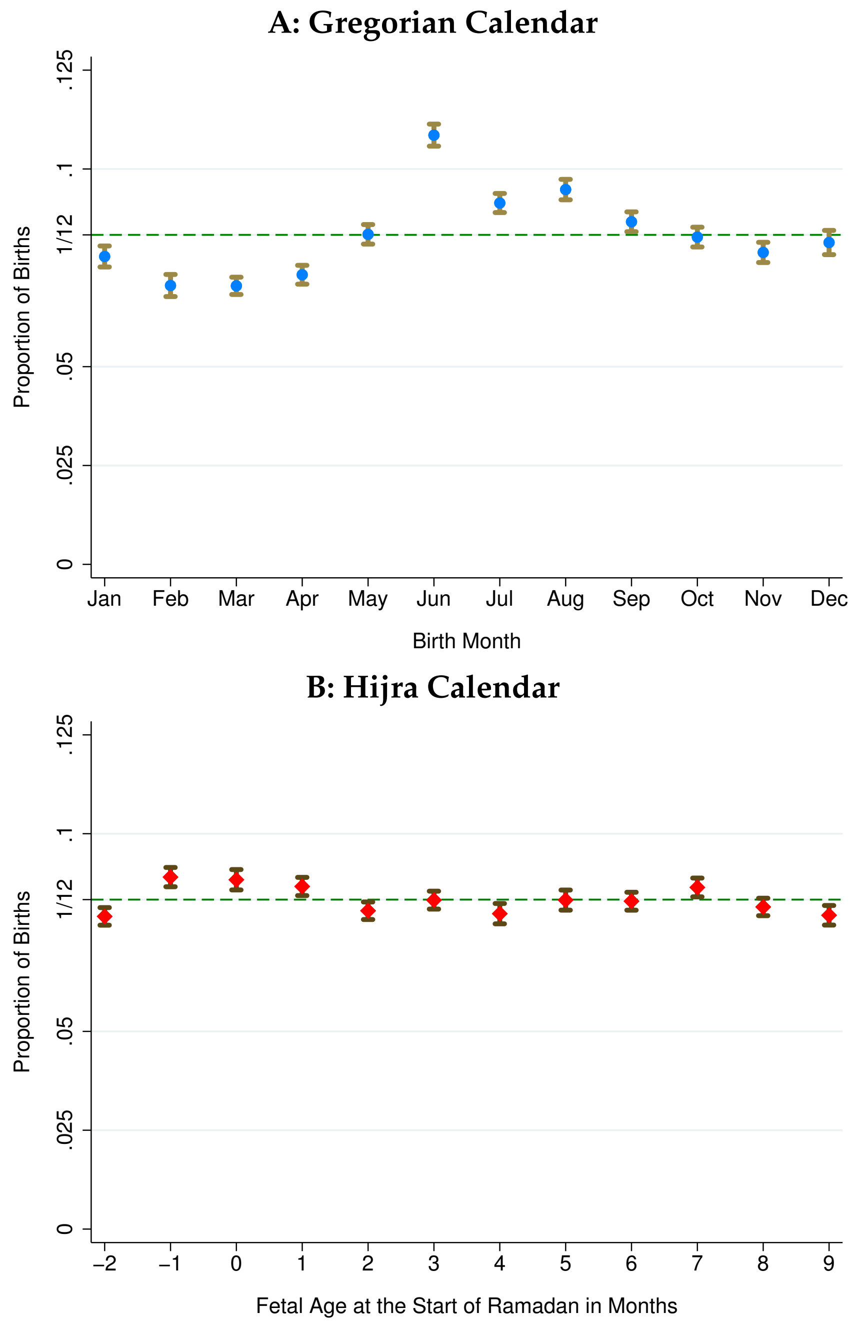
Notes: Predictive Adaptive Responses are the processes through which environmental changes in the early developmental phase lead to long-term irreversible changes in the physiology and physical phenotype of the developing embryo/fetus (Gluckman & Hanson, 2004). The figure shows how this process works. Upon receipt of an environmental cue, the body initiates short-term adaptive responses for immediate survival. In case the cue persists, the embryo/fetus uses it to predict the long-term environment it would be delivered into. Based on this prediction, it makes strategic adaptive choices that offer survival advantage until the reproductive age in the predicted environment. Such adaptations are good if the predicted environment matches the actual postnatal environment and maladaptations if it does not.

FIGURE II: **IN-UTERO RAMADAN EXPOSURE**



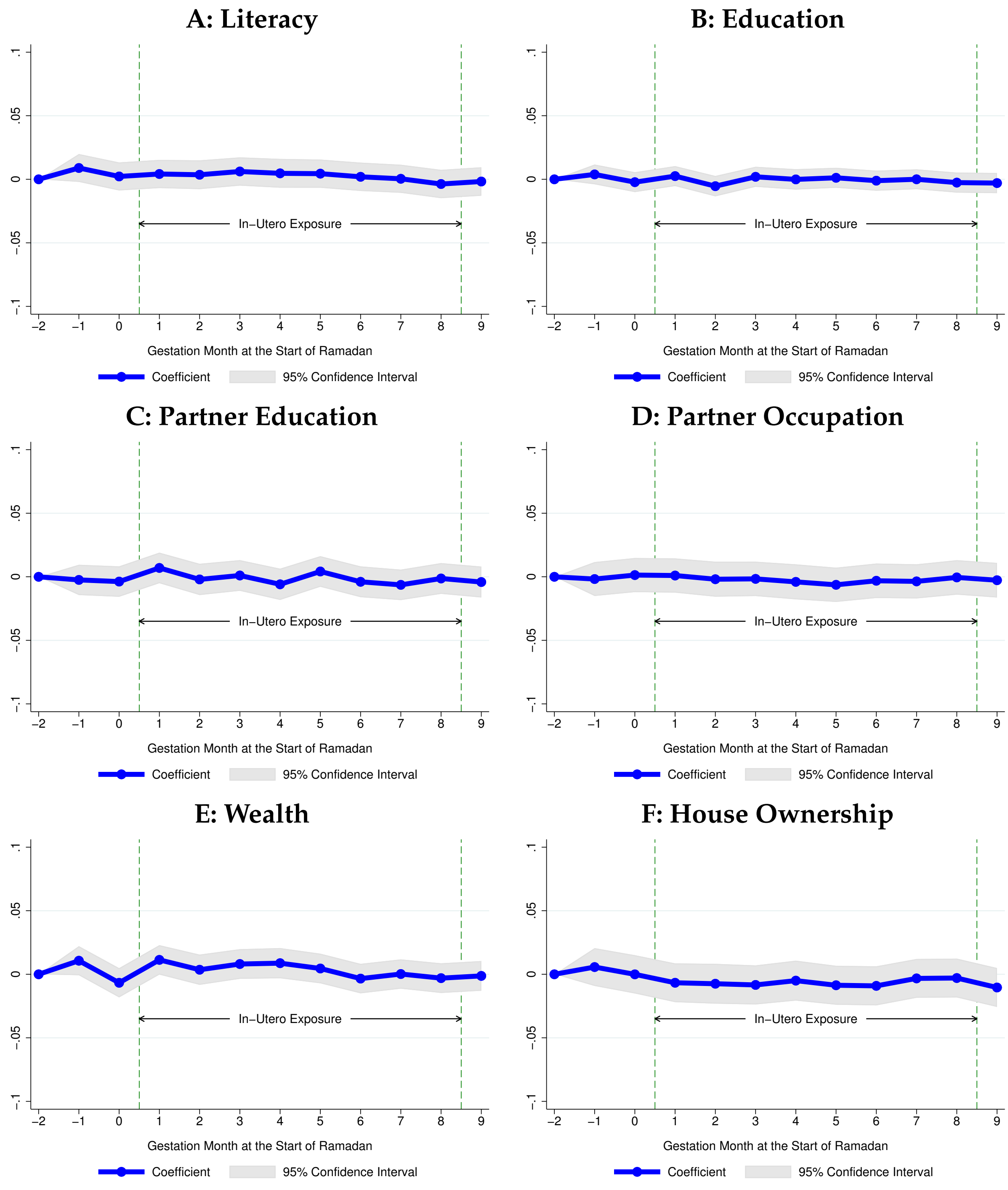
Notes: The figure illustrates how we define our Ramadan exposure measures. The top panel shows the cohort born between 7th September 1975 and 26th August 1976. The left y-axis indicates the conception date of these individuals, which is defined as the birth date minus the normal gestation length of 266. The relevant Ramadan for this cohort began on 7th September and ended on the 7th October of 1975. Individuals in Gestation Month 0, indicated along the horizontal axis, were conceived between 1 and 31 days after the beginning of Ramadan. They therefore are partially exposed. In comparison, individuals in groups -2 and -1 are unexposed and in groups 1–8 are fully exposed. Individuals in group 9 were born in Ramadan. They are also partially exposed for between 1 and 29 days in the period just before their birth. The right y-axis indicates the maximum days the individual has been in utero at the beginning of Ramadan. The bottom panel repeats the exercise for the preceding cohort.

FIGURE III: **BIRTH SEASONALITY**



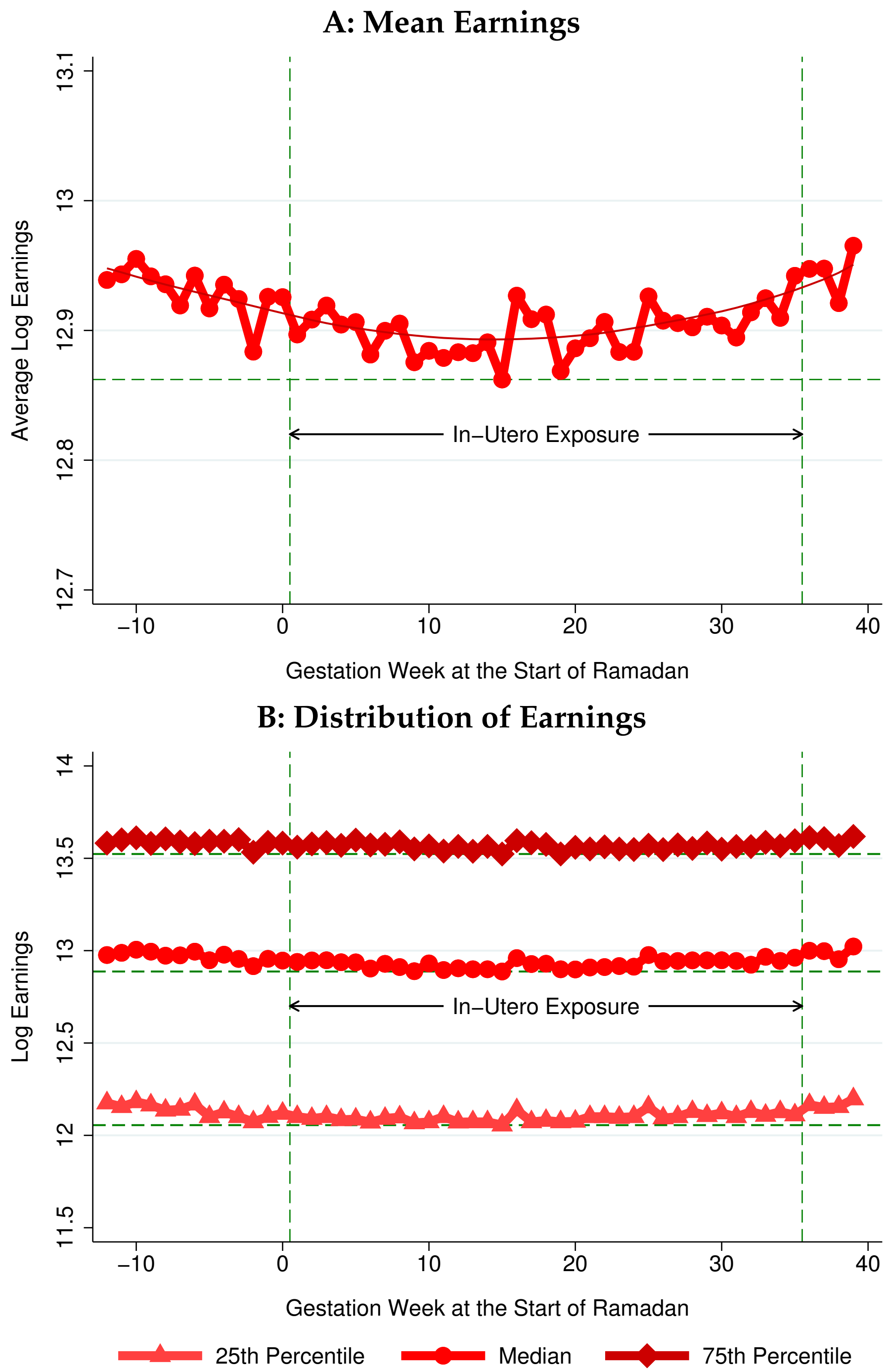
Notes: The figure explores seasonality in births over both the Western and Islamic calendar years. We regress a dummy variable indicating the month of birth on a constant using the DHS data. We run one such regression for each month and plot the estimated coefficients and 95% confidence intervals around them from these regressions. The regressions are weighted by sampling weights so that the results are nationally representative. The top panel defines the month of birth as the Gregorian calendar month the person was born in. The bottom panel, on the other hand, defines the month of birth according to the Islamic Hijra calendar. To maintain consistency, we divide people here into the same twelve month groups we used in Figure II. Persons in the month 0 for example are persons conceived in the month Ramadan began in. The sample here includes all three waves of the DHS that occurred in 1990, 2006, and 2012.

FIGURE IV: **SELECTION INTO IN-UTERO RAMADAN EXPOSURE?**



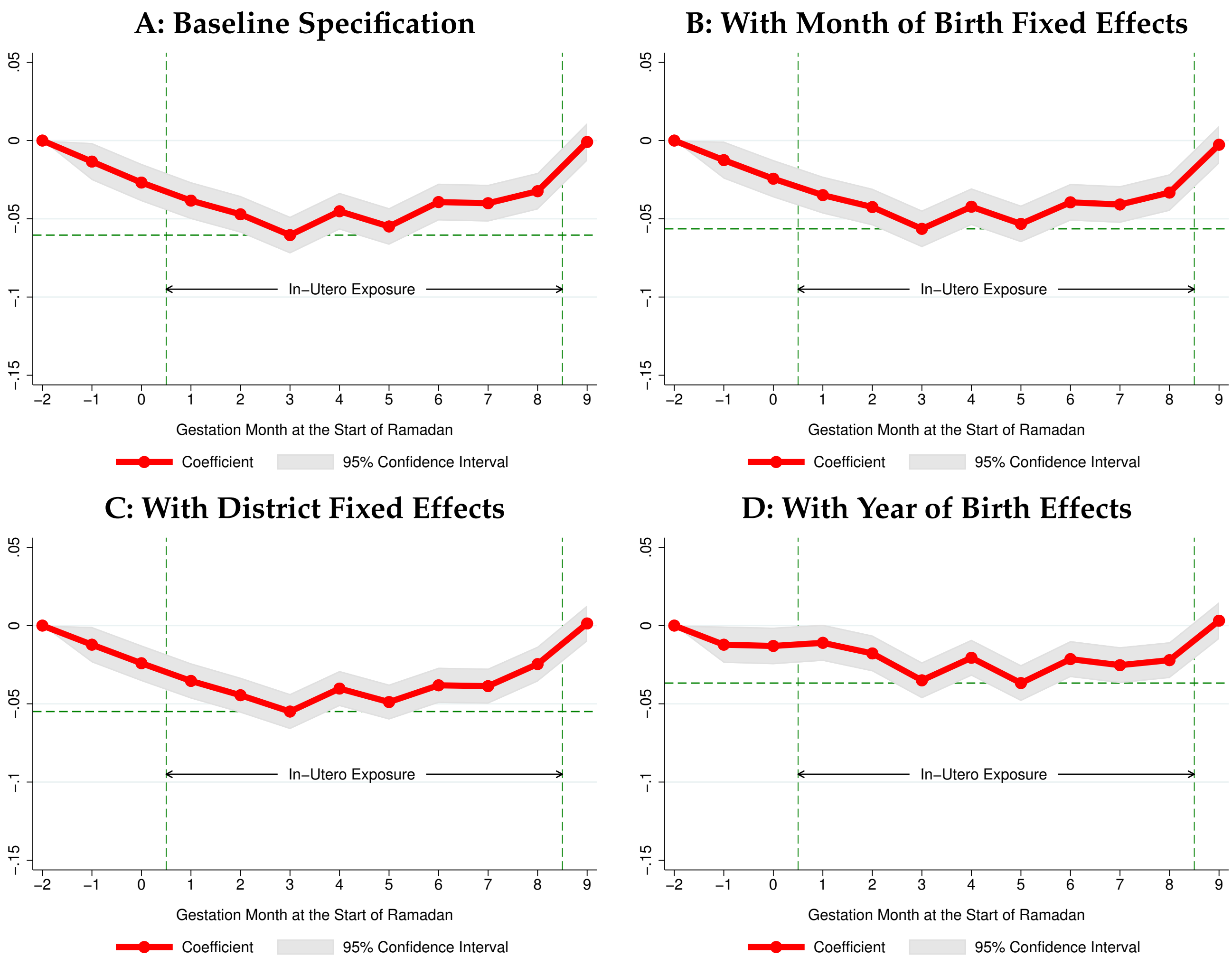
Notes: The figure examines parental sorting by the Hijra month of conception of children. We estimate equation (1) using the DHS data and plot the coefficients $\hat{\beta}_{\mu}$'s along with the 95% confidence interval around them. The outcome variable in each of these regressions is indicated in the heading of each column. We weight the regressions by sampling weights so that the results are nationally representative. All specifications include the month, district, and year of birth fixed effects. For details of the variables used here see Appendix A.1. The sample here includes all three waves of the DHS that occurred in 1990, 2006, and 2012. Please see Figure II on how we define the gestation month of exposure. Certainly unexposed individuals, i.e., those who were conceived two months after Ramadan (month −2), are the omitted category.

FIGURE V: **IN-UTERO RAMADAN EXPOSURE AND EARNINGS**



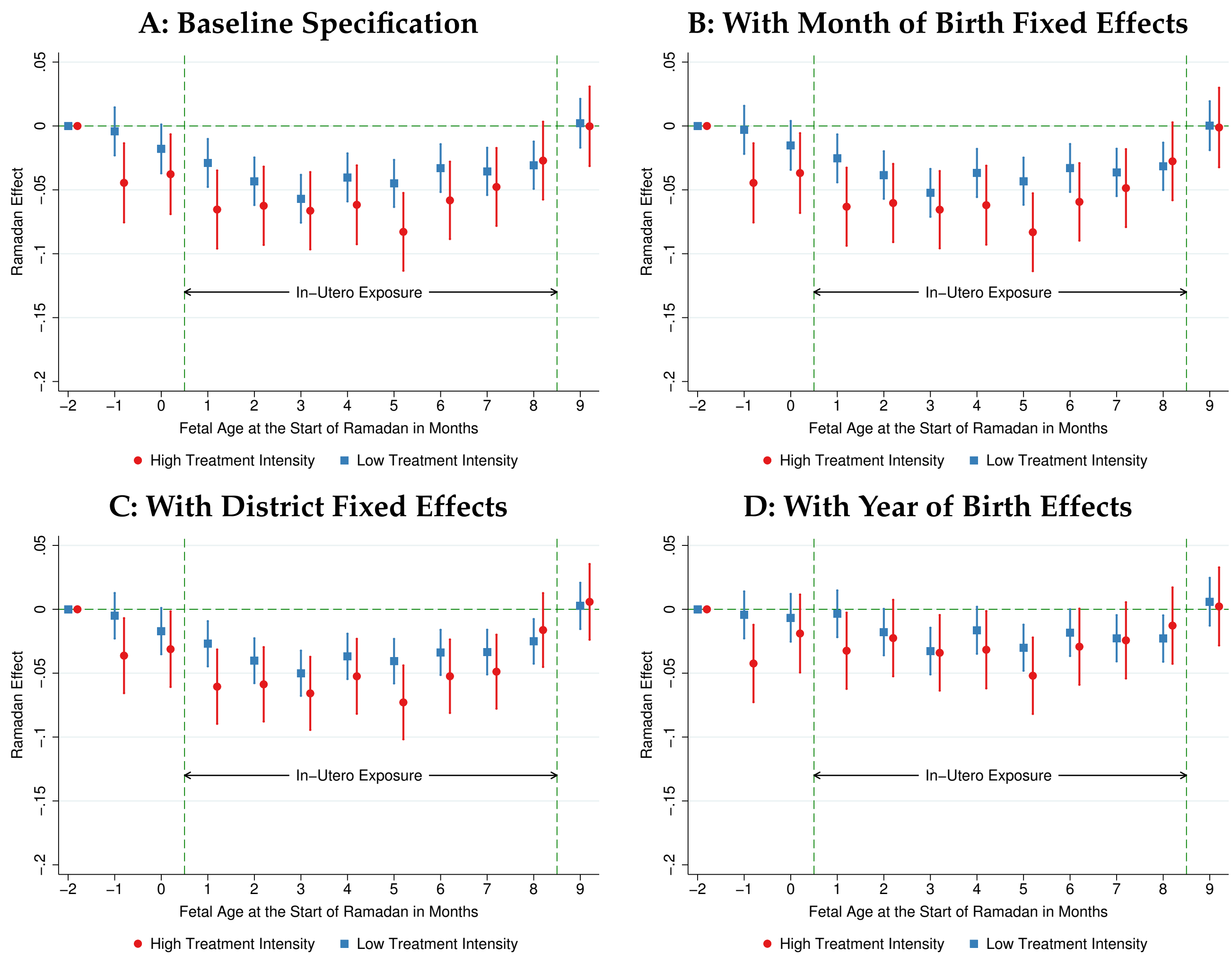
Notes: The figure shows the raw relationship between earnings and Ramadan exposure. We divide individuals into 52 groups depending upon the gestation week in which they experience Ramadan. Individuals in week 0 are conceived in the same week Ramadan began in. For example, in 1975 Ramadan began on the 8th of September. Individuals conceived between 8–14 September are included in group 0. We find the conception date by subtracting the normal gestation length of 266 days from the exact date of birth. Individuals in weeks $[1, 36]$ are exposed, in weeks $[-3, 0]$ and $[37, 40]$are partially exposed, and other are not exposed. Panel A shows average earning of individuals in each group and Panel B the other three moments of the distribution. Earnings here represent the taxable income reported by the individual in their tax return filed in the period 2007–2009.

FIGURE VI: **IN-UTERO RAMADAN EXPOSURE AND EARNINGS**



Notes: The figure explores the relationship between earnings and Ramadan exposure. We divide individuals into 12 groups depending upon the gestation month in which they experience Ramadan. Individuals in month 0 are conceived in the same month Ramadan began in. For example, in 1975 Ramadan began on the 8th of September. Individuals conceived between 8th September and 7th October are included in group 0. We find the conception date by subtracting the normal gestation length of 266 days from the exact date of birth. Individuals in months $[1, 8]$ are exposed, in month 0 and 9 are partially exposed, and other are not exposed. We estimate a version of equation (1) and plot the coefficients $\hat{\beta}_\mu$'s along with the 95% confidence interval around them. We progressively introduce our three main sets of control: month of birth fixed effects in Panel B; district of birth fixed effects in Panel C; and year of birth fixed effects in Panel D. The sample includes all tax returns filed in 2007–2009. The horizontal dashed line indicates the minimum $\hat{\beta}_\mu$ from the regression, showing the gestation month of exposure for which we estimate the strongest negative effect.

FIGURE VII: **IN-UTERO RAMADAN EXPOSURE AND EARNINGS BY TREATMENT INTENSITY**



Notes: The figure investigates if the effect size varies with the intensity of exposure. We divide our sample into two groups. The first group, which we call the high exposure intensity group, comprises individuals whose given name is Muhammad. We treat the name as a proxy for the religiousness of the family, arguing that mothers of these individuals are more likely to have fasted during pregnancy. The second group comprises all other individuals. We estimate equation (1) separately for the two groups and plot the coefficients $\hat{\beta}_{\mu}$'s along with the 90% confidence interval around them from these regressions. We progressively introduce our three main sets of control: month of birth fixed effects in Panel B; district of birth fixed effects in Panel C; and year of birth fixed effects in Panel D. We treat all English variants of the Urdu name Muhammad—Mohammad, Muhammed, and Mohammed—as the same.

TABLE I: **SELECTION INTO IN-UTERO RAMADAN EXPOSURE?**

In-Utero Ramadan	Literacy		Education		Partner Education		Partner Occupation		Wealth	
Exposure in	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
No/Partial Exposure	0.004	0.005	-0.001	0.000	-0.001	0.000	-0.005	-0.004	0.006	0.005
	(0.007)	(0.006)	(0.004)	(0.004)	(0.007)	(0.006)	(0.007)	(0.007)	(0.006)	(0.006)
First Trimester	-0.003	0.005	-0.007	-0.002	-0.000	0.003	-0.004	-0.002	-0.002	0.005
	(0.006)	(0.006)	(0.004)	(0.004)	(0.006)	(0.006)	(0.007)	(0.007)	(0.007)	(0.006)
Second Trimester	-0.001	0.003	-0.003	-0.000	0.003	0.004	-0.006	-0.006	-0.004	0.003
	(0.007)	(0.006)	(0.004)	(0.004)	(0.007)	(0.006)	(0.007)	(0.007)	(0.007)	(0.006)
Third Trimester	0.002	-0.000	-0.003	-0.003	0.002	0.002	-0.001	-0.002	-0.003	-0.001
	(0.007)	(0.006)	(0.004)	(0.004)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.006)
Observations	116,555	116,555	116,656	116,656	116,542	116,542	116,656	116,656	89,287	89,287
Joint test, coefficients on trimesters 1-3 equal 0:										
p-value	0.752	0.718	0.394	0.796	0.892	0.912	0.705	0.805	0.920	0.532
Mean Value	0.232	0.232	0.096	0.096	0.267	0.267	0.365	0.365	0.186	0.186
Fixed Effects:										
Month of Birth	-	✓	-	✓	-	✓	-	✓	-	✓
District of Birth	-	✓	-	✓	-	✓	-	✓	-	✓
Year of Birth	-	✓	-	✓	-	✓	-	✓	-	✓

Notes*:* The table rules out parental sorting across different Hijra months of conception. We estimate equation (2) using the DHS data. The outcome variable in each of these regressions is indicated in the heading of each column. We weight the regressions by sampling weights so that the results are nationally representative. Even-numbered columns include the month, district, and year of birth as controls. Mean value of the outcome variable is indicated in the row above fixed effects. P-value of the hypothesis that the three trimester dummies are jointly zero is provided in the row before that. For details of the variables used here see Appendix A.1. The sample here includes all three waves of the DHS that occurred in 1990, 2006, and 2012. Individuals exposed to Ramadan in months 1–3 of their pregnancy are included in the First Trimester group, in months 4–6 in the Second Trimester group, and in months 7–9 in the Third Trimester group. Please see Figure II on how we define the gestation month of exposure. Certainly unexposed individuals, i.e., those who were conceived two months after Ramadan (month -2), are the omitted category, and individuals in months -1 and 0 are grouped together as the No/Partial Exposure category. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

TABLE II: **SELECTION INTO IN-UTERO RAMADAN EXPOSURE?**

In-Utero Ramadan	Owns Home		Has Electricity		Has Television		Has Refrigerator		Has Motorcycle	
Exposure in	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
No/Partial Exposure	0.011	0.007	0.005	-0.000	-0.005	-0.010	0.008	0.004	0.005	0.000
	(0.008)	(0.008)	(0.007)	(0.006)	(0.008)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
First Trimester	-0.002	-0.008	0.003	-0.001	-0.006	-0.005	0.004	0.003	0.003	0.003
	(0.008)	(0.008)	(0.006)	(0.005)	(0.008)	(0.007)	(0.007)	(0.007)	(0.006)	(0.006)
Second Trimester	0.008	-0.003	0.005	-0.002	-0.003	-0.007	0.005	0.001	0.007	0.003
	(0.008)	(0.007)	(0.007)	(0.005)	(0.008)	(0.007)	(0.008)	(0.007)	(0.006)	(0.006)
Third Trimester	0.002	-0.004	0.001	-0.004	-0.005	-0.009	-0.003	-0.006	0.004	-0.000
	(0.007)	(0.007)	(0.006)	(0.006)	(0.008)	(0.007)	(0.007)	(0.006)	(0.006)	(0.006)
Observations	39,049	39,049	116,606	116,606	116,604	116,604	116,604	116,604	116,574	116,574
Joint test, coefficients on trimesters 1-3 equal 0:										
p-value	0.394	0.784	0.809	0.886	0.838	0.594	0.476	0.235	0.679	0.807
Mean Value	0.890	0.890	0.869	0.869	0.531	0.531	0.360	0.360	0.229	0.229
Fixed Effects:										
Month of Birth	-	✓	-	✓	-	✓	-	✓	-	✓
District of Birth	-	✓	-	✓	-	✓	-	✓	-	✓
Year of Birth	-	✓	-	✓	-	✓	-	✓	-	✓

Notes: The table rules out parental sorting across different Hijra months of conception. We estimate equation (2) using the DHS data. The outcome variable in each of these regressions is indicated in the heading of each column. We weight the regressions by sampling weights so that the results are nationally representative. Even-numbered columns include the month, district, and year of birth as controls. Mean value of the outcome variable is indicated in the row above fixed effects. P-value of the hypothesis that the three trimester dummies are jointly zero is provided in the row before that. For details of the variables used here see Appendix A.1. The sample here includes all three waves of the DHS that occurred in 1990, 2006, and 2012. Individuals exposed to Ramadan in months 1–3 of their pregnancy are included in the First Trimester group, in months 4–6 in the Second Trimester group, and in months 7–9 in the Third Trimester group. Please see Figure II on how we define the gestation month of exposure. Certainly unexposed individuals, i.e., those who were conceived two months after Ramadan (month -2), are the omitted category, and individuals in months -1 and 0 are grouped together as the No/Partial Exposure category. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

TABLE III: **IN-UTERO RAMADAN EXPOSURE AND EARNINGS**

Gestation Month at the	Outcome: Log Earnings					
Start of Ramadan	(1)	(2)	(3)	(4)	(5)	(6)
-1	-0.014	-0.013	-0.013	-0.013	-0.013	-0.011
	(0.010)	(0.010)	(0.009)	(0.009)	(0.010)	(0.009)
0	-0.027***	-0.024**	-0.024***	-0.023**	-0.013	-0.008
	(0.010)	(0.010)	(0.009)	(0.009)	(0.010)	(0.009)
1	-0.039***	-0.035***	-0.035***	-0.034***	-0.011	-0.005
	(0.010)	(0.010)	(0.009)	(0.009)	(0.009)	(0.009)
2	-0.048***	-0.044***	-0.045***	-0.043***	-0.018*	-0.011
	(0.010)	(0.010)	(0.009)	(0.009)	(0.009)	(0.009)
3	-0.061***	-0.058***	-0.056***	-0.054***	-0.035***	-0.026***
	(0.010)	(0.010)	(0.009)	(0.009)	(0.009)	(0.009)
4	-0.046***	-0.043***	-0.041***	-0.040***	-0.020**	-0.013
	(0.010)	(0.010)	(0.009)	(0.009)	(0.010)	(0.009)
5	-0.056***	-0.054***	-0.050***	-0.050***	-0.037***	-0.030***
	(0.010)	(0.010)	(0.009)	(0.009)	(0.009)	(0.009)
6	-0.040***	-0.041***	-0.039***	-0.040***	-0.022**	-0.021**
	(0.010)	(0.010)	(0.009)	(0.009)	(0.009)	(0.009)
7	-0.040***	-0.041***	-0.039***	-0.040***	-0.025***	-0.024***
	(0.010)	(0.010)	(0.009)	(0.009)	(0.009)	(0.009)
8	-0.032***	-0.032***	-0.024***	-0.024***	-0.022**	-0.016*
	(0.010)	(0.010)	(0.009)	(0.009)	(0.009)	(0.009)
9	-0.000	-0.002	0.002	0.001	0.003	0.005
	(0.010)	(0.010)	(0.009)	(0.009)	(0.010)	(0.009)
Observations	832,175	832,175	832,096	832,096	832,175	832,096
Joint test, coefficients on months 1-9 equal 0:						
p-value	0.000	0.000	0.000	0.000	0.000	0.000
Fixed Effects:						
Month of Birth	-	✓	-	✓	-	✓
District of Birth	-	-	✓	✓	-	✓
Year of Birth	-	-	-	-	✓	✓

Notes*:* The table reports estimates from equation (1). We regress the outcome variable—log of taxable income—on eleven Ramadan exposure dummies, omitting the reference category—certainly unexposed individuals, who were conceived two months after Ramadan (month -2). Please see Figure II on how we define these exposure dummies. The sample here includes all three years 2007–2009. Standard errors are in parentheses and clustered at the individual level. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

TABLE IV: **IN-UTERO RAMADAN EXPOSURE AND EARNINGS**

In-Utero Ramadan Exposure in	Outcome: Log Earnings					
	(1)	(2)	(3)	(4)	(5)	(6)
No/Partial Exp.	-0.020**	-0.019**	-0.018**	-0.018**	-0.013	-0.009
	(0.009)	(0.009)	(0.008)	(0.008)	(0.008)	(0.008)
First Trimester	-0.049***	-0.046***	-0.046***	-0.044***	-0.021***	-0.014**
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.007)
Second Trimester	-0.047***	-0.046***	-0.043***	-0.044***	-0.026***	-0.021***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.007)
Third Trimester	-0.025***	-0.026***	-0.021***	-0.022***	-0.015*	-0.012*
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.007)
Observations	832,175	832,175	832,096	832,096	832,175	832,096
Joint test, coefficients on trimesters 1-3 equal 0:						
p-value	0.000	0.000	0.000	0.000	0.005	0.028
Fixed Effects:						
Month of Birth	-	✓	-	✓	-	✓
District of Birth	-	-	✓	✓	-	✓
Year of Birth	-	-	-	-	✓	✓

Notes: The table reports estimates from equation (2). We regress the outcome variable—log of taxable income—on four dummies indicating the four exposure groups. Individuals exposed to Ramadan in months 1–3 of their pregnancy are included in the First Trimester group, in months 4–6 in the Second Trimester group, and in months 7–9 in the Third Trimester group. Please see Figure II on how we define the gestation month of exposure. Certainly unexposed individuals, who were conceived two months after Ramadan (month -2), are the omitted category, and individuals in months -1 and 0 are grouped together as the No/Partial Exposure category. The sample here includes all three years 2007–2009. Standard errors are in parentheses and are clustered at the individual level. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

TABLE V: **IN-UTERO RAMADAN EXPOSURE AND OTHER OUTCOMES**

In-Utero Ramadan			Income >					
Exposure in	Employee		Median		75th Percentile		90th Percentile	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
No/Partial Exp.	-0.006*	-0.003	-0.017***	-0.009***	-0.007**	-0.003	-0.003	-0.002
	(0.003)	(0.003)	(0.004)	(0.004)	(0.003)	(0.003)	(0.002)	(0.002)
First Trimester	-0.013***	-0.007**	-0.033***	-0.010***	-0.012***	-0.001	-0.006***	-0.001
	(0.003)	(0.003)	(0.004)	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)
Second Trimester	-0.013***	-0.006*	-0.031***	-0.014***	-0.015***	-0.007***	-0.006***	-0.004**
	(0.003)	(0.003)	(0.004)	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)
Third Trimester	-0.002	0.000	-0.015***	-0.008**	-0.009***	-0.005*	-0.004**	-0.003
	(0.003)	(0.003)	(0.004)	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)
Observations	437,627	437,478	318,385	318,288	318,385	318,288	318,385	318,288
Joint test, coefficients on trimesters 1-3 equal 0:								
p-value	0.000	0.001	0.000	0.000	0.000	0.003	0.004	0.096
Mean Value	0.563	0.563	0.414	0.414	0.186	0.186	0.069	0.069
Fixed Effects:								
Month of Birth	-	✓	-	✓	-	✓	-	✓
District of Birth	-	✓	-	✓	-	✓	-	✓
Year of Birth	-	✓	-	✓	-	✓	-	✓

Notes*:* The table reports estimates from equation (2). We regress the outcome variable on four dummies indicating the four exposure groups. The outcome variable in the first two columns is an indicator showing that the individual is an employee as opposed to self-employed. The outcome variable in the rest of the columns is a dummy indicating that the individual earns more than the threshold given in the heading of each column. The exposure dummies are defined as earlier. Individuals exposed to Ramadan in months 1–3 of their pregnancy are included in the First Trimester group, in months 4–6 in the Second Trimester group, and in months 7–9 in the Third Trimester group. Please see Figure II on how we define the gestation month of exposure. Certainly unexposed individuals, who were conceived two months after Ramadan (month -2), are the omitted category, and individuals in months -1 and 0 are grouped together as the No/Partial Exposure category. The sample here includes all three years 2007–2009. Standard errors are in parentheses and clustered at the individual level. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

TABLE VI: **EMPLOYEES AND HUMAN CAPITAL**

	Outcome: $\mathbb{1}(Employee_i = 1)$									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Minimum Education Attainment:										
< Middle School	-0.055***	-0.052***								
	(0.003)	(0.003)								
Middle School			0.055***	0.052***						
			(0.003)	(0.003)						
High School					0.110***	0.104***				
					(0.003)	(0.003)				
Undergraduate							0.137***	0.137***		
							(0.004)	(0.004)		
Postgraduate									0.158***	0.161***
									0.004	0.005
Observations	273,942	273,942	273,942	273,942	273,942	273,942	273,942	273,942	273,942	273,942
Controls:										
District of Birth FEs	-	✓	-	✓	-	✓	-	✓	-	✓
Gender FEs	-	✓	-	✓	-	✓	-	✓	-	✓
Age	-	✓	-	✓	-	✓	-	✓	-	✓

Notes*:* The table explores the correlation between educational attainment and occupation choice among Pakistani workers. We use data from the Pakistan Social and Living Standards Measurement survey and regress the occupation choice on the individual's educational attainment. We exclude from the sample both the unemployed and workers employed in the agriculture sector. The sample thus is restricted to workers who are either employees (dummy variable $Employee_i = 1$) or self-employed. The regressor in all these regressions is a binary variable indicating that the individual has attained at least the level of education indicated in each row. We weight these regressions by sampling weights so that the results are nationally representative. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

A Online Appendix

A.1 Definition of Variables

(*i*) **Earnings.** Taxable income reported on the tax return.

(*ii*) **Conception Date.** The exact date of birth minus 266 days.

(*iii*) **Literacy.** Takes the value 1 if the DHS surveyor classifies the mother as "can read easily" in distinction to "reads with difficulty" or "cannot read".

(*iv*) **Education.** Takes the value 1 if the mother has completed secondary school or higher.

(*v*) **Partner Education.** Takes the value 1 if the mother's partner has completed secondary school or higher.

(*vi*) **Partner Occupation.** Takes the value 1 if the mother's partner is employed in one of the following four relatively skilled occupations: (1) professional, technical or managerial; (2) clerical; (3) sales; and (4) services.

(*vii*) **Wealth.** The DHS data divide households into five categories based on a composite measure of their cumulative living standard: (1) poorest; (2) poorer; (3) middle; (4) richer; and (5) richest. The dummy variable Wealth indicates that the household belongs to the top category.

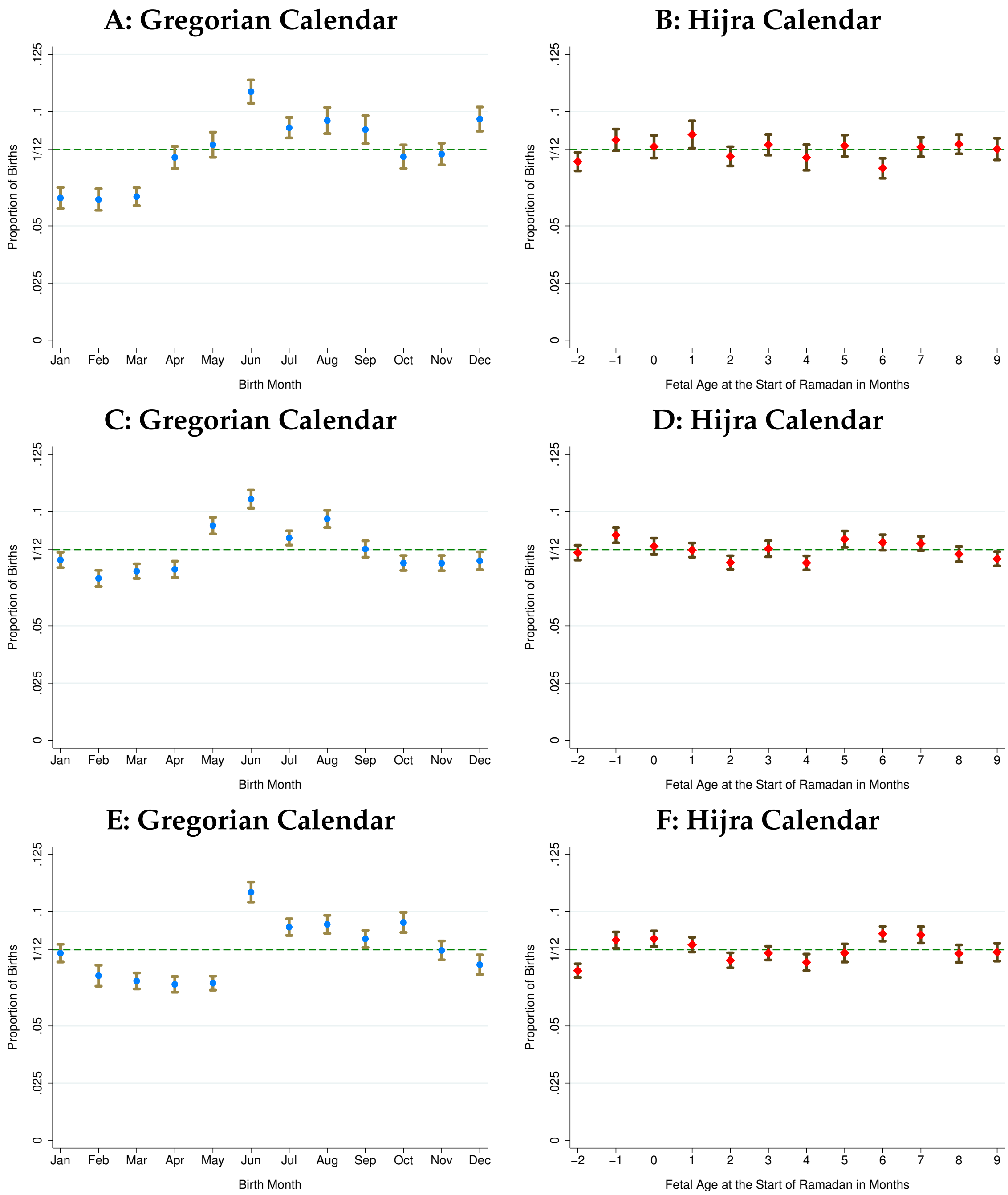
(*viii*) **Owns Home etc.** Takes the value 1 if the mother lives in an owned or rent-free house as opposed to a rented mortgaged house. Other such variables such as "Owns Television" are self-explanatory.

(*ix*) **Middle School.** The variable is from the PSLM data indicating that the respondent has completed at least ten years of education, obtaining classification called "Matriculation" in Pakistan.

(*x*) **High School.** The variable is from the PSLM data indicating that the respondent has completed at least twelve years of education.

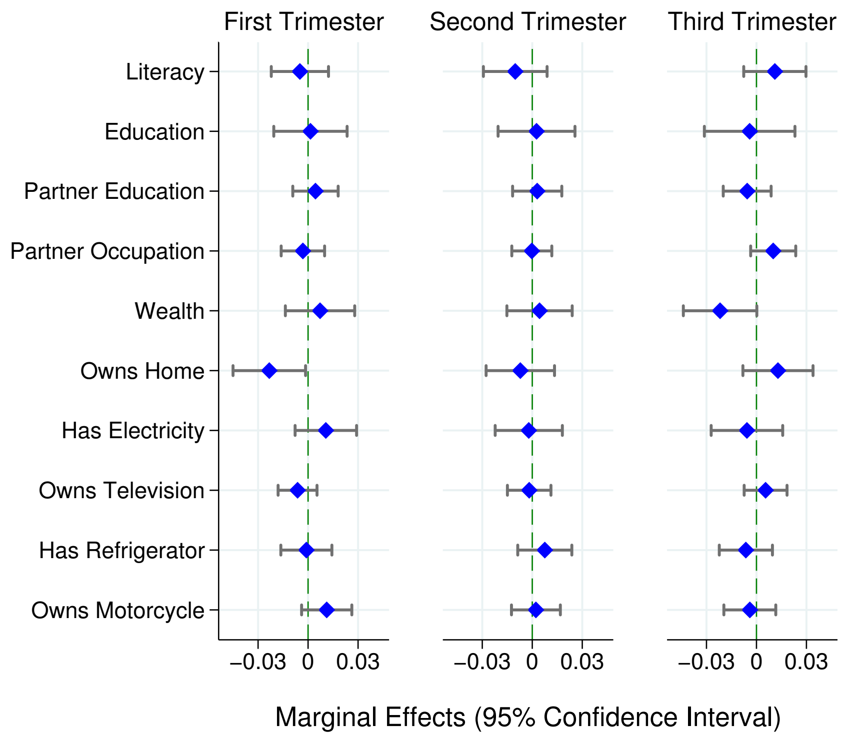
(*xi*) **Undergraduate/Postgraduate.** The variable is from the PSLM data indicating that the respondent has completed at least an undergraduate/postgraduate degree.

FIGURE A.I: **BIRTH SEASONALITY**



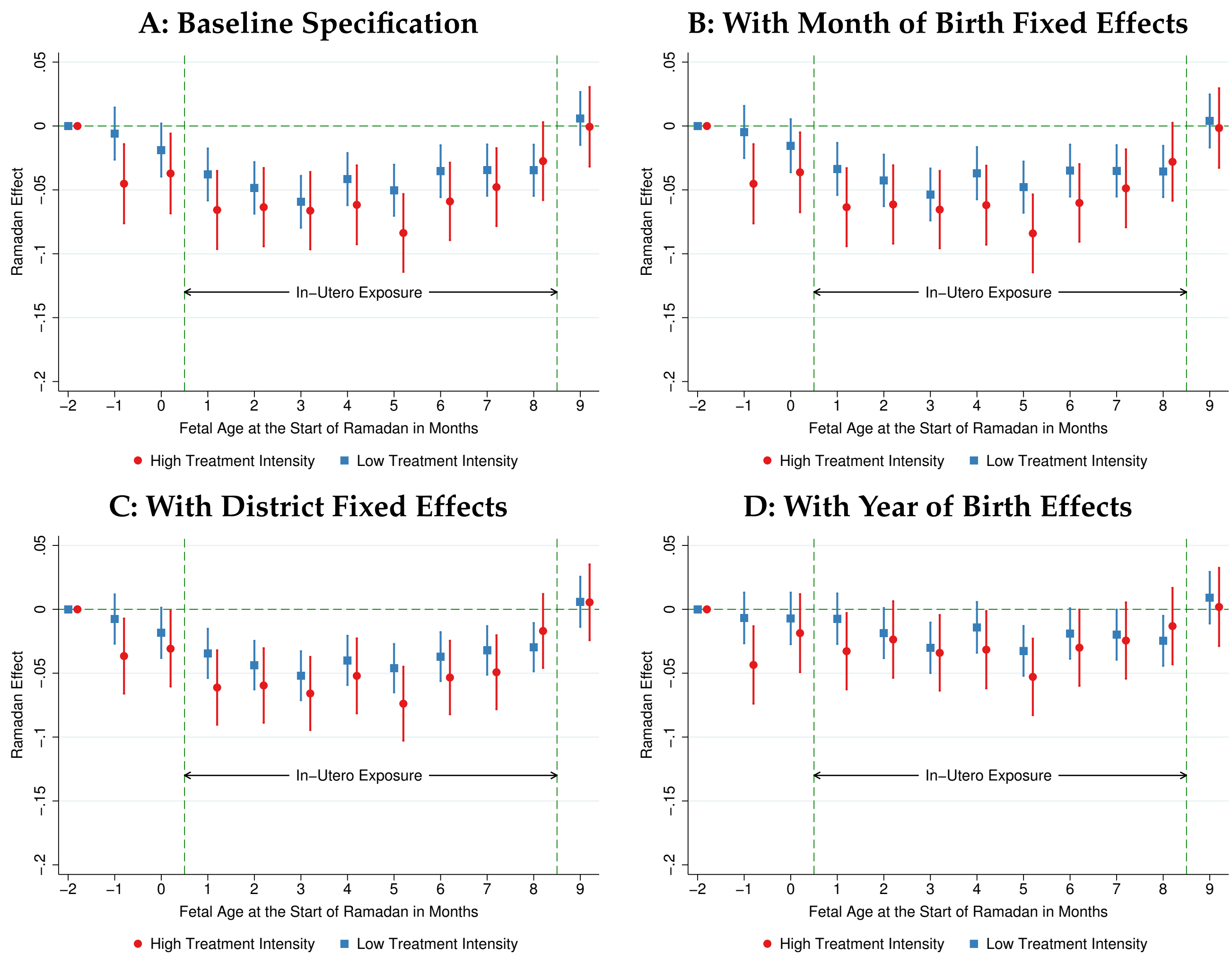
Notes: The figure replicates the analysis in Figure III after separating the sample of each DHS survey wave. The top panels are based on the 1990-1991 wave, the middle on the 2006-2007 wave, and the bottom on the 2012-2013 wave. Each panel regress a dummy variable indicating the month of birth on a constant using the corresponding wave of the DHS data. We run one such regression for each month and plot the estimated coefficients and 95% confidence intervals around them from these regressions. The regressions are weighted by sampling weights so that the results are nationally representative. The LHS panels define the month of birth as the Gregorian calendar month the person was born in. The RHS panels, on the other hand, define the month of birth according to the Islamic Hijra calendar. To maintain consistency, we divide people here into the same twelve month groups we did in Figure II. Persons in the month 0 for example are persons conceived in the month Ramadan began in.

FIGURE A.II: **SELECTION INTO IN-UTERO RAMADAN EXPOSURE? MARGINAL EFFECTS**



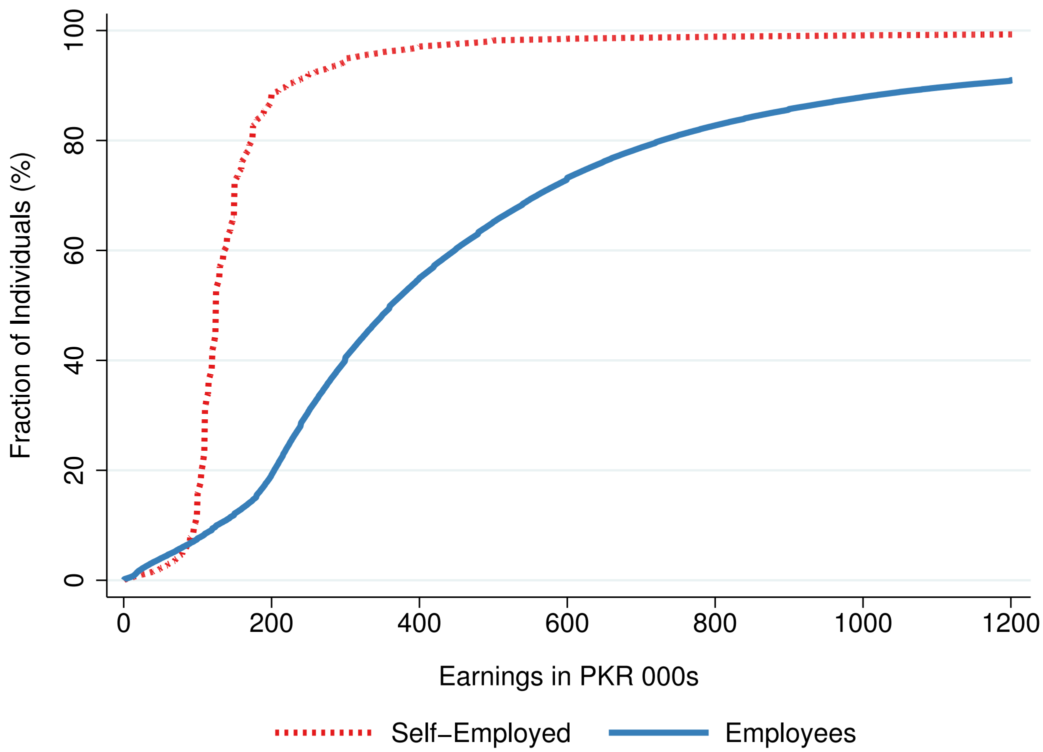
Notes*:* The figure rules out parental sorting across different trimesters of Ramadan exposure. We estimate a multinomial logistic model where the outcome variable is the trimester of exposure as defined in Figure II. We omit the unexposed and partially exposed individuals (exposure months -2,-1,and 0 in Figure II) and plot the marginal effects with their accompanying 95% confidence intervals from the model for the remaining three categories. The model's coefficients and tests of joint significance are reported in Table A.III. For details of the explanatory variables used here see Appendix A.1. The model also includes the month of birth, district of birth, and year of birth fixed effects. The sample here comprises 33,856 observations and includes all three waves of the DHS that occurred in 1990, 2006, and 2012.

FIGURE A.III: **IN-UTERO RAMADAN EXPOSURE AND EARNINGS BY TREATMENT INTENSITY (MALES ONLY)**



Notes: The figure investigates if the effect size varies with the intensity of exposure. We divide our sample into two groups. The first group, which we call the high exposure intensity group, comprises individuals whose given name is Muhammad. We treat the name as a proxy for the religiousness of the family, arguing that mothers of these individuals are more likely to have fasted during pregnancy. The second group comprises all other individuals. Since Muhammad is a male name, we restrict the sample here to males only to make the two groups compatible. We estimate equation (1) separately for the two groups and plot the coefficients $\hat{\beta}_{\mu}$'s along with the 90% confidence interval around them from these regressions. We progressively introduce our three main sets of control: month of birth fixed effects in Panel B; district of birth fixed effects in Panel C; and year of birth fixed effects in Panel D. We treat all English variants of the Urdu name Muhammad—Mohammad, Muhammed, and Mohammed—as the same.

FIGURE A.IV: **EMPLOYEES VS. SELF-EMPLOYED**



Notes: The figure plots the cumulative distribution function of earnings separately for the self-employed and employees. The sample here is the same as in our other analyses (for example, in Table III), comprising the tax returns filed in the period 2007–2009.

TABLE A.I: **SEASONALITY IN GREGORIAN QUARTER OF BIRTH**

Gregorian Quarter of Birth	Literacy (1)	Literacy (2)	Education (3)	Education (4)	Partner Education (5)	Partner Education (6)	Partner Occupation (7)	Partner Occupation (8)	Wealth (9)	Wealth (10)
Second Quarter	-0.042***	-0.029***	-0.022***	-0.014	-0.032***	-0.019	-0.026***	-0.021	-0.023***	-0.014***
	(0.005)	(0.005)	(0.003)	(0.000)	(0.005)	(0.000)	(0.006)	(0.000)	(0.005)	(0.004)
Third Quarter	-0.006	-0.006	0.002	0.002	-0.008	-0.004	-0.007	-0.006	-0.000	0.002
	(0.006)	(0.005)	(0.004)	(0.000)	(0.006)	(0.000)	(0.006)	(0.000)	(0.006)	(0.004)
Fourth Quarter	0.007	0.001	0.007*	0.005	-0.011*	-0.008	-0.002	-0.000	0.014**	0.012**
	(0.006)	(0.006)	(0.004)	(0.000)	(0.006)	(0.000)	(0.007)	(0.000)	(0.006)	(0.005)
Observations	116,555	116,555	116,656	116,656	116,542	116,542	116,656	116,656	89,287	89,287
Joint test, coefficients on Quarters 2-4 equal 0:										
p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Mean Value	0.232	0.232	0.096	0.096	0.267	0.267	0.365	0.365	0.186	0.186
Fixed Effects:										
District of Birth	-	✓	-	✓	-	✓	-	✓	-	✓
Year of Birth	-	✓	-	✓	-	✓	-	✓	-	✓

Notes*:* The table explores parental sorting across different Gregorian months of birth. We estimate a version of our equation (2), regressing the outcome indicated in the heading of each column on three quarter of birth dummies, dropping the first as the omitted category. Second Quarter dummy, for example, includes individuals born in calendar months April to June. We use the DHS data for this purpose and weight the regressions by sampling weights so that the results are nationally representative. Even-numbered columns include the district and year of birth as controls. Mean value of the outcome variable is indicated in the row above fixed effects.. For details of the variables used here see Appendix A.1. The sample here includes all three waves of the DHS that occurred in 1990, 2006, and 2012. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

TABLE A.II: **SEASONALITY IN GREGORIAN QUARTER OF BIRTH**

Gregorian Quarter	Owns Home		Has Electricity		Has Television		Has Refrigerator		Has Motorcycle	
of Birth	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Second Quarter	0.004	-0.003	-0.017***	-0.005	-0.037***	-0.020***	-0.030***	-0.016	-0.025***	-0.014***
	(0.006)	(0.005)	(0.006)	(0.005)	(0.007)	(0.005)	(0.006)	(0.000)	(0.005)	(0.004)
Third Quarter	0.004	0.000	-0.017***	-0.009*	-0.017**	-0.009*	-0.003	0.003	-0.002	-0.001
	(0.007)	(0.006)	(0.007)	(0.005)	(0.007)	(0.005)	(0.006)	(0.000)	(0.005)	(0.005)
Fourth Quarter	-0.017**	-0.015**	-0.017**	-0.010**	-0.017**	-0.012**	-0.003	-0.000	0.002	-0.001
	(0.008)	(0.007)	(0.007)	(0.005)	(0.008)	(0.006)	(0.007)	(0.000)	(0.006)	(0.005)
Observations	39,049	39,049	116,606	116,606	116,604	116,604	116,604	116,604	116,574	116,574
Joint test, coefficients on Quarters 2-4 equal 0:										
p-value	0.026	0.117	0.032	0.181	0.000	0.002	0.000	0.000	0.000	0.002
Mean Value	0.890	0.890	0.869	0.869	0.531	0.531	0.360	0.360	0.229	0.229
Fixed Effects:										
District of Birth	-	✓	-	✓	-	✓	-	✓	-	✓
Year of Birth	-	✓	-	✓	-	✓	-	✓	-	✓

Notes*:* The table explores parental sorting across different Gregorian months of birth. We estimate a version of our equation (2), regressing the outcome indicated in the heading of each column on three quarter of birth dummies, dropping the first as the omitted category. Second Quarter dummy, for example, includes individuals born in calendar months April to June. We use the DHS data for this purpose and weight the regressions by sampling weights so that the results are nationally representative. Even-numbered columns include the district and year of birth as controls. Mean value of the outcome variable is indicated in the row above fixed effects.. For details of the variables used here see Appendix A.1. The sample here includes all three waves of the DHS that occurred in 1990, 2006, and 2012. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

TABLE A.III: **SELECTION INTO IN-UTERO RAMADAN EXPOSURE? A MULTINOMIAL LOGISTIC MODEL**

	Coefficients		
	First Trimester (1)	Second Trimester (2)	Third Trimester (3)
Literacy	-0.043	-0.064	0.030
	(0.057)	(0.072)	(0.066)
Education	0.007	0.011	-0.018
	(0.086)	(0.095)	(0.106)
Partner Education	0.029	0.022	-0.017
	(0.048)	(0.052)	(0.048)
Partner Occupation	0.013	0.029	0.073
	(0.047)	(0.047)	(0.048)
Wealth	-0.008	-0.027	-0.141
	(0.078)	(0.075)	(0.082)
Owns Home	-0.180*	-0.112	-0.016
	(0.072)	(0.074)	(0.067)
Has Electricity	0.059	0.004	-0.015
	(0.068)	(0.075)	(0.075)
Owns Television	-0.040	-0.020	0.013
	(0.043)	(0.049)	(0.046)
Has Refrigerator	-0.001	0.034	-0.026
	(0.054)	(0.060)	(0.054)
Owns Motorcycle	0.090	0.052	0.021
	(0.062)	(0.065)	(0.060)
Joint test, above coefficients equal 0 (by column):			
F-test	1.310	0.564	0.733
p-value	0.222	0.843	0.694
Joint test, above coefficients equal 0 (all columns):			
F-test	0.830		
p-value	0.726		
Observations	33,856		

Notes*:* The table rules out parental sorting across different trimesters of Ramadan exposure. We estimate a multinomial logistic model where the outcome variable is the trimester of exposure as defined in Figure II. We omit the unexposed and partially exposed individuals (exposure months -2,-1,and 0 in Figure II) and report the coefficients from the model for the remaining three categories. Figure A.II reports the marginal effects from this model. For details of the explanatory variables used here see Appendix A.1. The model also includes the month of birth, district of birth, and year of birth fixed effects. The sample here includes all three waves of the DHS that occurred in 1990, 2006, and 2012. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

TABLE A.IV: **SELECTION INTO IN-UTERO RAMADAN EXPOSURE? AN ALTERNATIVE IMPUTATION**

In-Utero Ramadan	Literacy		Education		Partner Education		Partner Occupation		Wealth	
Exposure in	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
No/Partial Exposure	-0.002	-0.001	-0.001	0.000	-0.005	-0.003	-0.008	-0.007	0.004	0.002
	(0.007)	(0.006)	(0.004)	(0.004)	(0.006)	(0.006)	(0.007)	(0.007)	(0.007)	(0.006)
First Trimester	-0.007	0.001	-0.006	-0.002	-0.005	-0.001	-0.005	-0.003	-0.004	0.001
	(0.007)	(0.006)	(0.005)	(0.004)	(0.006)	(0.006)	(0.007)	(0.007)	(0.008)	(0.006)
Second Trimester	0.000	0.003	-0.002	0.000	-0.001	0.001	-0.009	-0.009	-0.002	0.002
	(0.007)	(0.006)	(0.004)	(0.004)	(0.007)	(0.006)	(0.007)	(0.007)	(0.008)	(0.007)
Third Trimester	0.001	-0.002	-0.001	-0.001	-0.002	-0.001	-0.002	-0.002	-0.007	-0.007
	(0.006)	(0.006)	(0.004)	(0.004)	(0.007)	(0.006)	(0.007)	(0.007)	(0.007)	(0.006)
Observations	116,555	116,555	116,656	116,656	116,542	116,542	116,656	116,656	89,287	89,287
Joint test, coefficients on trimesters 1-3 equal 0:										
p-value	0.451	0.655	0.396	0.893	0.861	0.969	0.420	0.385	0.653	0.173
Mean Value	0.232	0.232	0.096	0.096	0.267	0.267	0.365	0.365	0.186	0.186
Fixed Effects:										
Month of Birth	-	✓	-	✓	-	✓	-	✓	-	✓
District of Birth	-	✓	-	✓	-	✓	-	✓	-	✓
Year of Birth	-	✓	-	✓	-	✓	-	✓	-	✓

Notes*:* The table rules out parental sorting across different Hijra months of conception. We estimate our equation (2) using the DHS data. The outcome variable in each of these regressions is indicated in the heading of each column. Where we do not observe the exact day of birth of an individual, we impute it by drawing a random day of birth from a uniform distribution. We weight the regressions by sampling weights so that the results are nationally representative. Even-numbered columns include the month, district, and year of birth as controls. Mean value of the outcome variable is indicated in the row above fixed effects. P-value of the hypothesis that the three trimester dummies are jointly zero is provided in the row before that. For details of the variables used here see Appendix A.1. The sample here includes all three waves of the DHS that occurred in 1990, 2006, and 2012. Individuals exposed to Ramadan in months 1–3 of their pregnancy are included in the First Trimester group, in months 4–6 in the Second Trimester group, and in months 7–9 in the Third Trimester group. Please see Figure II on how we define the gestation month of exposure. Certainly unexposed individuals, who were conceived two months after Ramadan (month -2), are the omitted category, and individuals in months -1 and 0 are grouped together as the No/Partial Exposure category. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

TABLE A.V: **SELECTION INTO IN-UTERO RAMADAN EXPOSURE? AN ALTERNATIVE IMPUTATION**

In-Utero Ramadan	Owns Home		Has Electricity		Has Television		Has Refrigerator		Has Motorcycle	
Exposure in	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
No/Partial Exposure	0.003	0.000	0.003	-0.003	-0.004	-0.008	0.005	0.001	-0.003	-0.006
	(0.009)	(0.008)	(0.007)	(0.006)	(0.008)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
First Trimester	-0.003	-0.009	0.002	-0.005	-0.001	-0.002	0.005	0.002	-0.002	-0.002
	(0.009)	(0.008)	(0.006)	(0.005)	(0.008)	(0.007)	(0.008)	(0.006)	(0.007)	(0.006)
Second Trimester	0.003	-0.008	0.004	-0.005	0.002	-0.003	0.002	-0.003	0.001	-0.001
	(0.009)	(0.008)	(0.007)	(0.005)	(0.008)	(0.007)	(0.008)	(0.007)	(0.007)	(0.006)
Third Trimester	-0.001	-0.008	-0.001	-0.007	-0.001	-0.005	-0.003	-0.007	-0.002	-0.006
	(0.009)	(0.008)	(0.007)	(0.006)	(0.008)	(0.007)	(0.007)	(0.006)	(0.007)	(0.006)
Observations	39,049	39,049	116,606	116,606	116,604	116,604	116,604	116,604	116,574	116,574
Joint test, coefficients on trimesters 1-3 equal 0:										
p-value	0.772	0.731	0.837	0.689	0.953	0.856	0.554	0.281	0.861	0.586
Mean Value	0.890	0.890	0.869	0.869	0.531	0.531	0.360	0.360	0.229	0.229
Fixed Effects:										
Month of Birth	-	✓	-	✓	-	✓	-	✓	-	✓
District of Birth	-	✓	-	✓	-	✓	-	✓	-	✓
Year of Birth	-	✓	-	✓	-	✓	-	✓	-	✓

Notes*:* The table rules out parental sorting across different Hijra months of conception. We estimate our equation (2) using the DHS data. The outcome variable in each of these regressions is indicated in the heading of each column. Where we do not observe the exact day of birth of an individual, we impute it by drawing a random day of birth from a uniform distribution. We weight the regressions by sampling weights so that the results are nationally representative. Even-numbered columns include the month, district, and year of birth as controls. Mean value of the outcome variable is indicated in the row above fixed effects. P-value of the hypothesis that the three trimester dummies are jointly zero is provided in the row before that. For details of the variables used here see Appendix A.1. The sample here includes all three waves of the DHS that occurred in 1990, 2006, and 2012. Individuals exposed to Ramadan in months 1–3 of their pregnancy are included in the First Trimester group, in months 4–6 in the Second Trimester group, and in months 7–9 in the Third Trimester group. Please see Figure II on how we define the gestation month of exposure. Certainly unexposed individuals, who were conceived two months after Ramadan (month -2), are the omitted category, and individuals in months -1 and 0 are grouped together as the No/Partial Exposure category. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

TABLE A.VI: **IN-UTERO RAMADAN EXPOSURE AND OCCUPATION – HIGH-SKILLED**

Fetal Age (Months) at the Onset of Ramadan	Outcome: $\mathbb{1}$(High-Skilled)					
	(1)	(2)	(3)	(4)	(5)	(6)
No/Partial Exposure	-0.003	-0.003	-0.003	-0.003	-0.001	-0.001
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
First Trimester	-0.013***	-0.012***	-0.012***	-0.012***	-0.006*	-0.006*
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Second Trimester	-0.010***	-0.010***	-0.009***	-0.010***	-0.002	-0.003
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Third Trimester	-0.002	-0.002	-0.001	-0.001	-0.000	0.000
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Observations	437,615	437,615	437,464	437,464	437,615	437,464
Joint test, coefficients on trimesters 1-3 equal 0:						
p-value	0.000	0.000	0.000	0.000	0.044	0.033
Mean Value	0.596	0.596	0.596	0.596	0.596	0.596
Fixed Effects:						
Month of Birth	-	✓	-	✓	-	✓
District of Birth	-	-	✓	✓	-	✓
Year of Birth	-	-	-	-	✓	✓

Notes*:* The table reports estimates from equation (2). We regress an indicator that individual i is in a high-skill profession on four dummies indicating the four exposure groups. Individuals exposed to Ramadan in months 1–3 of their pregnancy are included in the First Trimester group, in months 4–6 in the Second Trimester group, and in months 7–9 in the Third Trimester group. Please see Figure II on how we define the gestation month of exposure. Certainly unexposed individuals, who were conceived two months after Ramadan (month -2), are the omitted category, and individuals in months -1 and 0 are grouped together as the No/Partial Exposure category. The sample here includes all three years 2007–2009. Standard errors are in parentheses and clustered at the individual level. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

TABLE A.VII: **IN-UTERO RAMADAN EXPOSURE AND OCCUPATION – RETAIL**

Fetal Age (Months) at the Onset of Ramadan	Outcome: $\mathbb{1}$(Low-Skilled)					
	(1)	(2)	(3)	(4)	(5)	(6)
No/Partial Exposure	0.003	0.003	0.003	0.003	0.002	0.002
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
First Trimester	0.005***	0.005***	0.005***	0.005***	0.003	0.003*
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Second Trimester	0.003*	0.003*	0.003*	0.003*	0.001	0.001
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Third Trimester	0.003*	0.003*	0.003*	0.003*	0.003	0.003
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Observations	437,615	437,615	437,464	437,464	437,615	437,464
Joint test, coefficients on trimesters 1-3 equal 0:						
p-value	0.037	0.046	0.024	0.024	0.155	0.136
Mean Value	0.092	0.092	0.092	0.092	0.092	0.092
Fixed Effects:						
Month of Birth	-	✓	-	✓	-	✓
District of Birth	-	-	✓	✓	-	✓
Year of Birth	-	-	-	-	✓	✓

Notes: The table reports estimates from equation (2). We regress an indicator that individual i works in the retail, wholesale, or distribution sector on four dummies indicating the four exposure groups. Individuals exposed to Ramadan in months 1–3 of their pregnancy are included in the First Trimester group, in months 4–6 in the Second Trimester group, and in months 7–9 in the Third Trimester group. Please see Figure II on how we define the gestation month of exposure. Certainly unexposed individuals, who were conceived two months after Ramadan (month -2), are the omitted category, and individuals in months -1 and 0 are grouped together as the No/Partial Exposure category. The sample here includes all three years 2007–2009. Standard errors are in parentheses and clustered at the individual level. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

TABLE A.VIII: **IN-UTERO RAMADAN EXPOSURE AND EARNINGS – EMPLOYEES ONLY**

Fetal Age (Months) at	Outcome: Log Earnings					
the Onset of Ramadan	(1)	(2)	(3)	(4)	(5)	(6)
-1	-0.009	-0.008	-0.009	-0.009	-0.007	-0.006
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.009)
0	-0.021**	-0.020*	-0.020**	-0.019*	-0.003	0.000
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
1	-0.026***	-0.025**	-0.025***	-0.024**	0.002	0.005
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.009)
2	-0.034***	-0.032***	-0.034***	-0.033***	-0.001	0.002
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.009)
3	-0.044***	-0.043***	-0.044***	-0.043***	-0.021**	-0.018*
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.009)
4	-0.024**	-0.023**	-0.024**	-0.024**	-0.007	-0.004
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.009)
5	-0.042***	-0.042***	-0.040***	-0.040***	-0.029***	-0.024***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.009)
6	-0.032***	-0.033***	-0.033***	-0.034***	-0.018*	-0.018*
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.009)
7	-0.039***	-0.040***	-0.039***	-0.039***	-0.025***	-0.024***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.009)
8	-0.029***	-0.030***	-0.026***	-0.026***	-0.018*	-0.015
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.009)
9	-0.007	-0.009	-0.005	-0.005	-0.001	0.001
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.009)
Observations	594,820	594,820	594,762	594,762	594,820	594,762
Joint test, coefficients on months 1-9 equal 0:						
p-value	0.000	0.000	0.000	0.000	0.001	0.001
Fixed Effects:						
Month of Birth	-	✓	-	✓	-	✓
District of Birth	-	-	✓	✓	-	✓
Year of Birth	-	-	-	-	✓	✓

Notes: The table reports estimates from equation (1). We restrict the sample here to employees only. We regress the outcome variable—log of taxable income—on eleven Ramadan exposure dummies, omitting the reference category—certainly unexposed individuals, who were conceived two months after Ramadan (month -2). Please see Figure II on how we define these exposure dummies. The sample here includes all three years 2007–2009. Standard errors are in parentheses and clustered at the individual level. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

TABLE A.IX: **IN-UTERO RAMADAN EXPOSURE AND EARNINGS – EMPLOYEES ONLY**

In-Utero Ramadan	Outcome: Log Earnings					
Exposure in	(1)	(2)	(3)	(4)	(5)	(6)
No/Partial Exposure	-0.015*	-0.014	-0.014*	-0.014	-0.005	-0.003
	(0.009)	(0.009)	(0.008)	(0.008)	(0.008)	(0.008)
First Trimester	-0.035***	-0.033***	-0.035***	-0.033***	-0.007	-0.004
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
Second Trimester	-0.033***	-0.033***	-0.032***	-0.033***	-0.018**	-0.015**
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
Third Trimester	-0.026***	-0.027***	-0.024***	-0.024***	-0.015*	-0.013*
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
Observations	594,820	594,820	594,762	594,762	594,820	594,762
Joint test, coefficients on trimesters 1-3 equal 0:						
p-value	0.000	0.000	0.000	0.000	0.047	0.054
Fixed Effects:						
Month of Birth	-	✓	-	✓	-	✓
District of Birth	-	-	✓	✓	-	✓
Year of Birth	-	-	-	-	✓	✓

Notes*:* The table reports estimates from equation (2). We restrict the sample here to employees only. We regress the outcome variable—log of taxable income—on four dummies indicating the four exposure groups. Individuals exposed to Ramadan in months 1–3 of their pregnancy are included in the First Trimester group, in months 4–6 in the Second Trimester group, and in months 7–9 in the Third Trimester group. Please see Figure II on how we define the gestation month of exposure. Certainly unexposed individuals, who were conceived two months after Ramadan (month -2), are the omitted category, and individuals in months -1 and 0 are grouped together as the No/Partial Exposure category. The sample here includes all three years 2007–2009. Standard errors are in parentheses and clustered at the individual level. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

Table A.X: **In-Utero Ramadan Exposure and Earnings – High-Skilled Only**

In-Utero Ramadan	Outcome: Log Earnings					
Exposure in	(1)	(2)	(3)	(4)	(5)	(6)
No/Partial Exposure	-0.021**	-0.020**	-0.020**	-0.020**	-0.012	-0.010
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
First Trimester	-0.041***	-0.040***	-0.042***	-0.041***	-0.018**	-0.015*
	(0.009)	(0.009)	(0.008)	(0.008)	(0.009)	(0.008)
Second Trimester	-0.043***	-0.043***	-0.041***	-0.042***	-0.029***	-0.024***
	(0.009)	(0.009)	(0.008)	(0.008)	(0.009)	(0.008)
Third Trimester	-0.030***	-0.031***	-0.027***	-0.028***	-0.021**	-0.018**
	(0.009)	(0.009)	(0.008)	(0.008)	(0.009)	(0.008)
Observations	576,612	576,612	576,556	576,556	576,612	576,556
Joint test, coefficients on trimesters 1-3 equal 0:						
p-value	0.000	0.000	0.000	0.000	0.008	0.027
Fixed Effects:						
Month of Birth	-	✓	-	✓	-	✓
District of Birth	-	-	✓	✓	-	✓
Year of Birth	-	-	-	-	✓	✓

Notes*:* The table reports estimates from equation (2). We restrict the sample here to high-skilled individuals only. We regress the outcome variable—log of taxable income—on four dummies indicating the four exposure groups. Individuals exposed to Ramadan in months 1–3 of their pregnancy are included in the First Trimester group, in months 4–6 in the Second Trimester group, and in months 7–9 in the Third Trimester group. Please see Figure II on how we define the gestation month of exposure. Certainly unexposed individuals, who were conceived two months after Ramadan (month -2), are the omitted category, and individuals in months -1 and 0 are grouped together as the No/Partial Exposure category. The sample here includes all three years 2007–2009. Standard errors are in parentheses and clustered at the individual level. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

TABLE A.XI: **ALTERNATIVE BIRTH SEASONALITY CONTROLS**

Fetal Age (Months) at the Onset of Ramadan	Outcome: Log Earnings (1)	(2)	(3)	(4)	(5)
-1	-0.014	-0.013	-0.013	-0.012	-0.014
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
0	-0.027***	-0.025**	-0.024**	-0.023**	-0.025**
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
1	-0.039***	-0.036***	-0.035***	-0.034***	-0.035***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
2	-0.048***	-0.044***	-0.044***	-0.043***	-0.044***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
3	-0.061***	-0.058***	-0.058***	-0.057***	-0.058***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
4	-0.046***	-0.043***	-0.043***	-0.042***	-0.043***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
5	-0.056***	-0.055***	-0.054***	-0.053***	-0.052***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
6	-0.040***	-0.041***	-0.041***	-0.039***	-0.039***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
7	-0.040***	-0.042***	-0.041***	-0.040***	-0.040***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
8	-0.032***	-0.033***	-0.032***	-0.032***	-0.032***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
9	-0.000	-0.002	-0.002	-0.000	-0.002
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
Observations	832,175	832,175	832,175	832,175	832,175
Joint test, coefficients on months 1-9 equal 0:					
p-value	0.000	0.000	0.000	0.000	0.000
Fixed Effects:					
Quarter of Birth	-	✓	-	-	-
Month of Birth	-	-	✓	-	-
Week of Birth	-	-	-	✓	-
Day of Birth	-	-	-	-	✓

Notes: The table reports estimates from equation (1). The first column replicates the specification in the first column of Table III. The rest of the columns introduce successively more granular birth seasonality controls. In each column, the outcome variable is the log of taxable income and as earlier we report coefficients on eleven Ramadan exposure dummies, omitting the reference category (month -2). Please see Figure II on how we define these exposure dummies. The sample here includes all three years 2007–2009. Standard errors are in parentheses and clustered at the individual level. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

TABLE A.XII: **ALTERNATIVE SPATIAL CONTROLS**

Fetal Age (Months) at the Onset of Ramadan	Outcome: Log Earnings (1)	(2)	(3)	(4)	(5)
-1	-0.014	-0.015	-0.013	-0.011	-0.009
	(0.010)	(0.010)	(0.009)	(0.009)	(0.009)
0	-0.027***	-0.027***	-0.024***	-0.022**	-0.020**
	(0.010)	(0.010)	(0.009)	(0.009)	(0.009)
1	-0.039***	-0.040***	-0.035***	-0.033***	-0.030***
	(0.010)	(0.009)	(0.009)	(0.009)	(0.009)
2	-0.048***	-0.052***	-0.045***	-0.043***	-0.040***
	(0.010)	(0.009)	(0.009)	(0.009)	(0.009)
3	-0.061***	-0.063***	-0.056***	-0.052***	-0.050***
	(0.010)	(0.009)	(0.009)	(0.009)	(0.009)
4	-0.046***	-0.046***	-0.041***	-0.038***	-0.035***
	(0.010)	(0.009)	(0.009)	(0.009)	(0.009)
5	-0.056***	-0.053***	-0.050***	-0.047***	-0.044***
	(0.010)	(0.009)	(0.009)	(0.009)	(0.009)
6	-0.040***	-0.041***	-0.039***	-0.037***	-0.035***
	(0.010)	(0.009)	(0.009)	(0.009)	(0.009)
7	-0.040***	-0.041***	-0.039***	-0.037***	-0.034***
	(0.010)	(0.009)	(0.009)	(0.009)	(0.009)
8	-0.032***	-0.029***	-0.024***	-0.023**	-0.021**
	(0.010)	(0.009)	(0.009)	(0.009)	(0.009)
9	-0.000	0.001	0.002	0.001	0.003
	(0.010)	(0.010)	(0.009)	(0.009)	(0.009)
Observations	832,175	832,136	832,096	831,926	831,873
Joint test, coefficients on months 1-9 equal 0:					
p-value	0.000	0.000	0.000	0.000	0.000
Fixed Effects:					
Province of Birth	-	✓	-	-	-
District of Birth	-	-	✓	-	-
Tehsil of Birth	-	-	-	✓	-
UC of Birth	-	-	-	-	✓

Notes*:* The table reports estimates from equation (1). The first column replicates the specification in the first column of Table III. The rest of the columns introduce successively more granular place of birth controls. In each column, the outcome variable is the log of taxable income and as earlier we report coefficients on eleven Ramadan exposure dummies, omitting the reference category (month -2). Please see Figure II on how we define these exposure dummies. The sample here includes all three years 2007–2009. Standard errors are in parentheses and clustered at the individual level. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

TABLE A.XIII: **ALTERNATIVE AGE CONTROLS**

In-Utero Ramadan	Outcome: Log Earnings				
Exposure in	(1)	(2)	(3)	(4)	(5)
No/Partial Exposure	-0.020**	-0.018**	-0.015*	-0.007	-0.007
	(0.009)	(0.008)	(0.008)	(0.008)	(0.008)
First Trimester	-0.049***	-0.044***	-0.024***	-0.011	-0.011
	(0.008)	(0.008)	(0.007)	(0.007)	(0.007)
Second Trimester	-0.047***	-0.044***	-0.025***	-0.021***	-0.022***
	(0.008)	(0.008)	(0.007)	(0.007)	(0.007)
Third Trimester	-0.025***	-0.022***	-0.014*	-0.015**	-0.015**
	(0.008)	(0.008)	(0.007)	(0.007)	(0.007)
Age			0.016***	0.082***	0.091***
			(0.000)	(0.001)	(0.004)
Age ^ 2				-0.001***	-0.001***
				(0.000)	(0.000)
Age ^ 3					0.000**
					(0.000)
Observations	832,175	832,096	832,096	832,096	832,096
Joint test, coefficients on trimesters 1-3 equal 0:					
p-value	0.000	0.000	0.002	0.023	0.019
Fixed Effects:					
Month of Birth	-	✓	✓	✓	✓
District of Birth	-	✓	✓	✓	✓

Notes: The table reports estimates from equation (2). The first two columns replicate the specifications in the first and fourth columns of Table IV respectively. The rest of the columns introduce age and its higher-order terms successively into the model. The outcome variable in each specification is the log of taxable income and as usual we report the coefficients on four exposure dummies along with the age controls. Individuals exposed to Ramadan in months 1–3 of their pregnancy are included in the First Trimester group, in months 4–6 in the Second Trimester group, and in months 7–9 in the Third Trimester group. Please see Figure II on how we define the gestation month of exposure. Certainly unexposed individuals, who were conceived two months after Ramadan (month −2), are the omitted category, and individuals in months −1 and 0 are grouped together as the No/Partial Exposure category. The sample here includes all three years 2007–2009. Standard errors are in parentheses and clustered at the individual level. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

TABLE A.XIV: **IN-UTERO RAMADAN EXPOSURE AND EARNINGS – 2007**

Fetal Age (Months) at the Onset of Ramadan	Outcome: Log Earnings					
	(1)	(2)	(3)	(4)	(5)	(6)
-1	-0.011	-0.012	-0.010	-0.011	-0.015	-0.014
	(0.013)	(0.013)	(0.012)	(0.012)	(0.013)	(0.012)
0	-0.023*	-0.024*	-0.026**	-0.026**	-0.018	-0.018
	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.012)
1	-0.046***	-0.047***	-0.049***	-0.049***	-0.021	-0.023*
	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.012)
2	-0.060***	-0.061***	-0.062***	-0.062***	-0.031**	-0.030**
	(0.013)	(0.013)	(0.013)	(0.012)	(0.013)	(0.012)
3	-0.071***	-0.071***	-0.068***	-0.067***	-0.039***	-0.031***
	(0.013)	(0.013)	(0.012)	(0.012)	(0.013)	(0.012)
4	-0.054***	-0.053***	-0.054***	-0.054***	-0.017	-0.014
	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.012)
5	-0.066***	-0.065***	-0.057***	-0.057***	-0.037***	-0.026**
	(0.013)	(0.013)	(0.012)	(0.012)	(0.013)	(0.012)
6	-0.058***	-0.057***	-0.057***	-0.057***	-0.029**	-0.027**
	(0.013)	(0.013)	(0.012)	(0.012)	(0.013)	(0.012)
7	-0.052***	-0.051***	-0.049***	-0.048***	-0.033***	-0.028**
	(0.013)	(0.013)	(0.012)	(0.012)	(0.013)	(0.012)
8	-0.044***	-0.042***	-0.036***	-0.034***	-0.034***	-0.025**
	(0.013)	(0.013)	(0.012)	(0.012)	(0.013)	(0.012)
9	-0.010	-0.010	-0.010	-0.010	-0.005	-0.005
	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.012)
Observations	165,952	165,952	165,937	165,937	165,952	165,937
Joint test, coefficients on months 1-9 equal 0:						
p-value	0.000	0.000	0.000	0.000	0.017	0.102
Fixed Effects:						
Month of Birth	-	✓	-	✓	-	✓
District of Birth	-	-	✓	✓	-	✓
Year of Birth	-	-	-	-	✓	✓

Notes*:* The table reports estimates from equation (1). The sample here includes tax returns filed in the tax year 2007 only. We regress the outcome variable—log of taxable income—on eleven Ramadan exposure dummies, omitting the reference category—certainly unexposed individuals, who were conceived two months after Ramadan (month -2). Please see Figure II on how we define these exposure dummies. Standard errors are in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

TABLE A.XV: **IN-UTERO RAMADAN EXPOSURE AND EARNINGS – 2008**

Fetal Age (Months) at	Outcome: Log Earnings					
the Onset of Ramadan	(1)	(2)	(3)	(4)	(5)	(6)
-1	-0.018	-0.016	-0.016	-0.016	-0.015	-0.013
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.010)
0	-0.030***	-0.027**	-0.025**	-0.024**	-0.013	-0.005
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
1	-0.039***	-0.034***	-0.034***	-0.032***	-0.007	0.001
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.010)
2	-0.050***	-0.044***	-0.045***	-0.043***	-0.018*	-0.009
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.010)
3	-0.064***	-0.059***	-0.058***	-0.056***	-0.037***	-0.025**
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.010)
4	-0.047***	-0.044***	-0.040***	-0.039***	-0.022**	-0.011
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.010)
5	-0.060***	-0.058***	-0.056***	-0.056***	-0.041***	-0.035***
	(0.011)	(0.011)	(0.010)	(0.010)	(0.011)	(0.010)
6	-0.042***	-0.042***	-0.041***	-0.043***	-0.023**	-0.023**
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.010)
7	-0.042***	-0.043***	-0.039***	-0.041***	-0.026**	-0.025**
	(0.011)	(0.011)	(0.010)	(0.011)	(0.011)	(0.010)
8	-0.030***	-0.031***	-0.022**	-0.022**	-0.019*	-0.012
	(0.011)	(0.011)	(0.010)	(0.010)	(0.011)	(0.010)
9	-0.004	-0.006	-0.001	-0.002	0.001	0.002
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
Observations	313,095	313,095	313,035	313,035	313,095	313,035
Joint test, coefficients on months 1-9 equal 0:						
p-value	0.000	0.000	0.000	0.000	0.000	0.001
Fixed Effects:						
Month of Birth	-	✓	-	✓	-	✓
District of Birth	-	-	✓	✓	-	✓
Year of Birth	-	-	-	-	✓	✓

Notes*:* The table reports estimates from equation (1). The sample here includes tax returns filed in the tax year 2008 only. We regress the outcome variable—log of taxable income—on eleven Ramadan exposure dummies, omitting the reference category—certainly unexposed individuals, who were conceived two months after Ramadan (month -2). Please see Figure II on how we define these exposure dummies. Standard errors are in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

TABLE A.XVI: **IN-UTERO RAMADAN EXPOSURE AND EARNINGS – 2009**

Fetal Age (Months) at	Outcome: Log Earnings					
the Onset of Ramadan	(1)	(2)	(3)	(4)	(5)	(6)
-1	-0.015	-0.013	-0.014	-0.014	-0.011	-0.009
	(0.011)	(0.011)	(0.010)	(0.010)	(0.010)	(0.010)
0	-0.029***	-0.025**	-0.025**	-0.023**	-0.009	-0.004
	(0.011)	(0.011)	(0.010)	(0.010)	(0.010)	(0.010)
1	-0.040***	-0.036***	-0.036***	-0.033***	-0.010	-0.002
	(0.011)	(0.011)	(0.010)	(0.010)	(0.010)	(0.010)
2	-0.048***	-0.043***	-0.044***	-0.041***	-0.014	-0.006
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
3	-0.061***	-0.057***	-0.055***	-0.053***	-0.033***	-0.024**
	(0.011)	(0.011)	(0.010)	(0.010)	(0.010)	(0.010)
4	-0.046***	-0.044***	-0.041***	-0.041***	-0.022**	-0.016
	(0.011)	(0.011)	(0.010)	(0.010)	(0.010)	(0.010)
5	-0.050***	-0.049***	-0.044***	-0.045***	-0.033***	-0.027***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
6	-0.038***	-0.039***	-0.035***	-0.037***	-0.021**	-0.021**
	(0.010)	(0.011)	(0.010)	(0.010)	(0.010)	(0.010)
7	-0.036***	-0.038***	-0.037***	-0.037***	-0.021**	-0.023**
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
8	-0.029***	-0.030***	-0.023**	-0.024**	-0.019*	-0.016
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
9	0.005	0.003	0.007	0.007	0.007	0.008
	(0.011)	(0.011)	(0.010)	(0.010)	(0.010)	(0.010)
Observations	353,128	353,128	353,049	353,049	353,128	353,049
Joint test, coefficients on months 1-9 equal 0:						
p-value	0.000	0.000	0.000	0.000	0.001	0.001
Fixed Effects:						
Month of Birth	-	✓	-	✓	-	✓
District of Birth	-	-	✓	✓	-	✓
Year of Birth	-	-	-	-	✓	✓

Notes*:* The table reports estimates from equation (1). The sample here includes tax returns filed in the tax year 2009 only. We regress the outcome variable—log of taxable income—on eleven Ramadan exposure dummies, omitting the reference category—certainly unexposed individuals, who were conceived two months after Ramadan (month −2). Please see Figure II on how we define these exposure dummies. Standard errors are in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

TABLE A.XVII: **IN-UTERO RAMADAN EXPOSURE AND EARNINGS – 2007**

In-Utero Ramadan	Outcome: Log Earnings					
Exposure in	(1)	(2)	(3)	(4)	(5)	(6)
No/Partial Exposure	-0.017	-0.018	-0.018*	-0.018*	-0.017	-0.016
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
First Trimester	-0.059***	-0.060***	-0.060***	-0.059***	-0.030***	-0.028***
	(0.011)	(0.011)	(0.010)	(0.010)	(0.010)	(0.010)
Second Trimester	-0.059***	-0.058***	-0.056***	-0.056***	-0.027***	-0.023**
	(0.011)	(0.011)	(0.010)	(0.010)	(0.010)	(0.010)
Third Trimester	-0.036***	-0.035***	-0.032***	-0.031***	-0.025**	-0.020**
	(0.011)	(0.011)	(0.010)	(0.010)	(0.010)	(0.010)
Observations	165,952	165,952	165,937	165,937	165,952	165,937
Joint test, coefficients on trimesters 1-3 equal 0:						
p-value	0.000	0.000	0.000	0.000	0.035	0.044
Fixed Effects:						
Month of Birth	-	✓	-	✓	-	✓
District of Birth	-	-	✓	✓	-	✓
Year of Birth	-	-	-	-	✓	✓

Notes*:* The table reports estimates from equation (2). The sample here includes tax returns filed in the tax year 2007 only. We regress the outcome variable—log of taxable income—on four dummies indicating the four exposure groups. Individuals exposed to Ramadan in months 1–3 of their pregnancy are included in the First Trimester group, in months 4–6 in the Second Trimester group, and in months 7–9 in the Third Trimester group. Please see Figure II on how we define the gestation month of exposure. Certainly unexposed individuals, who were conceived two months after Ramadan (month -2), are the omitted category, and individuals in months -1 and 0 are grouped together as the No/Partial Exposure category. Standard errors are in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

TABLE A.XVIII: **IN-UTERO RAMADAN EXPOSURE AND EARNINGS – 2008**

In-Utero Ramadan	Outcome: Log Earnings					
Exposure in	(1)	(2)	(3)	(4)	(5)	(6)
No/Partial Exposure	-0.024**	-0.021**	-0.021**	-0.020**	-0.014	-0.009
	(0.010)	(0.010)	(0.009)	(0.009)	(0.010)	(0.009)
First Trimester	-0.051***	-0.046***	-0.046***	-0.044***	-0.021**	-0.011
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.008)
Second Trimester	-0.050***	-0.048***	-0.046***	-0.046***	-0.029***	-0.023***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
Third Trimester	-0.026***	-0.027***	-0.021**	-0.022***	-0.015*	-0.012
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.008)
Observations	313,095	313,095	313,035	313,035	313,095	313,035
Joint test, coefficients on trimesters 1-3 equal 0:						
p-value	0.000	0.000	0.000	0.000	0.009	0.031
Fixed Effects:						
Month of Birth	-	✓	-	✓	-	✓
District of Birth	-	-	✓	✓	-	✓
Year of Birth	-	-	-	-	✓	✓

Notes*:* The table reports estimates from equation (2). The sample here includes tax returns filed in the tax year 2008 only. We regress the outcome variable—log of taxable income—on four dummies indicating the four exposure groups. Individuals exposed to Ramadan in months 1–3 of their pregnancy are included in the First Trimester group, in months 4–6 in the Second Trimester group, and in months 7–9 in the Third Trimester group. Please see Figure II on how we define the gestation month of exposure. Certainly unexposed individuals, who were conceived two months after Ramadan (month -2), are the omitted category, and individuals in months -1 and 0 are grouped together as the No/Partial Exposure category. Standard errors are in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

TABLE A.XIX: **IN-UTERO RAMADAN EXPOSURE AND EARNINGS – 2009**

In-Utero Ramadan	Outcome: Log Earnings					
Exposure in	(1)	(2)	(3)	(4)	(5)	(6)
No/Partial Exposure	-0.022**	-0.019**	-0.019**	-0.018**	-0.010	-0.007
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
First Trimester	-0.050***	-0.045***	-0.045***	-0.042***	-0.019**	-0.011
	(0.009)	(0.009)	(0.008)	(0.008)	(0.008)	(0.008)
Second Trimester	-0.045***	-0.044***	-0.040***	-0.041***	-0.025***	-0.021***
	(0.009)	(0.009)	(0.008)	(0.008)	(0.008)	(0.008)
Third Trimester	-0.021**	-0.023***	-0.019**	-0.019**	-0.012	-0.011
	(0.009)	(0.009)	(0.008)	(0.008)	(0.008)	(0.008)
Observations	353,128	353,128	353,049	353,049	353,128	353,049
Joint test, coefficients on trimesters 1-3 equal 0:						
p-value	0.000	0.000	0.000	0.000	0.010	0.041
Fixed Effects:						
Month of Birth	-	✓	-	✓	-	✓
District of Birth	-	-	✓	✓	-	✓
Year of Birth	-	-	-	-	✓	✓

Notes*:* The table reports estimates from equation (2). The sample here includes tax returns filed in the tax year 2009 only. We regress the outcome variable—log of taxable income—on four dummies indicating the four exposure groups. Individuals exposed to Ramadan in months 1–3 of their pregnancy are included in the First Trimester group, in months 4–6 in the Second Trimester group, and in months 7–9 in the Third Trimester group. Please see Figure II on how we define the gestation month of exposure. Certainly unexposed individuals, who were conceived two months after Ramadan (month -2), are the omitted category, and individuals in months -1 and 0 are grouped together as the No/Partial Exposure category. Standard errors are in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

TABLE A.XX: **HETEROGENEITY IN RAMADAN EFFECT – OLD VS. YOUNG COHORTS**

In-Utero Ramadan	Old Cohort: Age >					
Exposure in	40	45	50	55	60	65
	(1)	(2)	(3)	(4)	(5)	(6)
1st Trimester	-0.009	-0.007	-0.011	-0.011	-0.012	-0.013*
	(0.010)	(0.009)	(0.008)	(0.008)	(0.007)	(0.007)
2nd Trimester	-0.022**	-0.018**	-0.023***	-0.023***	-0.020***	-0.020***
	(0.010)	(0.009)	(0.008)	(0.007)	(0.007)	(0.007)
3rd Trimester	-0.009	-0.007	-0.010	-0.011	-0.011	-0.010
	(0.010)	(0.009)	(0.008)	(0.008)	(0.007)	(0.007)
1st Trimester × Old Cohort	-0.010	-0.020	-0.016	-0.026	-0.055	-0.073
	(0.014)	(0.014)	(0.017)	(0.023)	(0.037)	(0.054)
2nd Trimester × Old Cohort	0.001	-0.007	0.009	0.016	-0.041	-0.053
	(0.014)	(0.014)	(0.017)	(0.025)	(0.039)	(0.053)
3rd Trimester × Old Cohort	-0.007	-0.013	-0.012	-0.009	-0.049	-0.115**
	(0.014)	(0.014)	(0.016)	(0.024)	(0.041)	(0.057)
Observations	832,096	832,096	832,096	832,096	832,096	832,096
Joint test, coefficients on three Trimester × Old Cohort equal 0:						
p-value	0.701	0.507	0.274	0.172	0.519	0.205
Fixed Effects:						
Month of Birth	✓	✓	✓	✓	✓	✓
District of Birth	✓	✓	✓	✓	✓	✓
Year of Birth	✓	✓	✓	✓	✓	✓

Notes*:* The table reports estimates from an augmented version of equation (2), where we add double interaction terms interacting the exposure month ($\mathbb{1}\left[em_i \in \{-1, 0\}\right]$) and trimester ($\mathbb{1}(et_i = \tau)$) dummies with the dummy variable Old Cohort, which takes the value 1 if the age of individual i on July 1, 2007 exceeds the cutoff indicated in the heading of each column. The sample here includes tax returns filed in the tax years 2007–2009. The outcome variable is the log of taxable income of the individual, and all specifications include the full set of month, district and year of birth fixed effects. Standard errors are in parentheses and clustered at the individual level. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

TABLE A.XXI: **HETEROGENEITY IN RAMADAN EFFECT – WEATHER**

In-Utero Ramadan	Outcome: Log Earnings					
	(1)	(2)	(3)	(4)	(5)	(6)
1st Trimester	-0.045***	-0.042***	-0.041***	-0.040***	-0.024***	-0.012
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
2nd Trimester	-0.047***	-0.036***	-0.040***	-0.033***	-0.035***	-0.017**
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
3rd Trimester	-0.014*	-0.012	-0.006	-0.008	-0.018**	-0.009
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
1st Trimester × Ext Weather	-0.022**	-0.018*	-0.025***	-0.018*	0.016	-0.012
	(0.010)	(0.011)	(0.010)	(0.010)	(0.015)	(0.015)
2nd Trimester × Ext Weather	-0.004	-0.059***	-0.021**	-0.061***	0.051***	-0.024
	(0.011)	(0.011)	(0.010)	(0.011)	(0.015)	(0.015)
3rd Trimester × Ext Weather	-0.071***	-0.088***	-0.094***	-0.089***	0.014	-0.019
	(0.011)	(0.011)	(0.010)	(0.011)	(0.015)	(0.015)
Observations	832,175	832,175	832,096	832,096	832,175	832,096
Joint test, coefficients on three Trimester × Ext Weather equal 0:						
p-value	0.000	0.000	0.000	0.000	0.004	0.406
Fixed Effects:						
Month of Birth	-	✓	-	✓	-	✓
District of Birth	-	-	✓	✓	-	✓
Year of Birth	-	-	-	-	✓	✓

Notes: The table reports estimates from an augmented version of equation (2), where we add double interaction terms interacting the exposure month ($\mathbb{1}\left[em_i \in \{-1, 0\}\right]$) and trimester ($\mathbb{1}(et_i = \tau)$) dummies with the dummy variable Ext Weather. The dummy variable takes the value 1 if individual i was exposed to Ramadan while in-utero in the months May and June. These two months are the harshest months in Pakistan in terms of weather. Temperature during these two months is at its peak, reaching the level of 50 degree centigrade (or 122°F) on some days. Dry and ultra-hot weather makes Ramadan fasting during these months especially hard. The sample here includes tax returns filed in the tax years 2007–2009. The outcome variable is the log of taxable income of the individual. Standard errors are in parentheses and clustered at the individual level. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

TABLE A.XXII: **HETEROGENEITY IN RAMADAN EFFECT – LOCATION**

In-Utero Ramadan	Outcome: Log Earnings					
	(1)	(2)	(3)	(4)	(5)	(6)
1st Trimester	-0.270***	-0.267***	-0.065***	-0.064***	-0.234***	-0.022**
	(0.009)	(0.009)	(0.010)	(0.010)	(0.008)	(0.010)
2nd Trimester	-0.256***	-0.255***	-0.051***	-0.051***	-0.234***	-0.023**
	(0.009)	(0.009)	(0.010)	(0.010)	(0.009)	(0.010)
3rd Trimester	-0.223***	-0.221***	-0.020**	-0.020**	-0.221***	-0.012
	(0.009)	(0.009)	(0.010)	(0.010)	(0.009)	(0.010)
1st Trimester × Major City	0.440***	0.440***	0.038**	0.041***	0.429***	0.016
	(0.008)	(0.008)	(0.015)	(0.015)	(0.007)	(0.015)
2nd Trimester × Major City	0.418***	0.415***	0.015	0.015	0.419***	0.003
	(0.008)	(0.008)	(0.015)	(0.015)	(0.007)	(0.015)
3rd Trimester × Major City	0.396***	0.392***	-0.002	-0.003	0.413***	-0.000
	(0.008)	(0.008)	(0.015)	(0.015)	(0.007)	(0.015)
Observations	832,175	832,175	832,096	832,096	832,175	832,096
Joint test, coefficients on three Trimester × Major City equal 0:						
p-value	0.000	0.000	0.001	0.000	0.000	0.364
Fixed Effects:						
Month of Birth	-	✓	-	✓	-	✓
District of Birth	-	-	✓	✓	-	✓
Year of Birth	-	-	-	-	✓	✓

Notes: The table reports estimates from an augmented version of equation (2), where we add double interaction terms interacting the exposure month ($\mathbb{1}\left[em_i \in \{-1,0\}\right]$) and trimester ($\mathbb{1}(et_i = \tau)$) dummies with the dummy variable Major City. The dummy variable takes the value 1 if the district of birth of individual i is one of the three major cities of Pakistan in terms of per-capita income—Karachi, Lahore, and Islamabad. The sample here includes tax returns filed in the tax years 2007–2009. The outcome variable is the log of taxable income of the individual. Standard errors are in parentheses and clustered at the individual level. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

TABLE A.XXIII: **IN-UTERO RAMADAN EXPOSURE AND SEX RATIOS**

Gestation Month at the Start of Ramadan	Tax Data (1)	Tax Data (2)	DHS Data (3)	DHS Data (4)
-1	0.002	0.003	-0.004	-0.004
	(0.002)	(0.002)	(0.009)	(0.009)
0	-0.001	0.001	0.005	0.007
	(0.002)	(0.002)	(0.010)	(0.010)
1	0.000	0.003	0.013	0.013
	(0.002)	(0.002)	(0.009)	(0.009)
2	-0.004*	-0.001	0.006	0.007
	(0.002)	(0.002)	(0.010)	(0.010)
3	-0.002	0.001	0.003	0.001
	(0.002)	(0.002)	(0.009)	(0.009)
4	-0.003	0.000	0.002	0.002
	(0.002)	(0.002)	(0.009)	(0.009)
5	-0.003	-0.000	0.003	0.002
	(0.002)	(0.002)	(0.009)	(0.009)
6	-0.001	0.001	0.005	0.004
	(0.002)	(0.002)	(0.009)	(0.009)
7	-0.000	0.000	0.003	0.003
	(0.002)	(0.002)	(0.010)	(0.010)
8	-0.002	-0.002	0.003	0.003
	(0.002)	(0.002)	(0.009)	(0.009)
9	-0.001	-0.001	0.006	0.005
	(0.002)	(0.002)	(0.009)	(0.009)
Observations	437,145	437,122	116,656	116,656
Mean Value	0.109	0.109	0.483	0.483
Fixed Effects:				
Month of Birth	-	✓	-	✓
District of Birth	-	✓	-	✓
Year of Birth	-	✓	-	✓

Notes*:* The table estimates the effects of in-utero Ramadan exposure on the sex ratio. We estimate our equation (1) using an indicator that individual i is a female as the outcome variable. The first two columns estimate the equation using the tax return data and the last two using the DHS data. We use sampling weights for the last two specifications so that the results are nationally representative. Even-numbered columns include the month, district, and year of birth as controls. Standard errors are in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

TABLE A.XXIV: **FASTING RATE**

Country	Study	Main Findings
(1)	(2)	(3)
Pakistan	Masood et al. (2018)	Around 82.8% of women reported fasting during Ramadan out of a sample of 279 pregnant women in a hospital in Karachi, Pakistan.; 11.6% reported fasting for more than 10 days.
Pakistan	Nusrat et al. (2017)	Nearly 53% of Mulim women reported fasting during pregnancy out of a sample of 150 women who underwent pregnancy during the 2016 Ramadan and attended a clinic in Karachi, Pakistan; 30% reported fasting for the whole month and 38% believed that fasting during pregnancy is essential.
Pakistan	Mubeen et al. (2012)	Around 87.5% of women reported fasting during pregnancy out of a sample of 353 women from Sindh and Punjab, Pakistan, who had experienced pregnancy during Ramadan at least once in their life. Nearly 42.5% reported fasting for the whole month, 23.8% on alternate days, and 10.5% on weekends/holidays only. About 88% believed that fasting during pregnancy (when in good health) is obligatory and 59% perceived no harm in doing so.
Iran	Firouzbakht et al. (2013)	About 31.8% of women reported fasting during Ramadan in 2011 out of a sample of 215 pregnant Muslim women who attended health centers in Amol, Iran; 16% reported fasting for more than 10 days.
Iran	Ziaee et al. (2010)	Nearly 65% of women reported fasting during pregnancy out of a sample of 189 women delivering in a hospital in Tehran, Iran during the 2004 Ramadan. Around 50% reported fasting for more than 10 days (mostly in first trimester), and 31.7% for more than 20 days.
Iran	Arab & Nasrollahi (2001)	Around 71% of women reported fasting 1-9 days of their pregnancy out of 4,343 women delivering in Hamadan, Iran in 1999. Nearly 40% of respondents reported fasting for more than 20 days. Fasting rates were 77% for the first, 72% for the second, and 65% for third trimester of gestation.

TABLE A.XXIV: **FASTING RATE (CONTD.)**

Country	Study	Main Findings
(1)	(2)	(3)
Indonesia	van Bilsen et al. (2016)	Studied 187 Muslim women in a hospital in Jakarta, Indonesia, examining the determinants of the decision to fast. Odds of fasting fall by 4% each week of pregnancy.
Iraq	Bander (2005)	Around 50.7% reported fasting for the whole month of Ramadan out of a sample of 225 women in Iraq who were in 22nd-28th week of gestation.
Singapore	Jooseph and SL. (2004)	Nearly 87% reported fasting for at least 1 day during pregnancy out of a sample of 182 Muslim women who had received antenatal care in a Singaporean hospital during Ramadan in 2001. Around 57% reported completing at least 20 days of fasting, 67% believed fasting is essential, and 79% perceived no harm in doing so.
Yemen	Makki (2002)	Almost 90% reported fasting for more than 20 days out of a sample of 2,242 women delivering in four hospitals in Sana'a City, Yemen, in 1995.
Malaysia	Salleh (1989)	Around 78.8% reported fasting out of a sample of 605 pregnant women attending a clinic in Muar, Malaysia, in 1985.
Gambia	Prentice et al. (1983)	Almost 90% of pregnant women (and all lactating women) from a village in Gambia fasted during Ramadan.
England	Petherick et al. (2014)	Nearly 43% of women reported fasting for at least one day and 14% for the full period of Ramadan out of a sample of 310 Muslim women of Asian or Asian British ethnicity giving birth in a hospital in Bradford, England, in 2010. Fasting occurred mostly in the 1st and 2nd trimester and was correlated with education and maternal age.

TABLE A.XXIV: **FASTING RATE (CONTD.)**

Country	Study	Main Findings
(1)	(2)	(3)
England	Malhotra et al. (1989)	Almost 45% reported fasting out of 44 Pakistani and Bangladeshi Muslim mothers in a hospital in Birmingham, England.
England	Eaton & Wharton (1982)	Three quarters of mothers in a hospital in Birmingham, England fasted during Ramadan.
England	Fowler (1990)	Around 56% reported they would observe the fast while pregnant out of a sample of 78 Muslim women who attended a clinic in Birmingham, England in 1989.
Netherland	Savitri et al. (2014)	Around 53.8% of Muslim women reported fasting to some extent out of a sample of 130 Muslim women from the Netherlands whose pregnancy overlapped with Ramadan in 2010. Nearly 37.7% fasted for more than half a month.
US	Lou & Hammond (2016)	Around 30% (11) reported fasting during Ramadan in their most recent pregnancy out of a sample of 37 Muslim women who visited a clinic in metropolitan Detroit, Michigan, US during Ramadan in 2013.
US	Robinson & Raisler (2005)	28 out of 32 Muslim women from Michigan, US, reported fasting during at least one pregnancy, 16 for the whole month. Participants estimated a fasting rate of 60-90% for pregnant Muslim women in their communities, but only 30-50% for American-born Muslim women.

Notes*:* The table lists studies that estimate the fasting rate among pregnant Muslim women in different countries. The first column shows the country the study relates to, the second the study's citation and the third its main findings.