Maternal Religious Observance and Child Cognitive Development

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Abstract

This paper examines the impact of prenatal exposure to the nutritional shock generated by Eid-ul-Adha on children's cognitive, health, and later-life outcomes in Pakistan. Exploiting the exogenous timing of Eid-ul-Adha under the lunar calendar, we identify causal effects using repeated cross-sectional data and variation in in utero exposure across trimesters. We show that exposure during the first trimester—a critical period for brain development—significantly improves mathematical and literacy skills, with stronger effects in rural areas and among females. The findings highlight how short, intense, and recurring cultural events can generate meaningful early-life human capital effects. By introducing a novel, annually occurring nutritional shock, this study extends the fetal-origins literature and provides new evidence on the long-term developmental consequences of early-life nutrition in low-income settings.

JEL Codes: J12, J13, O15, Q54

Keywords: Prenatal exposure; Nutritional shock; Economics of religion; Fetal origins; Human capital.

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1 Introduction

Religious ritual and observance can have a profound impact on the health and wellbeing of individuals, independent of any salvific concerns. Economists have been paying increasing attention to understanding the role religiosity can play in shaping outcomes of interest, including education, mental health, labor market outcomes, among others (Iyer, 2016). In the developing world, individual behaviors grounded in religious observance are even more likely to have an impact, owing to higher levels of religious adherence. Yet only a handful of studies have explored these avenues in detail (e.g., Clingingsmith et al. (2009)), with the only sustained literature developing around the consequences of negative nutritional shocks from Ramadan fasting (Campante and Yanagizawa-Drott, 2015; Majid, 2015; Aydilek and Karaoğlan, 2024).

In this paper, we instead study the effects of a 'religious boon' by focusing on the second major festival in the Islamic liturgical calendar, Eid-ul-Adha. This festival involves ritual feasting of meat via mass sacrifice of animals by Muslim adherents across the globe, as they mark the annual Hajj pilgrimage to Mecca. Most importantly, the festival involves charitable giving away of sacrificial meat, which in most low-income countries ends up being a major boost in protein consumption for poorer sections of society Khan (2026). Furthermore, Eid-ul-Adha also follows the lunar calendar, and thus its timing induces quasi-random variation, much like that exploited by earlier studies on Ramadan, albeit for a *positive* nutritional shock.

Focusing on Pakistan, the second most populous Muslim country, and a setting where women are particularly likely to be protein-starved, anaemic, and malnourished UNICEF (2018), we study how maternal exposure to ritual feasting during pregnancy affects their children's health and cognitive development. Within the Islamic ritual calendar, Eid-ul-Adha follows the period of Ramadan fasting after a fixed interval of around seventy days, requiring careful consideration for the assignment of individuals to treated and control groups to avoid potential confounding from opposite-directional nutritional shocks.[1] We define in-utero periods falling after the Eid festivities as a 'pure' control group, as this period largely overlaps with neither shock. Our main treated group comprises individuals whose first trimester over-

[1]Similar concerns can also plague the literature on Ramadan shocks, as the timing of Eid-ul-Adha (Eid) can partially offset the negative impacts of fasting, although previous papers have largely not accounted for this.

laps with Eid, the most critical phase of pregnancy for protein intake Mou et al. (2024); Prado and Dewey (2014).[2] We also separately consider the other two trimesters, but these furnish less clean comparisons due to overlap with Ramadan.

Children with in-utero exposure to higher maternal protein intake during the first trimester have 1.4 percentage points (pp) higher math skills and 2.2 pp higher literacy competency, measured when they are between 10 and 18 years old. These correspond to around a 1.6-2.6 percentage increase relative to the sample mean. While modest in magnitude, these effects stem from a few weeks of better nutritional exposure during early pregnancy, a crucial period for fetal brain development (Glewwe and King, 2001), implying non-trivial human capital returns at the aggregate level. Moreover, the effects are stronger in rural regions, where treatment intensity is likely to be greater due to higher economic deprivation. On the other hand, the estimated effects are slightly muted for in-utero exposure in the second and third trimester, as anticipated due to partial overlap with a potential Ramadan-based negative nutritional shock.

Separating the above effects by the gender of the child, our analysis finds very similar gains for both boys and girls, between 1.7 and 3%, among the treated cohorts. This makes sense as the maternal 'take-up' of the protein shock is for religious obligation reasons as opposed to any differential investment in fetal health owing to any son-preference based channels (Jayachandran and Kuziemko, 2011). Similarly, in Muslim-majority Pakistan, these effects bear out across all major ethnic groups, again underscoring the expansive implications of this unintended religious boon. Given cultural norms and public policy often distribute resources unequally across gender and ethnic lines, the religious imperative underlying Eid-ul-Adha generates developmental spillovers that cut across these divides. However, religious fault lines still deliver differential treatment effects as they impact treatment intensity itself. For instance, children in districts with above-median Sunni population shares exhibit a 4% increase in cognitive outcomes, compared to under 2% in below-median Sunni districts. This pattern reflects the structural concentration of charitable distribution networks in Sunni-majority areas (Limodio, 2022), which can translate into systematically higher meat availability for households in these districts during the Eid window.

[2]Importantly, for these individuals, there is minimal overlap between any phase of their in-utero period and a future Ramadan-based negative shock, giving us the cleanest treatment group possible in this complex design.

Next, we explore a supply-side channel that can also directly affect treatment intensity during the Eid window. Districts with above-median livestock production show significantly stronger cognitive gains of around 2-3%, while effects in below-median production districts are statistically indistinguishable from zero. This pattern is consistent with the economics of local meat markets: where animals are plentiful and affordable, more households can participate in ritual sacrifice, and more meat reaches the poor through community organizations. Furthermore, within high livestock production districts, the effects are amplified in years when rainfall is above average, conditions that boost pasture availability, livestock weight, and aggregate meat supply. It is important to note that in this analysis, even the pure control group experiences the same rainfall shocks, providing additional confidence that it is the meat availability channel, rather than increased precipitation, that drives our findings.

The inequalities observed in later life often emerge from early-life exposures Doyle et al. (2009). A substantial body of literature has linked maternal dietary intake during pregnancy to child development, emphasizing the importance of balanced diets for cognitive and health outcomes Mou et al. (2024). However, little is known about the impact of short, culturally-specific, and recurring nutritional shocks on later-life outcomes, particularly in economically disadvantaged populations. In Pakistan, where food poverty affects roughly 60% of the population World Food Programme (2018), households often have limited access to meat and other essential dietary components. Meat consumption is largely restricted to religious occasions, including Eid-ul-Fitr (BISP, 2011) and Eid-ul-Adha Muslim Hands United Kingdom (2021); World News (2021). During Eid-ul-Fitr, fitrana (mandatory charity) provides short-term nutritional support, typically lasting one to three days. In contrast, Eid-ul-Adha involves the sacrificial slaughter of animals, producing a substantial and temporally concentrated supply of meat that is distributed among family, friends, and underprivileged communities. This creates a natural, short-term nutritional shock that can meaningfully influence early-life development, particularly for children in low-income households.

Figure 1 illustrates this classification and highlights the treated and pure control groups (i.e., the first trimester of pregnancy).

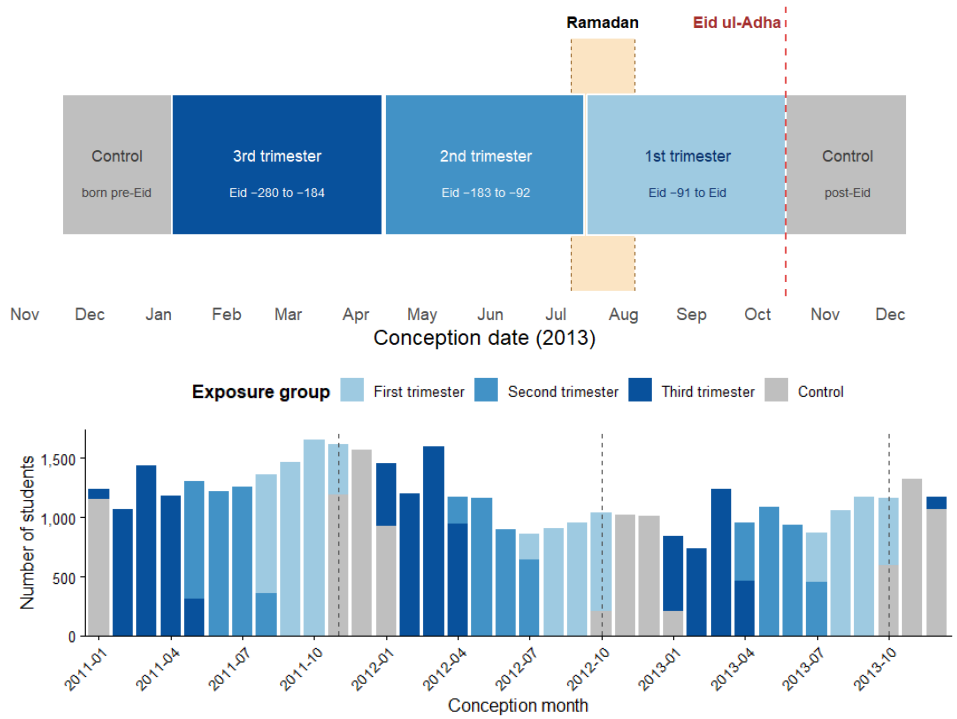


Figure 1: Treated VS. Control Overview

Note: The dashed vertical lines indicate the timing of Eid-ul-Adha. The upper panel shows the distribution of all exposed and non-exposed observations, while the lower panel presents the sample used in the analysis after excluding second- and third-trimester exposed observations.

This study makes three main contributions. First, it provides causal evidence that prenatal exposure to Eid-ul-Adha affects children's cognitive ability. Second, it extends the fetal-origins literature by examining a novel type of prenatal shock: short, intense, and recurring events that occur annually, unlike natural disasters or long-lasting economic shocks, which are rare and unpredictable. Third, it shows that the timing of major religious events can create unintended early-life impacts on human capital, even in the absence of formal policy interventions.

The paper contributes to three strands of literature. First, it adds to the seminal studies by Campante and Yanagizawa-Drott (2015); Majid (2015); Aydilek and Karaoğlan (2024), which focus on negative nutritional effects from Ramadan fasting and positive behavioral change in Hajj pilgrims as documented in Clingingsmith et al. (2009). Here, we exploit, for the first time in the literature, the quasi-random timing of the second biggest Islamic festival, Eid-ul-Adha, and estimate its causal impact on the future generations, i.e., on childrens' cognitive development. Much in line with Clingingsmith et al. (2009) positive finding, we also estimate positive

nutritional impact due to ritual feasting during pregnancy on childrens' follow on cognitive development.

Second, the study sheds light on the finer nuance of religion and economics by focusing on a well celebrated religious ritual and its long-run impact on human development, complementing the literature on religion and economic growth as synthesized in Becker et al. (2024) and posited in Barro and McCleary (2003). In our setting, religious feasting as a societal norm creates positive externalities for future generations which in turn have optimistic ramifications on educational and labor market outcomes for the treated cohorts.

Third, this article complements studies looking at factors contributing to child cognitive development (inter alia, Mou et al. (2024)). Figlio, Guryan, Karbownik and Roth (2014) finds that poor neonatal health adversely affects children's cognitive development. Brain development undergoes rapid and significant growth during early life, with the first 1,000 days being especially critical Glewwe and King (2001). Among these, the first trimester of pregnancy plays a particularly important role, as this is when the brain experiences volumetric growth and lays the foundation for later cognitive and socioemotional skills Prado and Dewey (2014). Adequate nutrition during pregnancy is essential not only for cognitive development but also for long-term health outcomes Almond (2006); Barker (1995). Nutritional deficiencies during this critical period can reduce cognitive abilities, productivity, and health outcomes in later life, highlighting the importance of interventions that ensure adequate maternal nutrition.

Our investigation reveals that the natural religious practice of Eid and the associated consumption of meat positively affect in-utero exposure and subsequent cognitive development in children in a developing country, Pakistan. Bolt (2025) reports that early childhood cognitive skills persist significantly into adulthood, and such skills do affect economic development later Hanushek and Woessmann (2008). Hence, our findings will have implications beyond cognitive development in the short-run and affect the outcomes of the labor market in the long run. In fact, we show that there is positive improvement in employment and monthly working days for the treated group. (TO BE COMPLETED)

The empirical results show differences across the three trimesters in response to positive shocks, summarized in Table 1. Panel A represents the first trimester, while Panels B and C show the second and third trimesters compared to the control group. Exposure to a positive shock in the first trimester has a positive and significant impact on both mathematical skills and literacy competence, highlighting the first trimester as a crucial period for brain development Mou et al. (2024); Prado and Dewey (2014). In the second trimester (Panel B), positive shocks continue to improve cognitive abilities, though the effect is slightly smaller, reflecting ongoing volumetric brain growth. For individuals who experienced a negative shock in the first trimester (e.g., during Ramadan), subsequent exposure to a positive shock (e.g., Eid-ul-Adha) may help offset earlier negative effects. In the third trimester (Panel C), positive shocks generally do not show significant impacts, except for urban literacy, suggesting that late-pregnancy exposures provide fewer cognitive benefits, though they may still partially mitigate prior negative shocks.

Our main empirical analysis—comparing the first-trimester exposed group with the control group—is presented in Table 2. The results show a positive and significant impact of the nutritional shock on cognitive ability, including mathematical skills and literacy competency. These findings align with the existing literature, which suggests that both positive and negative in-utero shocks can influence later-life outcomes Grossman et al. (2025); Alloush and Riaz (2025); Wilde et al. (2017); Almond (2006). In the gender-based analysis, we observe a significant improvement for both males and females relative to the control group. However, when comparing within gender, we find that females benefit slightly more than their male counterparts. Gender discrimination exists everywhere, and Pakistan is no exception. In the subcontinent, a male child is often viewed as an investment that provides returns when parents become economically inactive. Consequently, boys receive more childcare time, longer breastfeeding, and get more vitamin supplementation Barcellos et al. (2014); Jayachandran and Kuziemko (2011); Basu (1989). In such a male-dominant society, when females receive a positive shock during the in-utero period, it may help improve their brain development and overall health. This may explain why we observe slightly larger effects for females. However,

when we examine a regional comparison, rural areas lead with a positive and significant impact compared to urban areas. It might be because most animals are slaughtered in rural areas, as most of the people go back to their hometowns to celebrate the Eid festival. Therefore, we observe most meat distribution in rural areas. Apart from local sacrifice, international organizations are also focusing more on rural areas, as these are the areas where most economically deprived people live Muslim Hands (2025); World News (2021); Muslim Aid (2020).

Pakistan is a Muslim-majority country, with roughly 96% of the population identifying as Muslim, primarily divided into Sunnis (76%) and Shias (19%) (Izady, 2000). We leverage this variation by including religious composition in our analysis to examine whether living in areas dominated by a specific group affects access to positive nutritional shocks. This religious composition shapes access to nutritional resources, such as Qurbani meat (sacrificial activity). Sunni-majority areas may benefit from better-organized local charitable networks that facilitate collective slaughter and distribution, as most charitable organizations are Sunni and located in Sunni-majority areas, whereas Shia households often rely on individual Qurbani due to doctrinal differences and trust issues in cross-community collaborations Limodio (2022), resulting in comparatively smaller meat distribution. Consequently, the distribution of nutritional resources is systematically skewed toward Sunni-majority areas, which may lead to greater cognitive and developmental effects among children residing in those areas. Apart from religious composition, we also consider variation in local livestock production to assess its effect on nutritional access. We assume that in areas with higher production, lower prices encourage more households to participate in Qurbani, increasing the overall amount of meat distributed. This, in turn, allows poorer households to access more meat from these communal distributions, which may improve children's cognitive outcomes, including problem-solving and literacy skills. Our empirical results confirm this mechanism, showing that districts with higher animal production exhibit better cognitive performance among children.

Furthermore, in Pakistan, livestock production largely depends on natural grazing because many households cannot afford to purchase commercial feed. Natural grazing, in turn, is heavily influenced by rainfall. In years with higher rainfall, pasture availability increases, encouraging more households to engage in livestock farming. Additionally, animals have

access to more food, leading to higher weight and better productivity. To capture this mechanism empirically, I constructed a yearly measure of the share of high-production districts that experienced rainfall above one standard deviation. I then classified years into top and bottom quantiles based on this share to examine how variations in rainfall affect livestock supply. Ultimately, changes in livestock supply influence household affordability and market prices, which may have downstream effects on child outcomes, such as cognitive ability. The results reported in Table 9 indicate that in years when most high-production districts receive above-average rainfall, cognitive ability improves, likely due to increased livestock supply and lower prices making animal products more accessible. Conversely, in years when high-production districts experience below-average rainfall, the impact on cognitive ability is muted, reflecting constrained livestock production and limited market supply.

To ensure the robustness of our analysis, we conduct conduct robustness check. To establish causality, we conduct a placebo test to examine differences between a fake treated group and the control group. The placebo test confirms that there is no significant difference between the fake-treated and control groups, providing additional support for the causal interpretation of our results.

2 Background

2.1 Importance of Nutrients, Balanced Diet, and Nutritional Status

Parental nutrition during pregnancy directly shapes children's health and development Faa et al. (2024). A substantial body of medical literature highlights the importance of a balanced diet during pregnancy. Among these studies, Mou et al. (2024) recommends, among other dietary components, a weekly intake of 375 grams of meat for pregnant women. However, the benefits of nutritional intake are not uniform across the three trimesters. While the entire pregnancy period demands rich maternal nutrient stores, the early stage is particularly critical: brain development occurs at its most rapid volumetric growth during the first trimester DeLong (1993). Consistent with this, Mahmassani et al. (2022) finds a strong relationship between maternal diet during pregnancy and children's cognitive and behavioral outcomes.

More broadly, Almond and Currie (2011) documents that later-life differences in test scores, educational attainment, income, and health trace back to conditions experienced during pregnancy. These findings are further supported by a wider medical literature reaching similar conclusions (Na et al., 2023; Vancamp et al., 2024).

In developing countries like Pakistan, where a large portion of the population lives below the poverty line (World Bank, 2024; Asian Development Bank, 2025), meeting the required nutritional intake during pregnancy is often difficult (Asim et al., 2022; Naz et al., 2025). Women in these settings already face serious nutrition-related challenges, which become even more acute during pregnancy, when adequate nutrition is needed not only to maintain maternal health but also to support the optimal growth and development of the child. Detailed data on dietary intake patterns during pregnancy in Pakistan are scarce. However, UNICEF, in collaboration with Aga Khan University, has conducted three large-scale surveys covering both pregnant and non-pregnant women of reproductive age. The most recent wave, conducted in 2018, interviewed approximately 30,000 pregnant women and provided valuable insights into the nature and severity of nutritional deficiencies in this population. Figure 15 illustrates these deficiencies among women of reproductive age (15–49 years). The picture is particularly concerning: 18.2% of women experienced iron deficiency in 2018, a level that was even higher in 2001. Beyond iron deficiency, anaemia, zinc deficiency, and vitamin B12 deficiency follow alarming patterns, especially among pregnant women, as shown in Table 11. These deficiencies are closely linked to inadequate meat consumption, and under such conditions, improved access to meat during pregnancy has the potential to meaningfully alleviate these micronutrient shortfalls.

2.2 Eid al-Adha, Animal Sacrifice, and Improved Nutritional Access

Muslims celebrate two major religious festivals each year: Eid-ul-Fitr and Eid-ul-Adha. Eid-ul-Fitr marks the end of the month of Ramadan, during which Muslims observe daily fasting. Approximately seventy days after Eid-ul-Fitr, Muslims celebrate Eid-ul-Adha, which has a distinct religious and social significance. Unlike Eid-ul-Fitr, Eid-ul-Adha involves the ritual slaughter of livestock as a religious obligation for those who can afford it. The meat from the

sacrificed animal is then distributed within the community. According to Islamic teachings, the meat is traditionally divided into three parts: one for the household, one for relatives and friends, and one for the poor and needy. This practice is rooted in the Qur'an, which states: "So eat of them and feed the needy and the poor" (Qur'an 22:28). In practice, many households distribute a large share—or even all—of the meat to disadvantaged groups, recognizing that poorer households often consume meat only during this occasion and viewing wider distribution as a source of greater religious merit.

During Eid-ul-Adha, a significant number of animals are slaughtered every year. In Pakistan, there is no precise official annual slaughter count. However, as per the last livestock survey conducted in 2006, the total annual slaughter count was approximately 22.66 million animals (PBS, 2006). In 2023, 6.1 million animals were slaughtered during the 7-day Eid window (News, 2023), rising to 6.8 million in 2024 (Ali, 2024) and 7.4 million in 2025 GNN News (2025); Khan (2026). Based on the 2006 annual slaughter figures, these Eid-window counts represent 26%, 30%, and 32% of total annual slaughtering for 2023, 2024, and 2025, respectively. Even if the true percentage is lower due to growth in overall annual slaughter from rising population demand, these figures still represent a remarkably concentrated nutritional event.

The scale of this redistribution is striking. The 7.4 million animals slaughtered in 2025 yielded approximately 532,000 tonnes of edible meat, distributed across the country within three days (Khan, 2026). To put this in perspective, total spending on sacrificial animals and related activities in 2025 was estimated at Rs641 billion—equivalent to roughly 60 percent of Pakistan's entire federal development budget for that year (Khan, 2026). This redistribution occurs without any government coordination or subsidy, driven entirely by religious obligation. As Khan (2026) notes, Eid-ul-Adha is effectively Pakistan's largest annual food redistribution event, delivering protein to communities that formal social protection programmes rarely reach at a comparable scale.

3 Date and Methodology

3.1 Data

For our analysis, we use data from three sources: the Pakistan Social and Living Standards Measurement Survey (PSLM), the Oxford Policy Management (OPM) Survey, and 10th grade examination data from the Board of Intermediate and Secondary Education (BISE) Malakand and the Board of Intermediate and Secondary Education (BISE) D.I. Khan for 2024–2025. For cognitive ability and education outcomes, we specifically rely on data from the Pakistan Social and Living Standards Measurement Survey (PSLM), the country's largest ongoing household survey, conducted by the Pakistan Bureau of Statistics (PBS).[3] The PSLM survey is nationally representative and covers all four provinces of Pakistan, as well as the Islamabad Capital Territory. It began in 2004 under the PSDP-funded project and was renamed PSLM in 2015.

The second-to-last available round of the survey is from 2014–2015, referred to here as the 2014 wave. This wave collected information from approximately 80,000 households at both provincial and district levels, with interviews conducted from late 2014 to early 2015. The most recent round of PSLM, conducted in 2019-2020, represents a significant expansion of the survey, with interviews carried out primarily in 2020. This 2020 wave included 195,000 households, more than double the number from the 2014 wave. Although this is a rich data source, we could not preserve the total number of observations for our analysis, as it is based on complete birth records. Observations with incomplete birth records were therefore excluded from the data. Furthermore, for our analysis, we use six available district-level waves, with 2007 being the first and 2020 the last, as no updated waves are available on the Pakistan Bureau of Statistics website.

To study health outcomes, especially child weight, we use the OPM 2011 dataset, which includes complete birth date information. MICS and DHS datasets for Pakistan exist but do not provide full birth dates, so we rely on OPM to get useful health insights. This dataset

[3] https://www.pbs.gov.pk/ The Pakistan Bureau of Statistics (PBS) is the national organization responsible for collecting, analyzing, and disseminating official statistics in Pakistan. Established to provide accurate and reliable data, PBS supports evidence-based policy-making and research across economic, social, and demographic sectors. The bureau conducts censuses and surveys, ensuring transparency and data integrity. The timing of data collection varies; some waves are conducted annually, while others may take four to five years. Before 2015, the survey was a PSDP-funded project initiated in 2004.

is unique, used by few researchers, and offers detailed information on child health and consumption. However, it is not publicly available. Furthermore, for Eid-ul-Adha, we digitized the date by aligning the Islamic calendar with the Gregorian calendar. Muslims follow the lunar calendar to celebrate religious events, and since the lunar calendar is shorter than the Gregorian calendar, the date of Eid-ul-Adha shifts approximately 11 days earlier each year. To ensure accuracy, we carefully compared multiple Islamic event websites and, after thorough consideration, converted the Islamic dates into Gregorian dates for use in our analysis.

Methodology

This paper follows the basic identification strategy presented in (Majid (2015). Impact of meat shock during the pregnancy is inferred by comparing the outcomes for the children whose mother's pregnancy overlapped with the Eid-ul-Adha date to the children whose mother's pregnancy did not overlap with Eid-ul-Adha. Almond (2006) & Majid (2015), focus on the Ramadan shock in pregnancy on different outcomes variables. Although, we are working on the shock which is opposite to the Ramdan and different outcome variables but still this foundation is helpful in developing the our study.

3.2 Cohort Analysis

The cohort analysis exploits exposure to Eid-ul-Adha as a treatment for individuals aged 10–18 years, using PSLM data to examine cognitive and educational outcomes. The treated individuals were exposed to this positive nutritional shock early in utero, during pregnancy, when the potential benefits are likely to be the greatest. In contrast, those who were never exposed or were exposed at a later stage of pregnancy are expected to perform worse in terms of cognitive ability and educational outcomes.

The simplest specification of our econometric model is as follows:

$$Y_{idt} = \alpha_0 + \beta_1 \text{exposure} + X'_{idt}\delta + \alpha_d + \gamma_m + \sigma_t + \varepsilon_{idt}$$

Y_{idt} represents various outcome variables related to health, education, and cognitive abil-

ity. α_0 denotes the intercept, while β_1 measures the impact of the shock on the outcome variables. The variable *exposure* is a dummy variable equal to 1 if the Eid-ul-Adha date falls within the pregnancy period; otherwise, it equals 0. $X'_{idt}\delta$ includes the age, age^2 and sex of the child, as well as the social and educational status of their parents, used as control variables in the analysis. Finally, ε_{idt} represents the error term.

3.3 Fixed-Effects Analysis

The fixed effects analysis includes dummy variables for both birth month and birth year to remove seasonal and temporal variations from the analysis. Additionally, we include district fixed effects to account for unobserved heterogeneity across districts, such as socio-economic or institutional differences. The term α_d represents district fixed effects, while γ_m and σ_t capture birth month and birth year fixed effects, respectively. By including these fixed effects, the model focuses on within-district and within-time variation, helping to isolate the impact of the treatment while reducing potential omitted variable bias.

The exposure variable is categorized into four groups: general exposure (conception to birth), first trimester, second trimester, and third trimester. In the initial stage, we compare individuals whose pregnancy does not overlap with the Eid-ul-Adha date (control) with those in the first, second, and third trimesters to show how these trimesters behave differently. Notably, the second and third trimesters are also exposed to a negative shock (Ramadan) during early pregnancy, whereas the first trimester is only exposed to a positive shock (Eid-ul-Adha) at the early stage of pregnancy. We expect that individuals exposed to the positive shock in the first trimester will perform better than those in the second and third trimesters relative to the control group, as the latter groups are also exposed to a negative shock earlier in pregnancy. Within the second and third trimesters, we anticipate that the second-trimester group may perform better, as they experience the positive shock during a critical developmental period immediately after the first-trimester shock, which could offset the negative effects. In contrast, individuals exposed to the negative shock in the second trimester and the positive shock in the third trimester—the final stage of pregnancy—may not benefit as much, and their outcomes may not surpass those of the control group. Therefore, in the next stage, we fo-

cus on the first-trimester group for our main analysis, as it represents a clearly treated group exposed only to the positive shock at an early stage.

Our control group consists of individuals who were never exposed to the positive shock during their entire pregnancy. However, some of these individuals may have been exposed to the negative shock (Ramadan), but such exposure likely occurred in the later stage of pregnancy, which may not have had a strong effect, as discussed above. Among the available options, this control group is the most suitable for examining the causal impact of a positive nutritional shock on various outcome variables. Similar to the control group, not all—but the majority—of individuals in the treated group (first-trimester exposure) are also exposed to the negative shock at a later stage of pregnancy, and a few are even exposed to the negative shock during the first trimester. To strengthen the causal interpretation, we first compare the first, second, and third trimesters separately with the pure control group. Second, we employ alternative control groups, including those exposed during the second and third trimesters. We expect that individuals exposed to the negative shock (Ramadan) in the second trimester receive the positive shock in the third trimester, which is relatively less effective. If this holds, individuals exposed to the positive shock in the first trimester (treated group) should perform significantly better than those exposed in the second or third trimesters, as the third-trimester group does not benefit much from the positive shock.

4 Results and discussion

This section discusses the empirical results. First, we present the baseline findings from Tables 1 to 3. Second, one plausible mechanism or channel result is laid out in Table 4 and elaborated more in Table 5. Finally, a number of heterogeneity checks, long run outcome variables results, as well as placebo test findings are discussed in Table 6 onward.

4.1 Baseline results

Table 1 presents the overall and heterogeneous impacts of in-utero nutritional shock on two important cognitive skills: mathematical skills (solving) and literacy competency (writing and

reading). Panel A compares first-trimester exposure with the pure control group, while Panels B and C conduct the same analysis for second- and third-trimester exposure, respectively. Panel A, Column 1, Rows 1 & 2 indicate that children exposed to the positive shock during the first trimester performed better in both problem-solving ability and literacy. Specifically, the estimates reveal that their mathematical solving ability is 1.4 percentage points better with the literacy competency improved by 2.2 percentage points, measured when they are between 10 and 18 years old compared to their counterparts. These translate to around a 1.6-2.6 percentage increase relative to the sample mean. Even if modest in magnitude, these effects stem from a few weeks of better nutritional exposure during early pregnancy (first trimester), a crucial period for fetal brain development (Glewwe and King, 2001), implying non-trivial human capital returns at the aggregate level. In addition, the effects are stronger in rural regions (Table 1, Panel B) with math skills enhancing by 2.00 pp and literacy skills improving by 2.2 pp. This finding is in line with a priori expectation that the expected treatment intensity is likely to be greater in the rural places (than urban regions) due to higher economic deprivation. It could also be driven by the fact that most animals are slaughtered in rural areas, since a large proportion of people go back to their rural hometowns to celebrate the Eid festival. Thus, we observe most meat distribution in rural areas. Apart from local sacrifice, international organizations are also focusing more on rural areas, as these are the areas where most economically deprived people live Muslim Hands (2025); Muslim Aid (2020).

On the contrary, the estimated treatment effects are slightly less for in-utero exposure in the second trimester. This pattern aligns with established neuro-developmental theory, which posits that the first trimester constitutes a non-substitutable critical period for foundational brain architecture. The muted positive finding in the second trimester suggests that timely nutritional intervention during this stage also falls within the critical time period for effective intervention, a finding supported by the neuro developmental literature DeLong (1993). The benefits observed in this cohort suggest that timely support during the second critical period helps mitigate the effect of prior nutritional deficits.

Finally, for the third trimester, there is no statistically significant effect for the overall sample and the rural sample with the urban region showing only muted support for literacy

competency. This suggests that intervention at this later gestational stage — which is dominated by myelination and brain growth rather than early cellular formation — is too late to induce the measurable, significant positive effects observed in the earlier trimesters.

The small effect in the second trimester and no significant finding in the third trimester is expected due to partial overlap with a potential Ramadan-based negative nutritional shock as highlighted in Campante and Yanagizawa-Drott (2015).

Table 1: Impact of in-Utero Exposure to the Nutritional Shock on Cognitive Ability

	First Trimester		**Second Trimester**		**Third Trimester**	
	Math	Literacy	Math	Literacy	Math	Literacy
Panel A: Overall						
Treated	0.014***	0.022***	0.013**	0.018**	0.006	0.008
	(0.005)	(0.005)	(0.006)	(0.006)	(0.005)	(0.004)
Mean	0.881	0.855	0.869	0.837	0.856	0.825
Observations	34,956	34,956	32,895	32,895	35,750	35,750
Panel B: Rural						
Treated	0.020***	0.022***	0.018**	0.020**	0.009	0.008
	(0.007)	(0.008)	(0.009)	(0.009)	(0.007)	(0.007)
Mean	0.839	0.805	0.820	0.781	0.809	0.770
Observations	20,110	20,110	19,274	19,274	21,338	21,338
Panel C: Urban						
Treated	0.002	0.018**	0.007	0.016**	0.001	0.012**
	(0.007)	(0.008)	(0.007)	(0.008)	(0.006)	(0.005)
Mean	0.939	0.923	0.937	0.917	0.927	0.907
Observations	14,846	14,846	13,621	13,621	14,412	14,412

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. Standard errors are reported in parentheses. All specifications include district fixed effects, birth year fixed effects, and birth month fixed effects. The models additionally control for child characteristics (gender, age, and age squared) and parental characteristics, including income, employment status, and education.

Table 2: Gender Differential: Impact of in-Utero Exposure to the Nutritional Shock on Cognitive Ability

	First Trimester		Second Trimester		Third Trimester	
	Math	Literacy	Math	Literacy	Math	Literacy
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Overall						
Treated	0.014***	0.022***	0.013**	0.018***	0.006	0.008
	(0.005)	(0.007)	(0.007)	(0.006)	(0.005)	(0.004)
Mean	0.881	0.855	0.869	0.837	0.856	0.825
Observations	34,956	34,956	32,895	32,895	35,750	35,750
Panel B: Male						
Treated	0.015**	0.021***	0.006	0.013	0.004	0.010
	(0.007)	(0.006)	0.007	0.007	(0.005)	(0.005)
Mean	0.907	0.804	0.894	0.869	0.887	0.861
Observations	19,335	19,335	18,150	18,150	19,763	19,763
Panel C: Female						
Treated	0.014	0.024***	0.022**	0.028***	0.010	0.011
	(0.007)	(0.009)	(0.010)	(0.010)	(0.008)	(0.006)
Mean	0.850	0.819	0.837	0.798	0.818	0.781
Observations	15,621	15,621	14,745	14,745	15,987	15,987

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. Standard errors are clustered at the district level and reported in parentheses. All specifications include district fixed effects, birth year fixed effects, and birth month fixed effects. The models additionally control for child characteristics (gender, age, and age squared) and parental characteristics, including income, employment status, and education.

Table 2 presents the empirical estimates, separated by males and females to shed light on possible gender differentials of the treatment effect. Panel A presents the overall effect as was the case in Table 1 above. Panel B shows the estimates for males and Panel C presents the results for females. Disaggregating by gender, the analysis reveals very similar gains for both boys and girls with the estimated effects hovering between 1.5 pp and 2.4 pp, among the purely treated cohorts (first trimester). Relative to sample mean, this translates around 1.7 to 3.0 pp increase for males and females, respectively. The relative equality in the effects on gender stems from the fact that there is no differential investment in fetal health owing

to any son-preference based decision making, and rather the meat consumption for religious adherence works well for both genders in our context. This is particularly important for a male-dominated society where cultural norms and policy actions often distribute resources unequally based on gender and ethnicity. Regarding the gender-based comparison, we see more impact in females highlighting the effect of gender discrimination, which is typically more pronounced in rural settings. The extant literature confirms the gender discrimination Neumark et al. (1996); Kuhn and Shen (2013). In a male-dominated society, mothers carrying female fetuses may receive less investment in maternal nutrition during normal periods. When the female child's conception date overlaps with a positive, exogenous nutritional shock, the female fetus benefits disproportionately from this temporary increase in nutrient availability, resulting in a statistically larger treatment effect relative to males or the control group. This outcome suggests the positive shock effectively mitigates the severe nutritional disadvantage historically faced by female fetouses. The finding is in deference to the recent evidence about gender stereotypes based on religion Becker et al. (2025).

Table 3: The Cognitive Impact of Eid-ul-Adha Exposure: A Religious Sect Perspective.

	First Trimester		Second Trimester		Third Trimester	
	Math	Literacy	Math	Literacy	Math	Literacy
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Above Median Sunni Share Division						
Treated	0.033***	0.030***	0.027	0.016	0.015	0.014
	(0.006)	(0.004)	(0.016)	(0.011)	(0.010)	(0.007)
Mean	0.813	0.784	0.802	0.765	0.786	0.752
Observations	13,839	16,212	14,297	14,297	16,212	16,212
Panel B: Below Median Sunni Share Division						
Treated	0.002	0.016***	-0.0001	0.013	0.001	0.008
	(0.004)	(0.004)	(0.004)	(0.007)	(0.005)	(0.005)
Mean	0.930	0.904	0.925	0.897	0.887	0.861
Observations	19,109	19,109	16,717	16,717	17,751	17,751

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. Standard errors are clustered at the division level and reported in parentheses. All specifications include division fixed effects, birth year fixed effects, and birth month fixed effects. The models additionally control for child characteristics (gender, age, and age squared) and parental characteristics, including income, employment status, and education.

In Table 3, we exploit whether religious fault lines show differential treatment effects as they could impact the treatment intensity directly. Indeed, we find that children in above-median Sunni population share districts show a 4% increase in cognitive outcomes, whereas, for below-median Sunni districts, the improvement hovers under 2%. This could be attributed to the following.

In Muslim-majority Pakistan, the total population is primarily divided into two principal religious groups: Sunnism (roughly 76.3%) and Shi'ism (estimated at 19.1%) Izady (2000). This demographic reality systematically affects the distribution of positive nutritional shocks, such as meat from sacrificial activity (Qurbani). In Qurbani, participation in collective slaughter requires "collaboration", which is often difficult for the Shia group due to doctrinal differences concerning animal selection, slaughter timing, and underlying trust issues. As they only donate or trust in organizations that share the same beliefs Limodio (2022), this effectively forces more Shia households toward individual Qurbani, which generally results in a

smaller amount of distributed meat. Furthermore, since the country is Sunni-majority, the local charitable organizations that coordinate Qurbani and subsequent meat distribution are predominantly Sunni-based and operate in Sunni-majority areas. When international organizations distribute nutritional aid, they rely on these established local Sunni networks, which concentrates the positive nutritional shock primarily in Sunni-majority areas. Based on these differences in collaboration feasibility and the structural bias in distribution networks, we expect that individuals residing in Sunni-majority areas receive a higher dose of the nutritional shock and consequently experience greater beneficial effects on their cognitive outcomes.

4.2 Mechanism

Table 4: Impact of in-Utero Exposure on Cognitive Ability: Supply Side Meat Production Channel

	First Trimester		Second Trimester		Third Trimester	
	Math	Literacy	Math	Literacy	Math	Literacy
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Above Median Animal Production Districts						
Treated	0.017***	0.024***	0.014**	0.022**	0.006	0.011
	(0.005)	(0.006)	(0.006)	(0.008)	(0.006)	(0.006)
Mean	0.854	0.830	0.838	0.814	0.825	0.801
Observations	21,336	21,336	20,546	20,546	22,532	22,532
Panel B: Below Median Animal Production Districts						
Treated	0.010	0.018**	0.011	0.010	0.007	0.006
	(0.010)	(0.009)	(0.012)	(0.010)	(0.009)	(0.007)
Mean	0.927	0.890	0.921	0.875	0.951	0.866
Observations	11,634	11,634	10,529	10,529	11,156	11,156

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. Standard errors are clustered at the district level and reported in parentheses. All specifications include district fixed effects, birth year fixed effects, and birth month fixed effects. The models additionally control for child characteristics (gender, age, and age squared) and parental characteristics, including income, employment status, and education.

Table 4 lays out one possible mechanism or channel that harps on the supply side of meat production. The estimates reveal that districts with above-median livestock production have

significantly higher cognitive improvement of around 2-3%, whereas, the effects for below-median production districts are statistically indistinguishable from zero. This pattern seems consistent with economics of local meat markets elaborated below.

In Pakistan, certain districts are renowned for livestock farming Agriculture Census, (2006). Thus, individuals place of stay would matter in terms of getting access to free meat during Eid-ul-Adha. In high-production or above-median areas, animal prices may be lower compared to areas where production is less or below-median. Consequently, higher supply areas make it easier for people to buy more animals, leading to increased sacrificial slaughtering during this window. However, in low-production areas, where most of the supply is sourced from elsewhere, purchasing animals is often more difficult. Given this structure, we anticipate a greater cognitive impact in high-production districts, since individuals have access to more meat compared to low-production areas where a lower number of slaughtered animals results in less meat for distribution. Table 4 illustrates the cognitive differences based on districts categorized as being below or above-median livestock production. The left side of the table presents the results for districts above-median, while the right side shows the comparison for people located in districts below-median animal production. In the above-median case, we observe a positive and significant impact on both mathematical skills and literacy competency for the treated group. However, in the below-median production districts, the effect, although positive, shows no significant difference between the treated and control groups. Note that the effect magnitudes are quite comparable to the estimates from Table 1.

Now focusing on one important factor affecting the supply side, Table 9 (MAYBE WE SHOULD PLACE THIS TABLE AS TABLE 5 HERE?) in the appendix presents estimates with high rain exposure (top quintile) and low rain exposure (bottom quintile) in the above-median or high livestock production districts. The estimates reveal that within high livestock production districts, the effects are more in years when rainfall is in the top quintile with mathematics skills improving by around 2.8% of sample mean and the literacy performance enhancing by around 3%. This could be attributed to conditions that increase pasture availability, improve livestock weight and enhance aggregate meat supply in these districts. On the other hand, the

low rain exposure does not improve the literacy skills at all and the effect on mathematics skill improved is muted. It is important to note that in this instance, even the pure control group experiences the same rainfall exposure shocks, providing additional solace that it is driven my the meat production or availability channel, and not the increased rainfall exposure, driving these findings.

4.3 Heterogeneity results

Tables 5, 7, 8, 6, and provide estimates from a number of heterogeneity checks looking at (i) overall enrollment and labor market outcomes (Table 5), (ii) completion and marks of the 10th Grade (Table 6), (iii) differential impact based on incomes earned (Table 7) and (iv) birth weight and height (Table 8). The findings from these checks are discussed below.

Table 5 provides results from overall enrollment and labor market outcomes attributed to the meat consumption shock during Eid-ul-Adha. In a sense, these findings reveal long run implications of the in-utero exposure of the treatment effect. The table lists effect on overall enrollment, employment and monthly working days, respectively for pure treatment (first trimester) and other cohorts (second and third trimesters).

The enrollment focuses on individuals aged between 10 and 18 years. The sample for employment and monthly working days includes individuals aged 18-49 years. Enrollment estimates use all available survey waves; whereas, employment-related outcomes are restricted to waves from 2013 onward to maintain compatibility with the monthly frequencies of working days reported from 2013 onward. A quick look at the estimates reveal that enrollment increases by 2.75% relative to the sample mean for the pure treatment group. The biggest gain is attributed to employment with a 14.13% improvement in comparison to sample mean for the pure treatment cohort. Similarly, the monthly working days also increase by 2.54% relative to the sample mean. Taking a look at the second and third trimesters results, the only sustained improvement is coming from enrollment with no statistically significant impact for employment markers. These findings show that the improvement in cognitive ability translates well into human capital formation with increased years of school enrollments. From the employment and monthly working days perspective, there is significant improvement for

the pure treated cohort with large increase in employment as well monthly working days. Hence, the positive exposure to meat consumption shock in the first trimester in-utero leads to long run improvement in employment skills and opportunities also. This finding resonates with Hanushek and Woessmann (2008). The long run implications are in line with Baker et al. (2024) as in this instance we show that there is a positive long run effect on human capital formation due to a religious adherence and norm, and that too, in a developing country like Pakistan.

Table 5: Impact of in-Utero Exposure to the Nutritional Shock: Enrollment and Labor Market Outcomes

	First Trimester			Second Trimester			Third Trimester		
	Enrolment	Employment	MWD	Enrolment	Employment	MWD	Enrolment	Employment	MWD
Treated	0.020***	0.013***	0.381***	0.024***	0.006	0.201	0.019***	-0.004	-0.147
	(0.006)	(0.005)	(0.134)	(0.006)	(0.005)	(0.125)	(0.005)	(0.003)	(0.085)
Mean	0.726	0.092	15.0	0.715	0.081	15.0	0.698	0.084	15.1
Observations	35,070	71,543	71,084	32,985	66,896	66,475	35,856	67,794	67,384

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. Standard errors are clustered at the district level and are reported in parentheses. All models include district fixed effects, birth year fixed effects, and controls for household income and parental education. The sample for enrollment includes individuals aged 10–18 years, while the sample for employment and monthly working days includes individuals aged 18–49 years. Enrollment estimates use all available waves; however, employment-related outcomes are restricted to waves from 2013 onward due to differences in survey design. Prior to 2013, employment was measured over a one-week reference period, whereas from 2013 onward it is based on a one-month reference period, ensuring comparability. Individuals who report not working are assigned zero working days. However, a small number of individuals report being employed but do not provide information on working days; these observations are retained as missing in the working days variable. MWD = Monthly Working Days.

One logical extension of the above enrollment finding would be to analyze if the religious feasting during Eid-ul-Adha has any bearing on the 10th grade marks and completion. Finishing 10th grade gives a good indication of secondary school education and provides the basic pathway to the entry level job market (mostly informal or semi-formal jobs), especially in rural areas. Table 6 sheds light on the 10th grade completion in terms of marks and fail rate. Given the improvement in child cognitive ability and enrollment listed before, we would expect a surge in 10th grade marks for the treated groups. In a similar vein, there would be a significant drop on the fail rates as well for the pure treatment group. The estimates show overwhelming support to our conjectures. The marks improve by around 0.6% in comparison

to sample mean for the pure treatment group. Similarly, fail rate decreased by around 8.65% relative to the sample mean for the pure treatment group. Note that for the other trimesters, these effects remain muted. Thus exposure to the treatment really makes positive improvement for the 10th grade marks and the passing rate.

In Table 7, results are presented for differential impact based on incomes earned. As discussed previously in the baseline and mechanism sections, poor and rural regions, generally, tend to have more meat supply and hence probably gain more cognitive skills enhancement in comparison to other regions.

To provide a finer nuance, we conduct a disaggregated analysis by income level. Here, the respondents are categorized into three groups: zero income, below the median income, and above the median income. A challenge arose because some individuals did not report their income. It is difficult to determine whether these people had no earnings in the last month or simply chose not to report their income. Thus, to maintain clean sample selection, we excluded individuals who did not report their income in the survey and then proceeded with the below- and above-median analysis. We hypothesize that individuals below the median income are the actual beneficiaries of the nutritional shock. This is because these individuals are more sensitive to shocks Banerjee and Duflo (2007); Townsend (1994). The empirical analysis yielded the exact expected situation: there is positive and statistically significant impact on the cognitive abilities of individuals just below the median income with the estimates showing 3.86% improvement in mathematics skills relative to the sample mean and 3.7% improvement in literacy skills in comparison to sample mean. In contrast, there is essentially no statistically significant difference among individuals who are above-median level. This is a very important finding in the sense the low income individuals are gaining more due to the religious feasting. and hence any public policy to complement such improvement could be better targeted to below-median income individuals.

Given the child cognitive development is driven by the pure treatment group of first trimester in-utero exposure, one immediate indicator of health improvement could also be tied to such positive shock. These findings are laid out in Table 8 and discussed below.

When children experience a positive nutritional shock in-utero, the most immediate indicator of improvement is typically their birth weight. However, obtaining such detailed information in a developing country settings is challenging, which limits our ability to conduct a fully detailed analysis. Despite this constraint, we were able to access administrative data collected for the evaluation of Pakistan's poverty-alleviation program, the Oxford Policy Management Survey, 2011. Although birth weight for all age cohorts are not not available, the dataset provides information on the weight of children aged between one month and one year. This allows us to present suggestive, anecdotal evidence on early health outcomes that could serve as a good identifiers for interpreting our cognitive-ability findings. Table 8 reports the differences between treated and control group children in terms of both weight and height. Our primary focus is on weight, as it is more directly linked to prenatal nutrition, whereas height could be influenced by several postnatal factors. The estimates show a positive and statistically significant increase in weight among children exposed to the positive in-utero shock in the first trimester. There is around 0.04% increase in birth weight relative to sample mean in the first trimester with the effects in other trimesters showing negative signs. This evidence supports the notion that positive exposure in the first trimester remains crucial for healthy birth weight, which in turn could have contributed to improved brain and cognitive development. Hence, improved birth weight could also be treated as a plausible channel or mechanism for enhancing cognitive ability attributed to the Eid-ul-Adha meat intake. The finding resonates with Attanasio, Meghir and Nix (2020) which also reports the finding from a developing country, India.

4.4 Placebo test

In Table 11, we present results from a placebo test to prove the robustness of our analysis. Here, the original treated group is replaced with a fake treated group from the control by generating a falsified Eid-ul-Adha date with shifting the actual Eid date forward by 45 days. Table 10 The estimates reveal that there is no significant difference between the fake treated and control groups. The finding confirms that our main analysis reveals the causal impact of

the religious feasting during Eid-ul-Adha.

5 Conclusion

We provide causal evidence that the religious ritual of Eid-ul-Adha would lead to better child cognitive development as there is positive nutritional shock from meat consumption during first trimester of in-utero exposure. The results show that adherence to this religious norm is positively affecting birth weight outcomes as well as long run outcomes in terms of more school enrollments, higher 10th grade marks, employment improvement and increasing monthly workdays. Importantly, this positive religious shock works as a great equalizer for gender differential with girls literacy skills improvement outshining those from the boys. We provide a supply side mechanism explanation to explain our findings with more animal production districts driving the baseline findings. This is complemented by a nuanced ethnicity perspective where we present results that majority Sunni population based places would have more meat availability and consumption based on kinship and distribution networks in comparison to minority Shia places.

Exploiting novel datasets like the Oxford Policy Management Survey of 2011, and complementing this with rich information from the Pakistan Social and Living Standards Measurement Survey and National Nutrition Survey, we present our findings for Pakistan, a developing country with the second largest Muslim population in the world. Given many vagaries associated with a poor developing country setting in terms of its institutional and political frictions, our results show a refreshing perspective that a simple, in-grained religious ritual like Eid-ul-Adha, could lead to a positive improvement in child cognitive development when focusing at the in-utero meat consumption during the first trimester. MORE TO BE ADDED LATER.

References

Ali, M. F. (2024). The economy of sacrificed animals. Technical report, Pakistan Institute of Development Economics. Accessed: 2024.

Alloush, M. and Riaz, S. W. (2025). The health effects of in utero exposure to cash transfers. *Journal of Human Resources*.

Almond, D. (2006). Is the 1918 influenza pandemic over? long-term effects of in utero influenza exposure in the post-1940 us population. *Journal of political Economy*, 114(4):672–712.

Almond, D. and Currie, J. (2011). Killing me softly: The fetal origins hypothesis. *Journal of economic perspectives*, 25(3):153–172.

Asian Development Bank (2025). Poverty data: Pakistan. Asian Development Bank. Accessed: 2025.

Asim, M., Ahmed, Z. H., Nichols, A. R., Rickman, R., Neiterman, E., Mahmood, A., and Widen, E. M. (2022). What stops us from eating: a qualitative investigation of dietary barriers during pregnancy in punjab, pakistan. *Public health nutrition*, 25(3):760–769.

Aydilek, G. and Karaoğlan, D. (2024). The effect of prenatal exposure to ramadan on human capital: evidence from turkey. *Journal of Population Economics*, 37(3):65.

Banerjee, A. V. and Duflo, E. (2007). The economic lives of the poor. *Journal of economic perspectives*, 21(1):141–167.

Barcellos, S. H., Carvalho, L. S., and Lleras-Muney, A. (2014). Child gender and parental investments in india: Are boys and girls treated differently? *American Economic Journal: Applied Economics*, 6(1):157–189.

Barker, D. J. (1995). Fetal origins of coronary heart disease. *Bmj*, 311(6998):171–174.

Barro, R. J. and McCleary, R. M. (2003). Religion and economic growth across countries. *American sociological review*, 68(5):760–781.

Basu, A. M. (1989). Is discrimination in food really necessary for explaining sex differentials in childhood mortality? *Population studies*, 43(2):193–210.

Becker, S. O., Bentzen, J. S., and Kok, C. C. (2025). Gender and religion: a survey. *Journal of Demographic Economics*, pages 1–42.

Becker, S. O., Rubin, J., and Woessmann, L. (2024). Religion and growth. *Journal of Economic Literature*, 62(3):1094–1142.

Bolt, U. (2025). Cognitive skills beyond childhood. *The Economic Journal*, page ueaf107.

Campante, F. and Yanagizawa-Drott, D. (2015). Does religion affect economic growth and happiness? evidence from ramadan. *The Quarterly Journal of Economics*, 130(2):615–658.

Clingingsmith, D., Khwaja, A. I., and Kremer, M. (2009). Estimating the impact of the hajj: religion and tolerance in islam's global gathering. *The Quarterly Journal of Economics*, 124(3):1133–1170.

DeLong, G. R. (1993). Effects of nutrition on brain development in humans. *The American journal of clinical nutrition*, 57(2):286S–290S.

Doyle, O., Harmon, C. P., Heckman, J. J., and Tremblay, R. E. (2009). Investing in early human development: timing and economic efficiency. *Economics & Human Biology*, 7(1):1–6.

Faa, G., Fanos, V., Manchia, M., Van Eyken, P., Suri, J. S., and Saba, L. (2024). The fascinating theory of fetal programming of adult diseases: A review of the fundamentals of the barker hypothesis. *Journal of Public Health Research*, 13(1):22799036241226817.

Glewwe, P. and King, E. M. (2001). The impact of early childhood nutritional status on cognitive development: Does the timing of malnutrition matter? *The world bank economic review*, 15(1):81–113.

GNN News (2025). Total animals sacrificed on Eid-ul-Adha in Pakistan revealed. GNN News. Accessed: 2025.

Grossman, D., Khalil, U., and Panza, L. (2025). The intergenerational health effects of forced displacement: Japanese american incarceration during wwii. *Journal of Public Economics*, 242:105308.

Hanushek, E. A. and Woessmann, L. (2008). The role of cognitive skills in economic development. *Journal of economic literature*, 46(3):607–668.

Iyer, S. (2016). The new economics of religion. *Journal of Economic Literature*, 54(2):395–441.

Izady, M. (2000). Maps and statistics collection - gulf/2000 - columbia university. Technical report, Columbia University.

Jayachandran, S. and Kuziemko, I. (2011). Why do mothers breastfeed girls less than boys? evidence and implications for child health in india. *The Quarterly journal of economics*, 126(3):1485–1538.

Khan, A. H. (2026). The economics of Pakistan's Eidul Azha. *Dawn*. Published in Dawn, EOS, May 24, 2026.

Kuhn, P. and Shen, K. (2013). Gender discrimination in job ads: Evidence from china. *The Quarterly Journal of Economics*, 128(1):287–336.

Limodio, N. (2022). Terrorism financing, recruitment, and attacks. *Econometrica*, 90(4):1711–1742.

Mahmassani, H. A., Switkowski, K. M., Scott, T. M., Johnson, E. J., Rifas-Shiman, S. L., Oken, E., and Jacques, P. F. (2022). Maternal diet quality during pregnancy and child cognition and behavior in a us cohort. *The American Journal of Clinical Nutrition*, 115(1):128–141.

Majid, M. F. (2015). The persistent effects of in utero nutrition shocks over the life cycle: Evidence from ramadan fasting. *Journal of Development Economics*, 117:48–57.

Mou, Y., Jansen, P. W., Sun, H., White, T., and Voortman, T. (2024). Diet quality during pregnancy, adolescent brain morphology, and cognitive performance in a population-based cohort. *The American Journal of Clinical Nutrition*, 120(5):1125–1133.

Muslim Aid (2020). Pakistan qurbani programme 2020.

Muslim Hands (2025). Where your qurbani went: A global breakdown of impact in 2025.

Muslim Hands United Kingdom (2021). Qurbani 2021: You reached 900,000 people this year! ma sha allah!

Na, X., Glasier, C. M., Andres, A., and Ou, X. (2023). Maternal diet quality during pregnancy is associated with neonatal brain white matter development. *Nutrients*, 15(24):5114.

Naz, L., Ali, A., Yasmin, S., and Trueha, K. (2025). Geospatial inequalities in women's malnutrition in pakistan. *BMC Women's Health*, 25(1):225.

Neumark, D., Bank, R. J., and Van Nort, K. D. (1996). Sex discrimination in restaurant hiring: An audit study. *The Quarterly journal of economics*, 111(3):915–941.

News, A. (2023). Total animals sacrificied. Technical report, Arab News.

Prado, E. L. and Dewey, K. G. (2014). Nutrition and brain development in early life. *Nutrition reviews*, 72(4):267–284.

Townsend, R. M. (1994). Risk and insurance in village india. *Econometrica: journal of the Econometric Society*, pages 539–591.

UNICEF (2018). National nutritional survey, pakistan. *UNICEF*.

Vancamp, P., Frapin, M., Parnet, P., and Amarger, V. (2024). Unraveling the molecular mechanisms of the neurodevelopmental consequences of fetal protein deficiency: insights from rodent models and public health implications. *Biological Psychiatry Global Open Science*, 4(5):100339.

Wilde, J., Apouey, B. H., and Jung, T. (2017). The effect of ambient temperature shocks during conception and early pregnancy on later life outcomes. *European Economic Review*, 97:87–107.

World Bank (2024). Poverty headcount ratio at national poverty lines: Pakistan. World Bank Open Data. Accessed: 2024.

World Food Programme (2018). Population growth, inflation and food insecurity in pakistan.

World News (2021). Charity to offer qurbani to over 750,000 beneficiaries around the world, including conflict and disaster zones.

Table 6: Impact of in-Utero Exposure to the Nutritional Shock: Completion of 10th Grade Marks

	First Trimester		**Second Trimester**		**Third Trimester**	
	Marks	Fail	Marks	Fail	Marks	Fail
Treat	5.340**	-0.008**	5.510	-0.008**	0.012	-0.006
	(2.360)	(0.004)	(3.620)	(0.004)	(2.240)	(0.004)
Mean	854.038	0.092	856.738	0.077	858.351	0.072
Observations	20,203	22,451	32,618	35,589	52,418	56,862

Note: ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. Standard errors are reported in parentheses and are clustered at the school level. All regressions include school and exam year fixed effects and control for date of birth.

Table 7: Impact of in-Utero Exposure on Cognitive Ability: Income heterogeneity

	First Trimester		Second Trimester		Third Trimester	
	Math	Literacy	Math	Literacy	Math	Literacy
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Above Median Income Districts						
Exposure	0.005	0.014**	0.007	0.020**	0.009	0.016**
	(0.007)	(0.006)	(0.008)	(0.009)	(0.007)	(0.007)
Mean	0.917	0.902	0.913	0.892	0.906	0.889
Observations	14,112	14,112	13,034	13,034	13,941	13,941
Panel B: Below Median Income Districts						
Treat	0.034***	0.031***	0.022**	0.012	0.013	-0.002
	(0.009)	(0.010)	(0.011)	(0.012)	(0.010)	(0.008)
Mean	0.879	0.839	0.858	0.816	0.844	0.801
Observations	12,420	12,420	11,725	11,725	12,786	12,786

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. Standard errors are clustered at the district level and reported in parentheses. All specifications include district fixed effects, birth year fixed effects, and birth month fixed effects. The models additionally control for child characteristics (gender and age) and parental characteristics.

Table 8: Impact of In Utero Exposure to the Nutritional Shock on Cognitive Ability

	First Trimester		**Second Trimester**		**Third Trimester**	
	Weight	Height	Weight	Height	Weight	Height
Treated	0.342***	0.071	-0.000000447***	-0.000000209**	-0.244***	-0.066***
	(0.082)	(0.036)	(0.0000000621)	(0.0000000943)	(0.076)	(0.018)
Observations	956	956	713	713	886	886

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. Standard errors are clustered at the district level and are reported in parentheses. The models include district fixed effects, birth year fixed effects, and control for household income.

Table 9: Impact of in-Utero Exposure on Cognitive Ability: Rainfall exposure

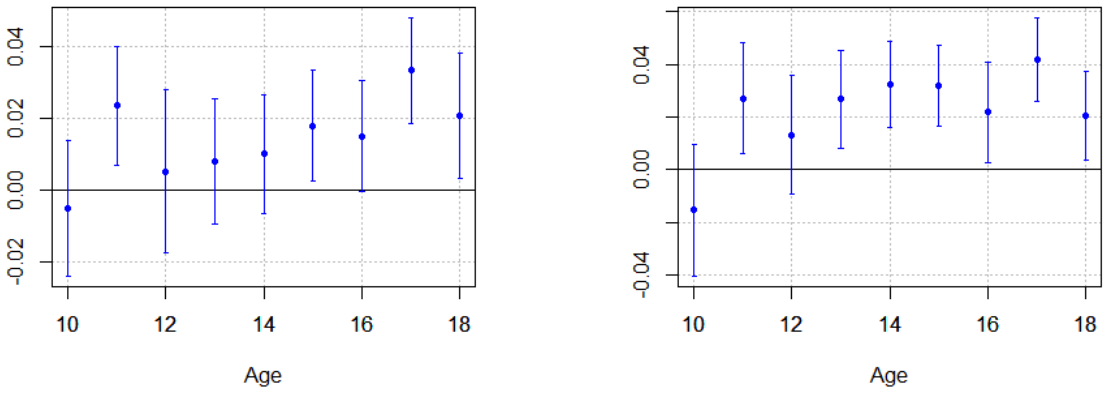
	First Trimester		Second Trimester		Third Trimester	
	Math	Literacy	Math	Literacy	Math	Literacy
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: High Rain Exposure (Top Quantile)						
Treat	0.024**	0.025***	0.015	0.010	-0.004	-0.003
	(0.007)	(0.006)	(0.009)	(0.008)	(0.014)	(0.014)
Mean	0.868	0.851	0.862	0.839	0.853	0.833
Observations	15,652	15,652	14,594	14,594	9,561	9,561
Panel B: Low Rain Exposure (Bottom Quantile)						
Treat	0.018**	0.016	0.016**	0.020**	0.011	0.014
	(0.007)	(0.008)	(0.005)	(0.007)	(0.010)	(0.011)
Mean	0.870	0.835	0.863	0.827	0.858	0.823
Observations	23,047	23,047	22,518	22,518	14,242	14,242

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. Standard errors are clustered at the district level and reported in parentheses. This table compares cohorts based on in utero exposure to rainfall variation in high-production districts. The measure is constructed as the annual share of such districts with rainfall above one standard deviation and divided into quantiles, with the top quantile compared to the bottom quantile. As restricting to the top and bottom quantiles reduces the number of years and sample size, third trimester observations are included in the control group for first and second trimester specifications. For third trimester specifications, only the pure control group is used, as first and second trimester exposures are more strongly treated and therefore cannot be included as controls..

Table 10: Placebo test: Impact of in-Utero Exposure on Cognitive Ability

	Overall		**Rural**		**Urban**	
	Treat	Obs.	Treat	Obs.	Treat	Obs.
Mathematical Skills	−0.004	14,770	−0.002	9,436	−0.007	5,334
	(0.005)		(0.005)		(0.009)	
Literacy Competency	−0.009	14,792	−0.008	9,450	−0.012	5,342
	(0.005)		(0.007)		(0.073)	
Covariates	✓	-	✓	-	✓	-
District FE	✓	-	✓	-	✓	-
Time FE	✓	-	✓	-	✓	-

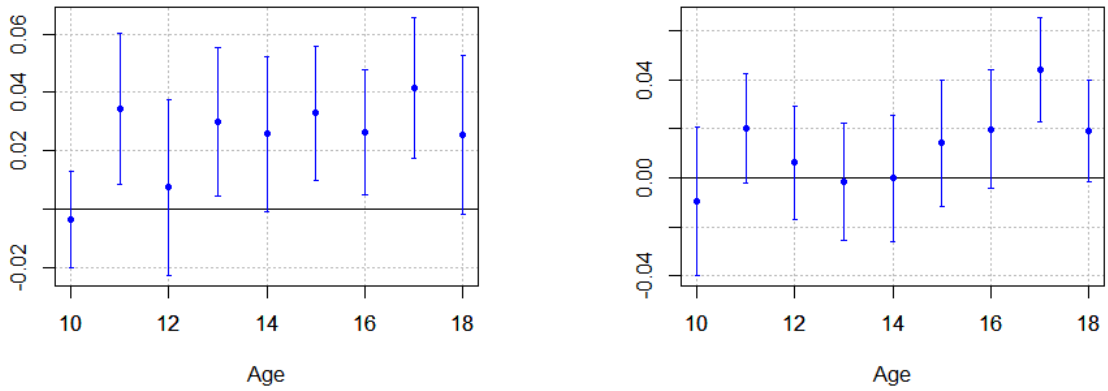
Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. This table estimates the impact of in utero exposure on cognitive ability by creating a placebo-treated group, shifting the original Eid date forward by 45 days. Controls include age, gender, parents' employment and income, and fixed effects for year and district. The results indicate no significant differences between treated and control groups.



(a) Math Ability

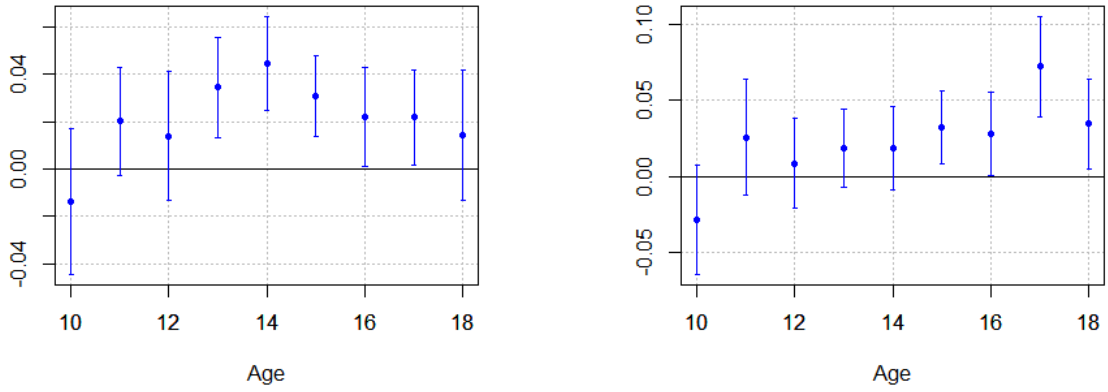
(b) Literacy Ability

Figure 2: Math and Literacy Ability (ages 10-18)



(a) Male (b) Female

Figure 3: Gender-based Math Ability (ages 10–18)



(a) Male (b) Female

Figure 4: Gender-based Literacy Ability (ages 10–18)

[H]

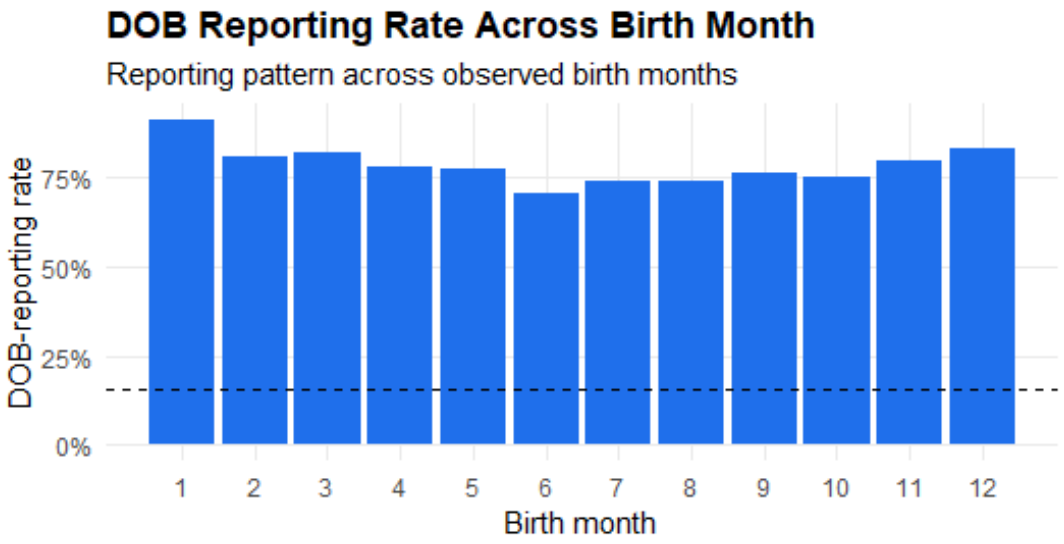


Figure 5: Reporting Pattern Across Different Months

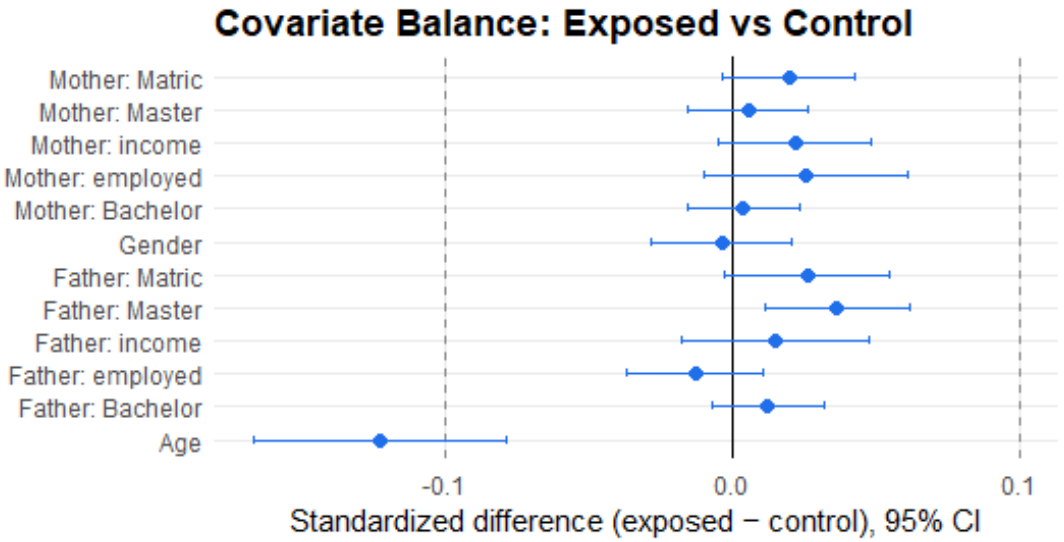


Figure 6: Reporting Pattern Across Different Months

Table 11: Micronutrient Deficiencies (Women of Reproductive Age 15–49 Years)

Micronutrient	Non-Pregnant	Pregnant	Overall
Anaemia	43.0%	35.5%	42.6%
Iron deficiency	33.6%	46.9%	34.3%
Iron deficiency anaemia	18.0%	21.2%	18.2%
Zinc deficiency	21.1%	37.5%	22.1%
Vitamin B12 deficiency	19.51%	32.3%	20.3%

Notes: Data are taken from the *National Nutritional Survey (NNS) 2018.*

Table 12: Manski Bounds on the First-Trimester Eid-ul-Adha Exposure Effect

	Literacy	Numeracy
Reporter estimate (FE)	+0.020	+0.014
Worst-case (assumption-free)	[−0.898, +0.939]	[−0.813, +0.887]
MTR + MTS combined	[0.000, +0.020]	[0.000, +0.014]

Notes: Exposure (first-trimester overlap with Eid-ul-Adha) is defined only for respondents reporting a complete date of birth; the outcome is observed for all. Assumption-free worst-case bounds (Manski, 1990) are uninformative at this coverage, as expected. Under monotone treatment response (MTR, effect ≥ 0) and monotone treatment selection (MTS), the effect is bounded between zero and the reporter point estimate, ruling out any adverse effect. Reporter estimates are the fixed-effects coefficients from Table 1 (district, birth-year, and birth-month fixed effects; standard errors clustered by district).

A Extra

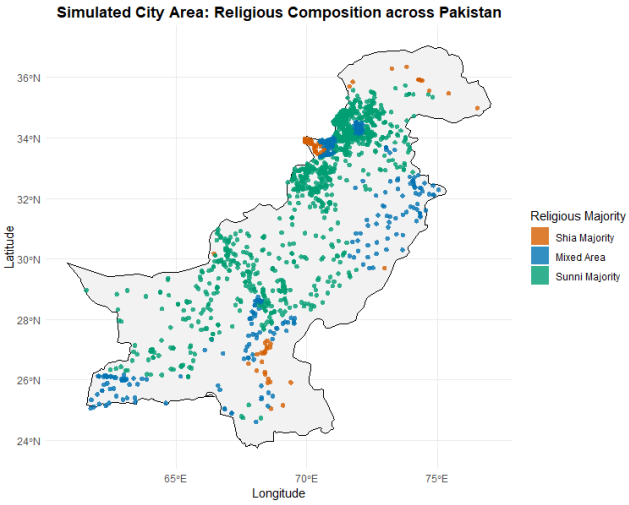


Figure 7: Sunni vs Shia

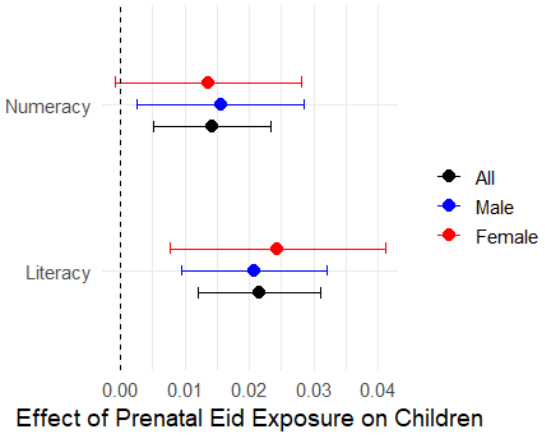
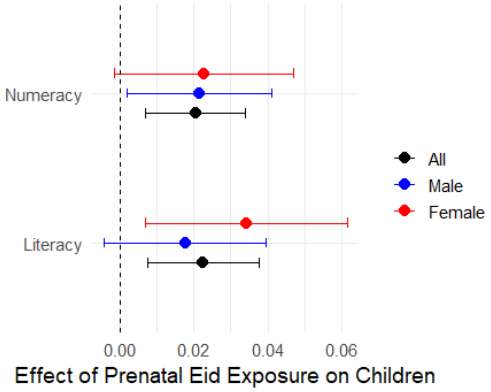
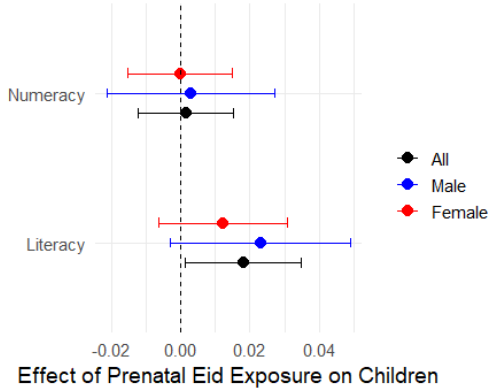


Figure 8: All



(a) Rural



(b) Urban

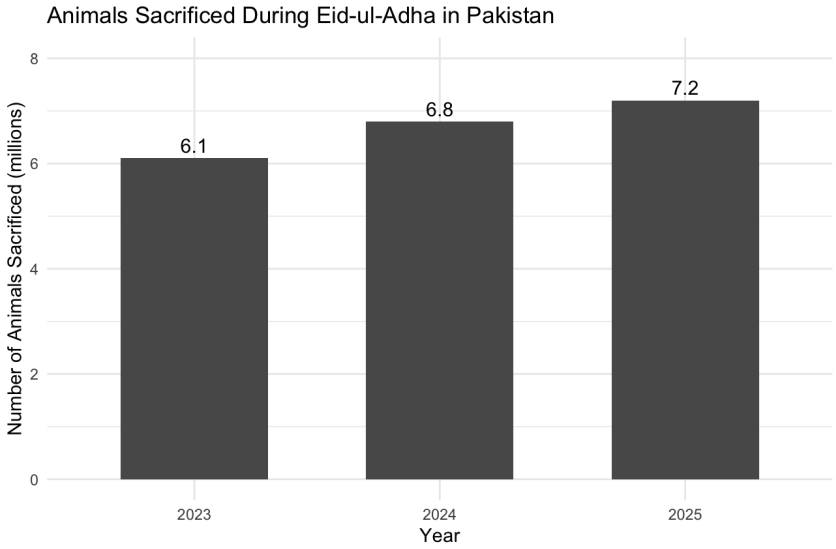
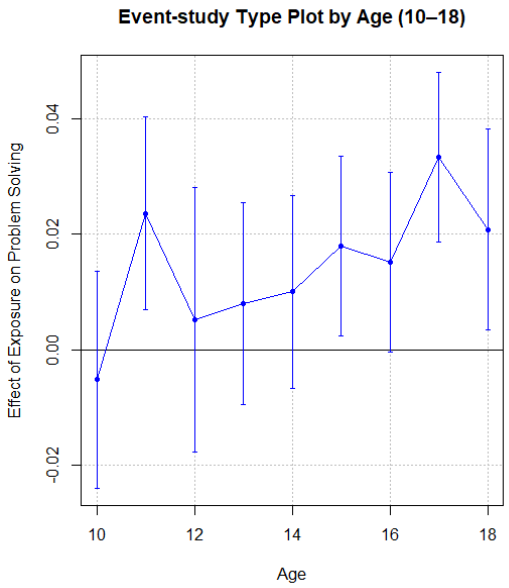
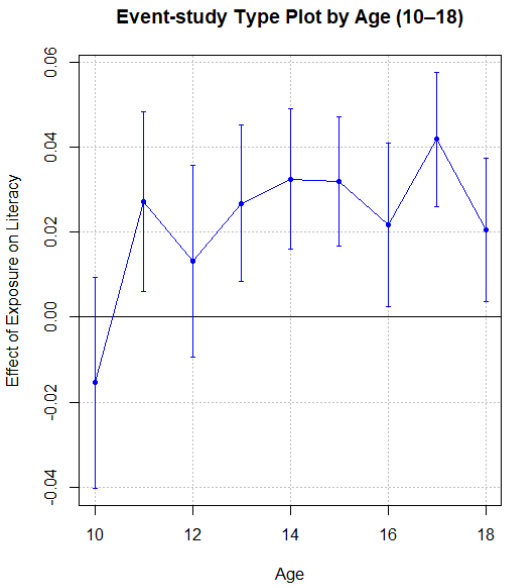


Figure 17: Total Animals Sacrificed During Eid-ul-Adha

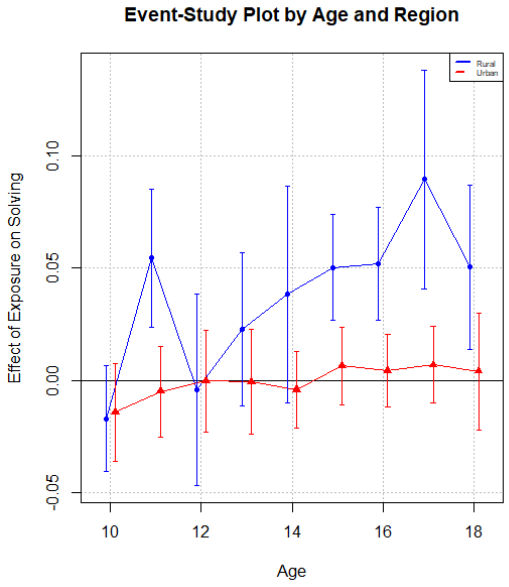
Notes: Data are national-level estimates compiled from reports by the Pakistan Tanners Association and media sources. Figures are shown in millions and are intended for descriptive purposes only.



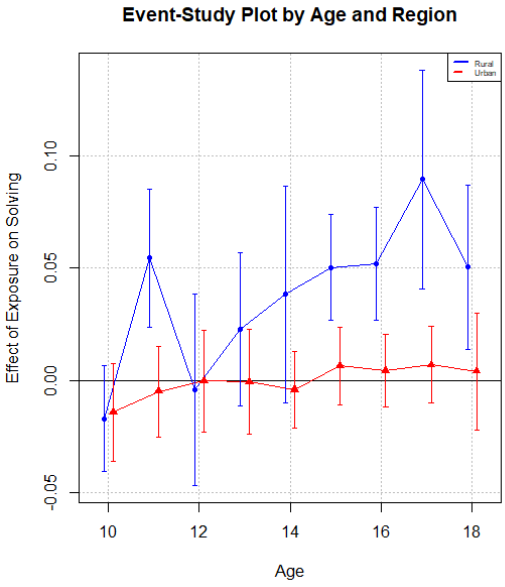
(a) Overall Numeracy



(b) Overall Literacy

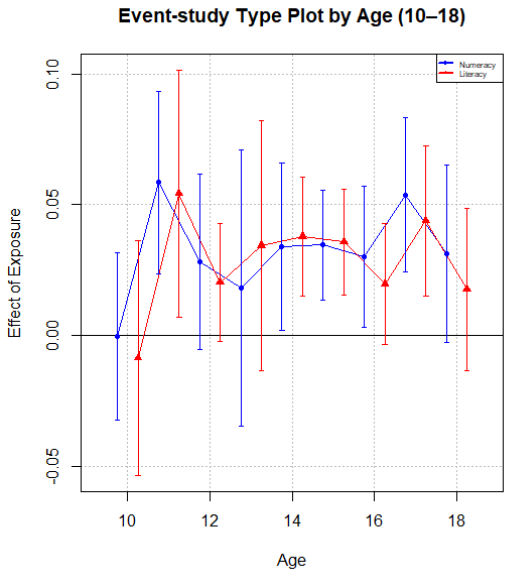


(c) Region-based Numeracy

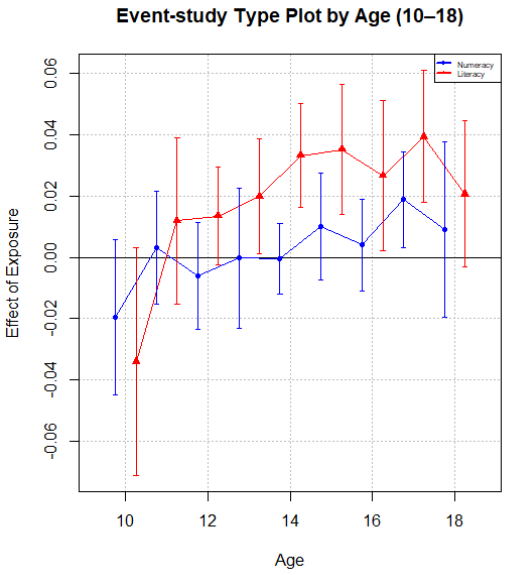


(d) Region-based Literacy

Figure 10: Event-study plots for overall and region-based cognitive outcomes.

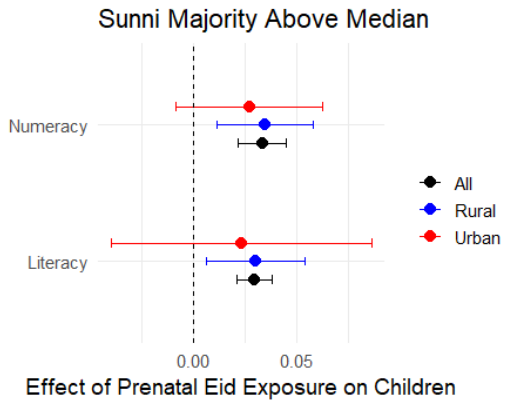


(a) Above Median Sunni Share



(b) Below Median Sunni Share

Figure 11: Event-study plots by Shia share: above and below the median.



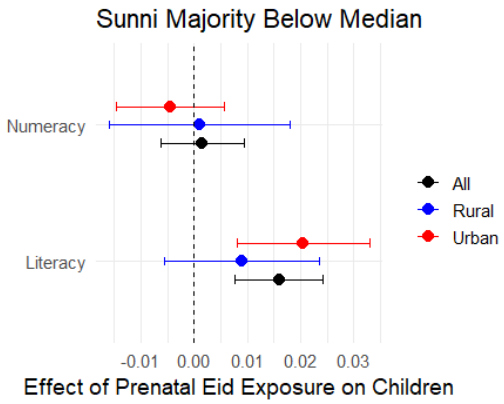
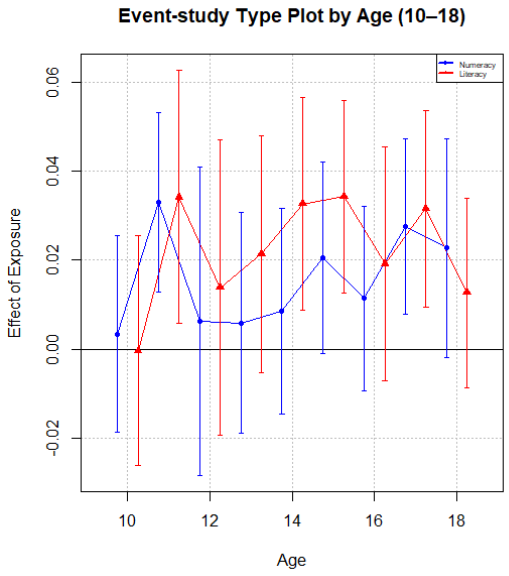
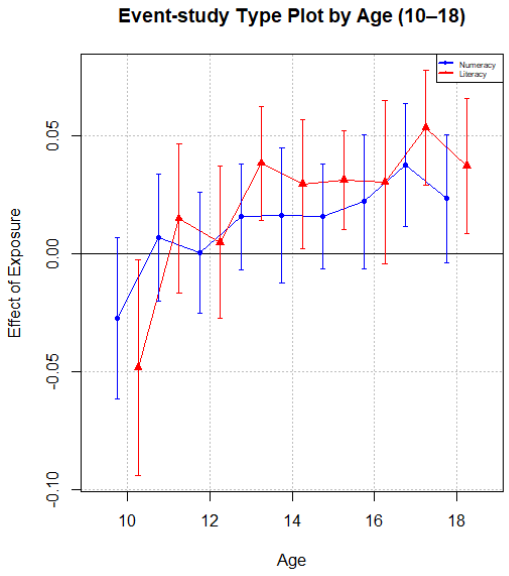


Figure 12: Graphical Representation of Empirical Results

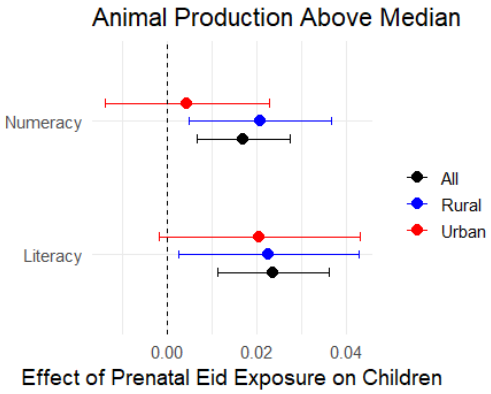


(a) Above Median Animal Production Districts



(b) Below Median Animal Production Districts

Figure 13: Event-study plots by Animal Production: above and below the median.



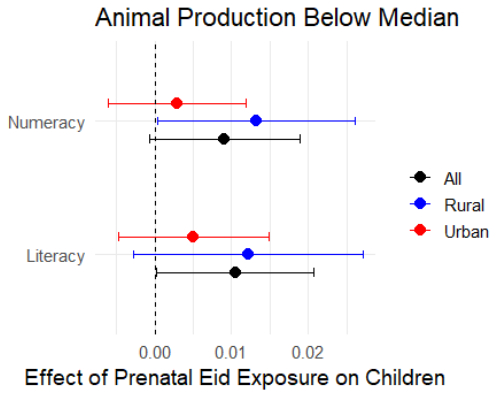


Figure 14: Graphical Representation of Empirical Results

Table 13: Impact of In Utero Exposure to the Nutritional Shock on Cognitive Ability

	First Trimester		**Second Trimester**		**Third Trimester**	
	Marks	Fail	Marks	Fail	Marks	Fail
Treat	5.340**	-0.008**	5.510	-0.008*	0.012	-0.006
	(2.360)	(0.004)	(3.620)	(0.004)	(2.240)	(0.004)
Mean	854.038	0.092	856.738	0.077	858.351	0.072
Observations	20,203	22,451	32,618	35,589	52,418	56,862

Note: ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. Standard errors are reported in parentheses and are clustered at the school level. All regressions include school and exam year fixed effects and control for date of birth.

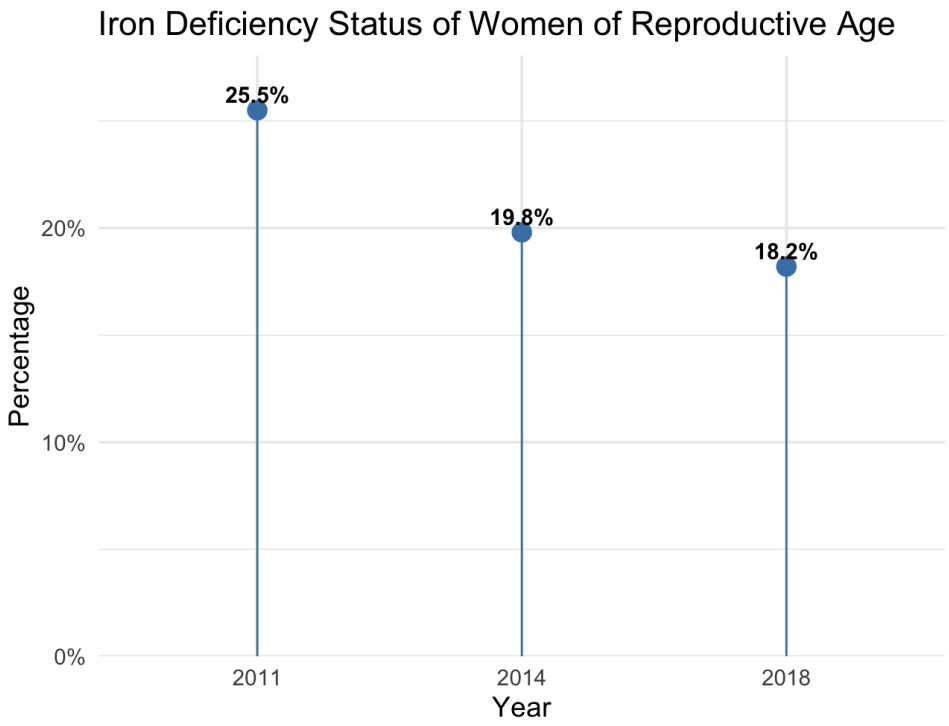


Figure 15: Iron Deficiency Status

Table 14: Impact of In Utero Exposure on Cognitive Ability Using a Sibling Fixed-Effect Approach

	Overall		**Rural**		**Urban**	
	Treat	Mean	Treat	Mean	Treat	Mean
Mathematical Skills	0.005	0.938	0.011**	0.829	−0.003	0.938
	(0.003)		(0.005)		(0.005)	
Literacy Competency	0.008**	0.918	0.016***	0.797	−0.001	0.918
	(0.003)		(0.005)		(0.004)	
Observations	34,191		19,661		14,530	
Year FE	✓		✓		✓	
Birth Month FE	✓		✓		✓	
Household FE	✓		✓		✓	
Age & Gender	✓		✓		✓	

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The table reports treatment effects (Treat) and sample sizes (Obs.) for Problem Solving and Literacy Competency under Below Median Income, separated into Overall, Rural, and Urban sub-samples. Controls include age and gender. District and year fixed effects are included, and standard errors are clustered at the district level.

Nusrat Bibi and her family were so thankful to receive your Qurbani to enjoy over Eid. Nusrat is a widowed mother of three living in a deprived rural village next to the city of Sahiwal. She works as a seamstress and earns less than £1 a day, barely enough to put food on the table. She says, 'I try my best to earn enough for my house but there is not enough work, and we rely on Allah (swt)'.



Nusrat added, 'During this COVID time, I could not afford to buy any meat, but alhamdulillah, after a long time we have cooked beef and my children are very excited to eat it. The smile on the faces of my kids is all I ever wished for and I am grateful to Muslim Hands for bringing happiness to their lives'.

Figure 16: Meat Consumption Situation

Table 15: Placebo: Impact of In Utero Exposure on 10th-Grade Completion

	Exposed		**First Exposed**		**Second Exposed**		**Third Exposed**	
	Treat	Obs.	Treat	Obs.	Treat	Obs.	Treat	Obs.
10th-Grade Completion	3.31	91,939	5.01***	19,919	5.89***	32,070	−0.13	51,380
	(1.94)		(1.87)		(2.33)		(1.82)	
DOB	✓	-	✓	-	✓	-	✓	-
School FE	✓	-	✓	-	✓	-	✓	-
District FE	✓	-	✓	-	✓	-	✓	-
Exam Year FE	✓	-	✓	-	✓	-	✓	-

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. This table reports estimates of the impact of in utero exposure on 10th-grade completion across different exposure timings. Controls include date of birth and fixed effects for exam year, school, and district of the examination board. The empirical results show a positive overall effect, although it is not statistically significant. However, when the analysis is disaggregated by trimester of exposure, first- and second-trimester exposure exhibit positive and statistically significant effects, while no significant impact is observed for third-trimester exposure.

Table 16: Impact of In Utero Exposure to the Nutritional Shock on Cognitive Ability

	Marks	A+ Grade	A Grade	B Grade	C Grade
Panel A: First Trimester					
Treated	5.01***	0.008	0.007	0.024**	0.027**
	(1.87)	(0.006)	(0.008)	(0.010)	(0.012)
Observations	19,919	19,919	15,136	9,087	3,206
Panel B: Second Trimester					
	5.89*	0.003	0.012	0.023**	0.036***
	(2.33)	(0.006)	(0.008)	(0.010)	(0.013)
Observations	32,070	32,070	24,488	14,570	4,969
Panel C: Third Trimester					
	-0.132	-0.005	-0.006	0.005	0.010
	(1.82)	(0.005)	(0.007)	(0.010)	(0.010)
Observations	51,380	51,380	38,687	23,093	7,935

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. Standard errors are clustered at the school level and are reported in parentheses. The models include district fixed effects, school fixed effects, exam year fixed effects, and control for date of birth.