Parental Response to Fetal Shocks and Macroeconomic Volatility

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Abstract

We examine parental response to a fetal shock using data from 126 Demographic and Health Surveys in 50 developing countries. Focusing on the impact of Ramadan fasting, a common shock experienced by more than a billion Muslims worldwide, we find that children exposed to Ramadan fasting during pregnancy have lower rates of full vaccination for DPT and polio compared to their non-exposed siblings. Further, parents tend to compensate for the fetal shock during booms and reinforce during economic downturns. Our estimations suggest that this has resulted in approximately half a million excess infant deaths over the past three decades.

Keywords: Birth Endowment, Intra Household Resource Allocation, Ramadan.

JEL Classification: I1, J1, O12

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1 Introduction

Human development begins in utero. More than 2000 studies in epidemiology and economics document that the fetal environment is a key predictor of later life disease, cognition and labor market success, suggesting serious long-run consequences of neglect of pregnant women today (Almond and Mazumder, 2011; Almond et al., 2017; Behrman and Rosenzweig, 2004; Crookston et al., 2013; Cunha et al., 2006; Currie and Vogl, 2013; Heckman et al., 2006; Hoddinott et al., 2008a,b; Majid, 2015; Maluccio et al., 2009; Richter et al., 2017). Parental investments can mitigate or exacerbate the impacts of fetal shocks. However, their exists no clear or consistent empirical pattern of parental investments (e.g. Almond and Mazumder (2013)) and the literature has documented evidence of both reinforcing investments (Adhvaryu and Nyshadham, 2016; Hsin, 2012) and as well as compensation (Akee et al., 2015; Breining et al., 2015).[1] It is challenging to reconcile the evidence and the literature does not explain why some parents in some households in some countries reinforce/compensate more than others.

One key challenge is that the fetal shocks and the broader economic conditions are not comparable across these studies. Innate ability and human capital is multi-dimensional, and each shock effects a different dimension of the innate endowment. Parental response to a shock in one dimension of the endowment may vary from another. Similarly, parental response also depends on the economic conditions and that varies across the contexts of these studies. Since these studies are set in varying economic conditions and also do not use a comparable fetal shock, it is not possible to provide an explanation for why we observe both reinforcement and compensatory parental response.

Our research is centered on examining the effects of Ramadan fasting, a comparable shock that is experienced across 50 different countries (126 Demographic and Health Surveys) that has substantial variation in their economic context. We choose Ramadan fasting as our focus due to its widespread practice by more than a billion Muslims across cultures and economic conditions. Studying parental responses across different contexts can be challenging, as finding a comparable exogenous shock that is commonly practiced across countries can be difficult. For instance, country-specific policies like food stamps are not comparable shocks to study parental responses. Additionally, economists have examined rainfall shocks in rural agricultural settings, but

[1] We use the word reinforcement to imply that parents invest less in a child exposed to an adverse fetal shock. Similarly, we use the word compensation to imply that parents invest more in the child exposed to an adverse fetal shock. For a detailed review on parental response see Almond et al. (2017).

their relevance may not extend to urban areas. Famine episodes, while significant, are not regularly occurring and don't offer the opportunity for a consistent comparison of shocks over time. Moreover, famines may have additional income effects that could overshadow the effects of the fetal period, making it harder to discern whether parental responses are primarily driven by the fetal shock or a broader early life shock. In contrast, Ramadan is a milder shock that occurs regularly every year, and fasting is practiced in both rural and urban areas across countries with diverse levels of economic development globally. By studying parental response to a comparable shock experienced by a similar faith community (Muslims) across 50 countries, we aim to provide a pooled estimate of parental response that allows us to draw generalizable conclusions.

A comparable fetal shock also allows us to study the variation in parental investment behaviour in response to broad economic conditions. Old age support is often considered an important motivation for investment in children. If investments are costly, markets are imperfect and there is some complementarity between the initial endowment and parental investments, efficiency concerns dictate that parents will invest less in children suffering from an adverse fetal shock. Thus, parents maximizing their old age support would reinforce motivated by efficiency concerns. At the same time, parents also have altruistic motives and may have a preference for equality between their children. Parents motivated by an inequality aversion between children would compensate. One hypothesis is that if there are diminishing returns to investments in human capital and if altruistic motives and inequality aversion are like normal goods, an improvement in aggregate economic conditions may lead to inequality aversion of parents to dominate the efficiency concerns. We use economic booms and downturns, a common aggregate shock across countries and time to study this hypothesis. We examine how aggregate income conditions influence parental responses and investigate whether parents' reactions differ during good and bad economic times, as well as whether the magnitude of the change in economic condition matters. Since we use a comparable fetal shock, this exercise provides us an explanation of why we may observe both compensation and reinforcement across different times and settings and thus helps us to reconcile the contrasting findings from the literature.

Our research focuses on assessing the completion of routine immunizations for children during their first year of life as our primary outcome. We specifically evaluate the completion of Polio, DPT (diphtheria, pertussis, and tetanus), Bacille Calmette-Guerin (BCG) and Measles vaccinations. Childhood immunizations play a crucial role in saving lives, with an estimated prevention of 2-3 million deaths worldwide each year. This significant impact has contributed to the reduction in the global infant mortality rate from 65 per 1,000 live births in 1990 to 29 in 2018 (Nandi and Shet (2020)). Vaccines are widely recognized as one of the most cost-effective health technologies, providing an estimated return of USD 52 for every USD invested, taking into account the broader social and economic costs avoided through vaccination in low- and middle-income countries (LMICs) (Sim et al., 2020)

Vaccines are an appropriate measure to understand parental responses to fetal shocks, not only because of their known benefits throughout the life but also due to the significant cost burden that they impose on parents in LMICs when providing vaccinations to multiple children. A recent review identified 64 unique barriers that parents face when vaccinating their children (Kaufman et al., 2021) These barriers include time constraints, distance to healthcare facilities, safe transportation, and long waiting times at clinics, among others. Furthermore, achieving complete vaccination for children often requires multiple visits over time, which adds further complexity and challenges for parents. In addition, the suggested dose of vaccines are common across contexts. This allows us to study a common outcome across 50 countries.

Our basic identification strategy involves studying the overlap of Ramadan fasting with pregnancies among Muslim biological siblings as a natural experiment to examine parental response to fetal undernutrition in 50 countries with a Muslim population of 10% or more. Though pregnant women are exempted from fasting, estimates from diverse societies show between 70 to 90 percent of Muslim pregnant women fast during Ramadan (Almond and Mazumder (2011)). Fasting during pregnancy leads to decline in maternal glucose levels, leads to biochemical changes and affects total calorie intake. We build on earlier studies which have shown overlap of pregnancies with Ramadan have long run consequences on birth weight, academic performance, cognitive ability and labour market outcomes (Almond and Mazumder, 2011; Almond et al., 2015; Majid, 2015).

Our approach effectively addresses challenges in assessing the impact of in utero Ramadan exposure, including issues related to seasonality and selective birth timing. Leveraging a pooled dataset spanning 32 birth cohorts across 50 countries, we untangle the effects of prenatal Ramadan overlap from birth season effects. Our dataset covers a complete cycle of the Gregorian calendar (32 years) due to the shifting occurrence of Ramadan on the lunar calendar. To account for country-specific seasonality, we integrate country-month fixed effects. Although limited by the absence of 32 cohorts for all 50 countries, this approach partially addresses seasonality. To counterbalance this limitation, we introduce mother fixed effects. Our model with biological mother fixed effects captures latent factors such as genetics, abilities, and family norms at the maternal level, addressing selective births not only concerning seasons but also

Ramadan. Drawing inspiration from Almond and Mazumder (2011); Almond et al. (2015) , we employ "difference in differences" estimates, eliminating shared seasonal effects experienced by the untreated non-Muslim group and yielding comparable impact estimates. For added robustness, we incorporate controls for child's age, gender, and birth order across all models.

In addition, we investigate variations in parental responses to Ramadan exposure in utero by examining how vaccinations vary with short-term fluctuations in aggregate income during the year of birth. To capture these dynamics, we utilize models that incorporate full interactions between GDP per capita (PPP) and exposure to Ramadan, allowing us to analyze the asymmetric effects of GDP fluctuations, taking into account the magnitude and direction (positive or negative) of deviations from GDP trends within countries over time.

Our study has two main findings. First, we find evidence suggesting that parents do not tend to make compensatory investments in vaccinations, particularly in the case of DPT and Polio vaccines, where we observe strict reinforcing behaviors: children exposed to Ramadan in utero are around 2% and 1.6% less likely to be fully vaccinated for DPT and polio, respectively, compared to their non-exposed siblings. These findings, based on a comprehensive dataset of 126 surveys from 50 countries, provide external validity to the estimates. The results presented in this section are robust to comparisons with non-Muslim populations, clustering approaches, and models that generalise to families with one or more child(ren) per mother.

Second, our study reveals that during economic booms, parents tend to compensate more for their children exposed to Ramadan in utero, while during recessions, they reinforce inequities by conducting fewer vaccinations for these exposed children. The result can be explained by a Separable Earnings Transfer Model, where parents balance between efficiency and inequality aversion. A rise in disposable income leads to inequality aversion dominate the efficiency concerns. (Behrman, 2022; Behrman et al., 1982).

Our paper makes several contributions to the literature. There is no clear or consistent pattern in the literature regarding whether parental investments reinforce or compensate for early life disadvantage (Almond and Mazumder, 2013; Behrman, 2022). Our extensive dataset, spanning 50 countries over three decades and 126 DHS surveys, enhances the generalizability of previous findings regarding parental responses to fetal shocks. Our results indicate that parents reinforce their investments through DPT and polio vaccines, highlighting that the motive of inequality aversion alone is insufficient to counteract the efficiency considerations faced by parents. Consequently, this leads to the reinforcement of inequalities at birth that is very costly to society. We estimate that more than half a million infant deaths in Muslim countries in the last three decades could have been avoided had parents not reinforced inequalities at birth (by vaccinating exposed children, for example). The Polio and DPT vaccine findings are of utmost policy interest in themselves. For Polio, as long as a single child remains infected, children in all countries are at risk of contracting polio. According to the World Health Organization, failure to eradicate polio from these last remaining strongholds could result in as many as 200000 new cases every year worldwide.(, n.d.) Moreover, economic modeling has found that the eradication of polio would save at least US$40-50 billion between 1988 and 2035 (, n.d.).

We are the first to investigate the role of aggregate conditions in shaping parental response to fetal shocks. To achieve this, we explore the multilevel heterogeneity in parental responses across countries based on fluctuations in aggregate income/deviation in GDP per capita PPP from its trends. We utilize spline regression to study the effects of large and smaller, positive and negative deviations in GDP from its trends. Our paper is the first to find that parental investment decisions at birth vary in a procyclical manner. However, there are diminishing returns to additional increases in GDP. Macroeconomic volatility is a prevalent issue in most developing countries. Studies estimate that the standard deviation of income over time has been approximately twice as large in developing countries compared to developed countries (Aguiar and Gopinath, 2007). Furthermore, volatility of economic conditions impose significant welfare costs on developing countries in terms of their inability to smooth consumption (Loayza et al., 2007), and infant health is particularly sensitive to business cycle variations (Baird et al., 2011; Bhalotra, 2010; Dehejia and Lleras-Muney, 2004; Ruhm, 2000). In our paper, we document another way in which aggregate economic fluctuations can have dramatic welfare consequences. In developing countries, infants exposed to adverse fetal health shocks are more likely to experience further reinforcing parental investments at times of negative economic shocks. Conversely, economic booms lead to compensation for the initial fetal shock.

Our paper is also connected to a recent literature that explores the generalizability of internally valid micro-estimates of causal effects over time and the role of aggregate conditions in shaping micro outcomes (e.g., (Adhvaryu et al., 2019; Barreca et al., 2016; Chatterjee and Vogl, 2018; Lu and Vogl, 2023; Rosenzweig and Udry, 2020; Vogl, 2015)). Further, the results of our paper also contributes to our understanding of the mechanisms that shape long term outcomes from fetal shocks. The findings suggest that studies investigating the long-term effects of fetal shocks are influenced not only by physiological/biological effects during pregnancy but also by postnatal investment decisions made by parent.

Finally, our paper also contributes to the better understanding of cultural and religious practices on human capital formation (Campante and Yanagizawa-Drott, 2015; Clingingsmith et al., 2009; Kuran, 2004, 2014; Kuran and Rubin, 2018; Meyersson, 2014). Though, some studies have focused on the effect of Islam on human capital, not much is known about the effect of Islamic cultural practices on parental investments (Ashraf et al., 2016). In the specific context of Ramadan, our research suggests that the long-term effects observed during fetal exposure to Ramadan fasting are not solely attributable to maternal fasting during pregnancy (e.g. (Almond and Mazumder, 2011; Almond et al., 2015; Majid, 2015)). Instead, additional reinforcing behaviors exhibited by parents after birth also contribute to these effects. This finding is significant as it implies that even if individuals are unable to modify fasting behavior during Ramadan due to cultural or other reasons, society can still mitigate the long-term impacts of unhealthy cultural practices in pregnancy. One potential strategy, based on our research, is to enhance public goods, such as greater coverage of vaccines, which can reduce the burden on parents and facilitate vaccination for their exposed children. By implementing policies that support and increase public health resources even after birth, the long-term effects of maternal behaviors during pregnancy, such as Ramadan fasting, can be potentially mitigated.

2 Data

2.1 Demographic Health Surveys

We use data from 126 Demographic Health Surveys (DHSs) from 50 countries and for the main analysis restrict our sample to Muslims only. In some DHS waves, information on religion is missing. For these countries-waves in the DHS (that have individual level data on religion missing) we do the following: If the country has a significantly large proportion of Muslim population (above 90 percent in the census), we include the entire country-wave and treat everybody in that DHS wave as Muslims. If the country has less than 90 percent of the population as Muslims in the census, we exclude that entire country-wave. [2]

[2] The countries used are Albania, Azerbaijan, Bangladesh, Benin, Burkina Faso, Burundi, Cameroon, Central African Republic, Chad, Comoros, Congo, Democratic Republic of Congo, Egypt,Ethiopia, Gabon, Gambia, Ghana, Guinea, Guyana, India, Ivory Coast, Jordan, Kazakhstan, Kenya, Kyrgz Republic, Liberia, Madagascar, Malawi, Maldives, Mali, Morocco, Mozambique, Niger, Nigeria, Pakistan, Phillippines, Rwanda, Senegal, Sierra Leone, Sri Lanka, Sudan, Tajikistan, Tanzania, Thailand, Togo, Tunisia, Turkey, Uganda, Uzbekistan and Yemen.

We use the children's recode file to construct measures of vaccinations and get information on date of birth. Most DHS's do not have exact date of birth and have information only on month of birth and year of birth. Thus we only use month of birth and year of birth information to construct our measure of Ramadan exposure. This may lead to some measurement error in our estimates, leading our estimates to be potentially biased downwards. Since DHS only ask information on vaccination for children younger than five years, we limit our sample to cohorts born five years prior to each survey. We also limit our sample to those who are either fully exposed or not exposed at all to Ramadan in utero, and drop cases with partial exposure. Our results are robust to including these too, but are in some cases more robustly estimated if we limit analysis to those who are either fully exposed to Ramadan or not exposed at all.

2.2 GDP Data

We use World Development Indicators from the World Bank open access data archives to investigate the degree to which aggregate economic factors moderate parental investment response to Ramadan exposure in utero. We primarily use data on indicators for economic development (GDP per capita in adjusted for PPP).

2.3 Ramadan Dates

Following previous work (e..g;. (Majid, 2015)), the start and end dates of Ramadan were taken from `www.phys.uu.nl/vgent/islam/ummalqura.htm`. Only very minor discrepancies in dates were found on other websites. It may also be noted, that, in many areas of the Muslim world, the start and end of Ramadan are determined by moon sightings which may cause small noise in the estimates of this paper.

2.4 Summary statistics

Table A1 presents the summary statistics used in this paper. Complete vaccination (in terms of all doses for BCG, Measles, DPT, and polio vaccines) for all the countries considered averaged 40 percent over the births in our data during the 1986-2017 period, which is rather low. Approximately 55 percent have fully completed the DPT vaccination, 57 percent have completed the polio vaccination, 56 percent have completed the measles vaccination, and 71 percent have completed the BCG vaccination. This suggests that the challenge of vaccine completion is not only about getting children to complete one type of vaccine but getting them vaccinated completely across all types. Figure A1 shows low polynomial smooth plots for all vaccines, by type. There is a trend for increasing vaccination rates over time, though not all vaccines have a similar rate of increase over time. Polio, especially, seems to be rather flat, whereas BCG seems to have had a dip in 1990 and then rose again. One difference between these vaccines is that BCG and the first dose of polio are given as a single dose at birth, while the first dose of polio is typically given separately, which makes it easier to obtain if one gives birth in a facility or through professional healthcare. However, DPT and measles, as well as later doses of polio, are administered after birth and may be more challenging for parents to access making their responses potentially more elastic to fetal shocks. To explore this, we also present results separately by types of vaccines. After dropping the partially exposed, about 90 percent of our sample is exposed to Ramadan in utero after we limit it to those with full or no exposure.

3 Empirical Strategy

3.1 Baseline Model

Our empirical strategy compares parental investment in children born with their in utero period overlapping with Ramadan, with individuals whose in utero period did not overlap with Ramadan. We limit our sample to Muslims only as the effect of Ramadan should only be on them and focus on models that compares biological siblings. In particular we estimate the Equation 1 as follows:

$$Y_{imcst} = \alpha + \beta\ Exposure_{imst} + \gamma\ X_{imst} + \delta_{cs} + \mu_m + \epsilon_{imcst} \tag{1}$$

were, Y_{imcst} is a measure of parental investments in form of basic vaccines in the first year of life in child i, from mother m in country c and born in month s and year t. $Exposure_{imst}$ is a dummy variable which takes the value one if the individual's in utero period fully overlapped with Ramadan and zero if in utero period did not overlap with Ramadan at all. Since we do not have the exact date of birth in our DHS data, we define a child as exposed using the month and year of birth and only using the month and year of Ramadan. We assume an average pregnancy lasts for 9 months and calculate the month of conception using the date of birth. We define a child as exposed if Ramadan both started and ended between and including the conception and birth month. However, if Ramadan started before conception but ended on the month of conception or if Ramadan started on the month of birth and ended the month after, we define them as partial exposure and drop them from our analysis.

X_{imst} includes controls like the age in years of the child and its square (Almond et al. (2015)), gender and birth order. δ_{cs} is the country specific month of birth fixed effect to account for country specific seasonality. μ_m is biological mother fixed effects to account for time invariant mother (and country) specific unobservables like genes, education, innate ability, measurement error, cultural factors etc. Say, if educated women tried to time their birth away from Ramadan or time their births around certain seasons, then our estimates may be driven by selective sample of less educated women. The mother fixed effects will ease any concerns regarding selective births around Ramadan and seasonality in general. We cluster our standard errors at the mother and country x month levels, but we also provide estimates that are not clustered or clustered at the country level for samples with and without sibling fixed effect models in order to test the robustness of our findings.

3.2 Models to study heterogeneous effects by aggregate income

3.2.1 Background and hypothesis

A comparable shock like Ramadan allows us to study the role of broader economic conditions in shaping reinforcing or compensatory parental behaviour. A distinct literature has studied the effect of economic booms and downturns on child health (Baird et al., 2011; Ferreira and Schady, 2009) . We build on this literature and study the change in parental investment response to the Ramadan shock between economic boom and downturns. Economic booms have a direct impact on investments in children. A rise in income leads to more investments in children, the income effect. Yet, as wages rise during economic booms, investments that require parental time become more costly, leading to a reduction in investments in children, the substitution effect. Ferreira and Schady (2009) reviews the evidence and argues that the income effect dominates the substitution effect in poor countries and the substitution effect dominates the income effect in richer countries, thus suggesting that the direct effect of economic fluctuations depend on the absolute level of economic prosperity.

Our hypothesis is that parents are more likely to compensate for the adverse fetal shock during economic booms and are more likely to reinforce at times of economic downturns. Our hypothesis is based on three arguably plausible assumptions. First, we believe as we are mostly focusing on low income countries, the income effect of economic booms are stronger than the substitution effect of economic booms. The implications is that combined parental investments across children is predicted to rise during economic booms (Ferreira and Schady (2009)). Second, we assume that there is diminishing marginal returns to investment in one child. The implication is that, as incomes rise and as parents keep investing more in the child not impacted by an adverse fetal shock, the marginal return diminishes. Third, we assume, that as the absolute level of investment increases, inequality aversion of parents also increase. The implication is that at higher levels of income, the inequality aversion motive dominates the efficiency motive. Our hypothesis also relates to previous literature that suggests that parents display higher levels of inequality aversion when resources are relatively abundant and may compensate for gender inequalities as household wealth increases (Behrman, 1988a,b, 2022; Behrman and Deolalikar, 1990; Behrman et al., 1982; Rosenzweig and Schultz, 1982).

3.2.2 Regressions

To study parental heterogeneity in responses to Ramadan in utero in response by fluctuations in birth year GDP, we build on Equation 1 to estimate Equation 2

$$Y_{imcst} = \alpha + \beta_1 \; Exposure_{imst} + \beta_2 \; Exposure_{imst} * LogGDP_{ct} + \gamma \; X_{imcst} + \delta_{cs} + \mu_m + \epsilon_{imcst} \tag{2}$$

were, Y_{imcst} is a measure of parental investments in form of basic vaccines in the first year of life in child i, from mother m in country c for a child born in a given month s and year t. Our key coefficient of interest is β_2 that measures the interaction of log GDP per capita (PPP) in child's birth year with exposure to Ramadan in utero. A positive value suggests that as GDP increases parents compensate in their exposed child, whereas a negative value would suggest reinforcement with higher GDP. X_{imct} also includes terms for $LogGDP_{ct}$ in birth year, linear, quadratic and cubic time trends based on birth year data.

It is also possible that parental responses to fetal shocks may vary by the magnitude of the GDP shock and, perhaps, the direction (either positive or negative). Past work found that large deviations in terms of GDP (e.g. booms or recessions) have larger effects on infant mortality and that these effects may be asymmetric as well, leading to much worse health outcomes during recessions than in booming times (e.g. Baird et al. (2011)). Furthermore, its possible that marginal increases in (log) GDP lead to different responses by parents in booms/recessions, suggesting that recessions in the past with lower levels of GDP may have different effects compared to recessions with higher levels of GDP. To investigate the relevance of this in our context, we build on Equation 2 to estimate Equation 3 with addition additional interaction terms as follows:

$$\begin{aligned} Y_{imcst} = \alpha + \beta_1 \; Exposure_{imst} + \beta_2 \; Exposure_{imst} * LogGDP_{ct} \\ + \beta_3 \; Exposure_{imst} * LogGDP_{ct} * Knot_{ct} + \beta_4 \; Exposure_{imst} * Knot_{ct} \\ + \beta_5 \; LogGDP_{ct} * Knot_{ct} + \gamma \; X_{imcst} + \delta_{cs} + \mu_m + \epsilon_{imcst} \end{aligned} \tag{3}$$

where $Knot_{ct}$ as a dummy (in sequential spline regressions) for whether GDP trend deviations are positive or not, which allows different slopes for positive and negative changes in GDP, and at knots of -1.5σ and 1.5σ (where σ stands for standard deviations of log GDP trend deviations in our sample) that allow for larger negative or positive shocks to GDP (recession/boom type conditions). X_{imcst} now includes $Knot_{ct}$ addition to covariates (e.g. $LogGDP_{ct}$) in Equation 2 . There are two coefficients of primary interest here: β_4 represents whether parents are more likely to reinforce/compensate in an economy that is doing better or worse than its trends (at different knots), while β_3 further tells us how the estimate for β_4 changes as economic conditions improve. For example, if parents reinforce more during recessions, we can study whether these reinforcing behaviors tend to diminish as the economy starts to improve. Alternatively, when the economy is booming, we can test if parents continue to compensate, or if there is a diminishing response, resulting in smaller and smaller responses to additional increases in GDP.

4 Results

4.1 Parental Response to Prenatal Shocks by Vaccine Type

In this section, we present results on the effects of exposure to Ramadan on investments in vaccinations from 50 LMICs countries. It is difficult to have a broad generalized pooled estimate on parental response as it is challenging to find comparable fetal shocks and a comparable outcome. The generalizability of such estimates is far from obvious and is an empirical question. Our primary outcome of interest is completion of all basic vaccinations, which include one dose of BCG, three doses of polio, three doses of DPT, and one dose of Measles. However, we are also interested in heterogeneity in parental responses by the type of vaccines. Vaccines like DPT that require three doses may be more challenging and most costly for to fully complete, which may make efficiency concerns more salient than equality concerns for parents in LMICs.

Table 1 presents the results from estimating Equation 1. In column 1, we show the pooled results for completion of all basic vaccines. We find a negative coefficient of exposure on vaccination, though it is not statistically significant. This is consistent with the average parents weakly reinforcing birth inequalities. However, this result may be masking important heterogeneity by type of vaccine. Vaccines like DPT and polio that require three doses may be more challenging and costly to fully complete than a single dose of Measles or BCG, which may make efficiency concerns more salient than inequality aversion motives for parents in LMICs. Columns (2)-(5) show that this is indeed the case: across their own biological children, parents reinforce in terms of DPT and Polio vaccines, but there is no clear significant pattern for BCG or Measles. In terms of magnitude, children exposed to Ramadan in utero are approximately 2 percent and 1.6 percent less likely to be fully vaccinated for DPT and Polio, respectively, compared to their non-exposed siblings. Controls for county x month of birth fixed effects within Muslim populations, biological-mother fixed effects , and use of data from 32 cohorts that allows Ramadan to overlay with all seasons (western), allows us to build in multiple controls to ease concerns regarding seasonality and selective timing of births. As these results are based on estimates from 126 DHS surveys conducted in 50 countries and across 32 cohorts, our results have broad relevance.

4.2 Robustness

4.2.1 Placebo analysis using non-Muslims and residual seasonality

Table A2 in the Appendix presents estimates where we take our model from Table 1 (for the Muslim sample) and allow the sample to include non-Muslims and fully interact the model and a dummy variable for Muslims versus non-Muslims. This analysis allows us to study the robustness of our estimates for Muslims responses to Ramadan in utero in terms of basic vaccinations in contrast to non-Muslims, who we dont expect to fast during Ramadan. For instance, we can eliminate any remaining shared seasonal effects experienced by Muslims and untreated non-Muslims. Our results in Table 1 remain robust, providing evidence of compensation for DPT and Polio vaccines and giving further confidence that our main effects are not driven by selectively timing of births or seasonality.

4.2.2 Clustering

As our treatment (fasting during pregnancy) is at the individual level, one may be concerned that our approach to cluster standard errors by mother and country-month may be too conservative (Abadie et al., 2023). In Table A3, we do not cluster standard errors. However, our results in Table 1 remain robust, providing consistent findings regarding parental responses in terms of vaccinations to prenatal exposure to Ramadan.

4.2.3 Generalizing mother fixed effects

In Appendix Table A4, we present estimates from the OLS model that excludes mother fixed effects from the sample that was earlier used for mother fixed effect estimates. Table 1 results remain robust even if we do not include mother fixed effects, though the point estimates are generally larger. Appendix Table A5 presents OLS estimates for the full sample, including families that only have a single child. In these estimates, we exclude mother fixed effects but still include country-by-month fixed effects. The results in Table 1 remain robust, and the point estimates are slightly larger. This suggests that the estimates from mother fixed effects are applicable to families with one or more children and may even be conservative.

4.3 Heterogeneity in Parental Response to Prenatal Shocks by Aggregate Economic Conditions

Table 2 presents the results from estimating Equation 2 in column (1) and estimates from Equation 3 in column (2-4). We fix outcome to completion of all basic vaccines. Table 2, Column (1), indicates that a 1 percentage increase in GDP per capita (PPP) is associated to a 0.733 percent increase in the completion of all basic vaccines among children exposed to Ramadan in utero (compared to those who are not), suggesting a compensatory response. However, these estimates are statistically insignificant at the 10 percent level of significance. As discussed earlier, past research on GDP fluctuations and infant health (e.g. Baird et al. (2011)) suggest that GDP may have systematic effects, either positive or negative, and the magnitude of the shock may also be influential.

In Column (2), estimating Equation 3 for the case of the knot at 0, we find that a 1 percent increase in GDP leads to a 2.817 percent increase in vaccine completion for exposed children during periods of economic decline (negative deviation from trends in GDP). We also find that positive deviations in GDP (good times) are associated with more compensatory responses. Furthermore, as GDP increases, the compensatory response in good times tends to taper off or diminish (consistent with a concave relationship). However, these estimates are not statistically significant in column (2).

In columns (3-4), we study if large deviations in GDP (+/- 1.5 standard deviations (SDs)) induce asymmetric and heterogeneous responses by parents. We find a remarkable pattern: Parents tend to compensate for their exposed children by 51.29 percent more during periods of economic boom (more than 1.5 standard deviations from GDP's trend) compared to other times.

However, the rate at which they do so diminishes as GDP increases. A 1 percent increase in GDP during a booming economy leads to a 6.6 percent fewer vaccinations in exposed children. Parents compensate in booming economies, but the rate at which they compensate diminishes as GDP improves. Conversely, studying effects of recessionary conditions-more than -1.5 standard deviations from GDP's trend we find that parents tend to reinforce and conducted fewer complete vaccinations in their exposed children by 53.89 percent. However, the rate at which they reinforce diminishes as

GDP increases. A 1 percent increase in GDP during a recessionary economy leads to a 7.3 percent greater vaccinations in exposed children. Parents reinforce fetal inequities in recessionary economies, but the rate at which they reinforce diminishes as GDP improves.

In Table A6 to Table A9 in the Appendix, we present the equivalent of Table 2 for each vaccine. Although we don't find any statistically significant effects in terms of DPT, the pattern in columns (3-4) in Table A6 is similar to what we found in Table 2. A greater compensatory response in booms but at diminishing rates as GDP increases, and greater reinforcement in recessions but also at diminishing rates as GDP increases.

For Polio, Table A7, we find larger effects that are statistically significant at 5 percent or 1 percent level of significance. Booms witness a 90.67 percent increase in vaccination among exposed children, but also a 10.41 percent reduction in compensation for each 1 percentage increase in GDP. Likewise, there is an 81.64 percent reduction in vaccination in recessions among exposed children (compared to those not exposed), and also a 10.52 percent increase in vaccination for every 1 percentage increase in GDP.

For Measles, Table A8, we find that every 1 percent increase in GDP (column 1) leads to a 2.849 percent increase in vaccination among exposed children (compared to those not exposed), which is statistically significant at the 10 percent level. Moreover, during good times (any positive deviation in GDP from the trend), we find that exposed children (compared to those not exposed) receive 34.52 percent more vaccines, and the rate of compensation decreases by 4.68 percent for every one percentage increase in GDP.

For BCG, Table A9, we also find a broadly similar pattern in terms of response to positive shocks to GDP. However, it seems that there is more significant asymmetry in the response. Booms witness a 48.27 percent increase in vaccination among exposed children (compared to those not exposed), but also a 6 percent reduction in compensation for each 1 percentage increase in GDP. However, there is no significant response to negative shocks (recessions). BCG vaccine is typically offered at birth, and this observation suggests a buffering effect of healthcare facilities that prioritize ensuring children receive BCG vaccinations even during challenging times.

Overall, we find a remarkably consistent pattern across different types of vaccines in how parents respond in to cyclical variations in economic conditions times in terms of vaccinating their exposed children relative to those not exposed.

5 Magnitude of Findings

In Table 1, we found that parents tend to reduce completion of all doses of DPT vaccines by 1.908 percentage points and reduce completion of polio vaccines by 1.594 percentage points. To estimate the loss of these missed vaccines in terms of lives lost, we conducted a rough calculation as follows. Pew Research indicates that there were approximately 213 million Muslim babies born between 2010 and 2015, which equates to roughly 42.6 million Muslim babies per year(Hackett et al., 2017). Assuming that 70 percent of them were fully exposed to Ramadan, we estimate that about 29.86 million Muslims were exposed to Ramadan each year. Over a 30-year period (approximately the length of our data), this totals to around 896 million births.

Considering that the reduction in DPT and polio vaccination rates corresponds to approximately 14.28 million fewer Muslim babies (1.594 percent of 896 million) getting vaccinated over the 30-year period, we can analyze the potential impact on infant mortality. Childhood vaccines have been estimated to have contributed to the reduction in infant mortality from 65 per 1000 live births in 1990 to 29 in 2018 (Nandi and Shet, 2020), representing a decline of 36 deaths per 1000 live births. Applying this decline to the 14.28 million Muslim live births over 30 years, the estimation suggests that approximately 514161 (approx 0.5 million) more child deaths could occur due to the lack of equity in vaccination among exposed and non-exposed children in the Muslim population.

6 Discussion and Conclusion

Previous papers studying parental response to fetal shocks have found mixed evidence of both reinforcement and compensation. Since these studies use different shocks, time periods, population, countries and investments, it is difficult to derive a generalizable conclusion on the impact of fetal shocks on parental investments. We contribute to this literature by estimating parental response to Ramadan fasting, a fetal shock that occurs every year and is common to Muslims around the world. We chose completion of vaccination as a measure of parental investment as medical requirements of vaccinations are nearly the same across the world. The commonality of the shock and the investment measure allows us to study parental response across 50 countries for over 30 years providing a large variation of the context.

We use 126 rounds of Demographic and Health Surveys (DHS) and include country-month fixed effects to control for the effect of seasons on parental investments and mother fixed effects to control for selection of mothers into timing their pregnancy and seasonality. Sensitivity analysis that investigates the difference in outcomes between Muslim and non-Muslim groups confirms that our estimates are unlikely to be driven by factors such as seasonality. We find strong evidence that parents reinforce the initial fetal shock. We find that children that were exposed to Ramadan during pregnancy are less likely to complete vaccinations for DPT and Polio compared to their unexposed sibling. Our estimates suggests that had parents not reinforced the initial fetal shock, over 30 years, 14.65 million more children would have completed their DPT and Polio vaccinations.

The commonality of the shock and the investment measure also allows us to study the changes in parental response as macro economic conditions change. We study the change in parental investment response to Ramadan shocks as countries experience economic booms and downturns. We find that economic booms indeed lead to a more compensatory investment behaviour and economic downturns lead to a more reinforcing investment behaviour. To the best of our knowledge, we are the first paper to study the change in parental investment investment behaviour in response to a fetal shock to change in macro economic conditions.

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7 Tables

Table 1: Parental Response to Prenatal Ramadan Exposure

VARIABLES	(1) All Basic Vaccines	(2) All DPT Vaccines	(3) All Polio Vaccines	(4) Measles Vaccines	(5) BCG Vaccines
Ramadan Exposure	-0.388	-1.908	-1.594	0.0685	-0.260
	(0.834)	(0.904)	(0.914)	(0.897)	(0.507)
Observations	149,280	153,014	153,750	151,367	153,724
R-squared	0.758	0.781	0.748	0.776	0.825

Notes: Robust multi-way clustered standard errors in parentheses at country x month and mother level. Estimates from models controlling for mother fixed effects and country x month fixed effects, limited to Muslims who are either fully exposed to Ramadan in utero or not exposed at all. Controls for age, age squared, gender, birth order of the child.

TABLE 2: PARENTAL RESPONSE TO PRENATAL EXPOSURE FOR ALL VACCINES BY FLUCTUATIONS IN GDP

VARIABLES	(1) All Vaccines	(2) All Vaccines	(3) All Vaccines	(4) All Vaccines
Ramadan Exposure x Log GDP	0.733	2.817	1.105	0.319
	(1.306)	(1.134)	(1.264)	(1.538)
Ramadan Exposure x GDP(>0 SD)		30.96		
		(22.65)		
Ramadan Exposure x GDP (>0 SD) x Log GDP		-4.103		
		(2.920)		
Ramadan Exposure x GDP (>+1.5 SD)			51.29	
			(24.11)	
Ramadan Exposure x GDP (>+1.5 SD) x Log GDP			-6.575	
			(2.692)	
Ramadan Exposure x GDP (<-1.5 SD)				-53.89
				(23.12)
Ramadan Exposure x GDP (<-1.5 SD) x Log GDP				7.294
				(2.768)
Observations	124,704	124,704	124,704	124,704
R-squared	0.762	0.762	0.762	0.762

Notes: Robust clustered standard errors in parentheses at country level. Estimates from models controlling for mother fixed effects and country x month fixed effects, limited to Muslims who are either fully exposed to Ramadan in utero or not at all. Controls for linear, quadratic cubic trends in birth year, age, age squared of child, gender, birth order of the child. Log GDP is natural log of GDP per capita in PPP. Terms GDP(>0 SD), GDP(>+1.5 SD), and GDP (<-1.5 SD) designate knots/dummies to indicate whether GDP deviates positively more than 1.5 SD from its trends or less than 1.5 SD from its trends. In the model estimated in column (1) we control for Ramadan Exposure and for Log GDP; in (2) in addition to controls in (1) we control for GDP(>0 SD), and for interactions: GDP(>0 SD) x Log GDP; in (3) in addition to controls in (1) we control for GDP(>+1.5 SD), and for interactions: GDP(>+1.5 SD) x Log GDP; ; in (4) in addition to controls in (1) we control for GDP(<-1.5 SD), and for interactions: GDP(<-1.5 SD) x Log GDP.

8 Appendix

Background on Ramadan - Ramadan is a holy month in Islam (9^{th} month in Islamic calendar). Practicing Muslims are required to fast from dawn to dusk during the month of Ramadan. They are required not to consume any water or food during the fasting period from dawn to dusk. Since the Islamic calendar follows a lunar calendar, the exact one month of Ramadan is not fixed in the Gregorian calendar. The exact one month moves 11 days backwards every year in the Gregorian calendar. Thus over approximately 33 years Ramadan covers all seasons and months.

A natural question is whether pregnant mothers fast during Ramadan? Islam does not require pregnant women to fast. However, pregnant women who exempt themselves from fasting are required to compensate for it by fasting later or under some interpretations of Koran by paying alms to the poor. Comprehensive data on fasting during pregnancy does not exist. In a survey from Iraq, 71 percent of $4,343$ pregnant mothers observed fast for at least one day in the one month period (Arab and Nasrollahi, 2001). In another study from Jakarta, Indonesia of the 187 pregnant women interviewed, 80 percent fasted during Ramadan (van Bilsen et al., 2016). Evidence from several other countries like Singapore, Yemen, Gambia, England and the U.S suggests between to 70 to 90 percent of pregnant women observe fasting (Almond and Mazumder, 2011). There are several possible reasons for observing the fast. Pregnant women want to avoid fasting alone and they fast with their family. Also, fasting during Ramadan is associated with several community or family level events like breaking the fast together, praying etc. Women do not want to feel alienated from these community activities. In addition, in many developing countries women are often not aware about their pregnancies in the first trimester. However, to the extent individuals choose to fast during Ramadan our estimates should be interpreted as the reduced form (or Intent to Treat (ITT)) estimates of the pregnancy overlapping with Ramadan.

There are several plausible mechanisms through which Ramadan affects fetal health. a) Fasting during Ramadan can reduce calorie intake. In a study from Iran, (Arab, 2004) shows most pregnant women have over 500 calorie deficiency due to fasting. In a study from Gambia authors find, a 1 Kg weight loss due to fasting from Ramadan (Strickland and Ulijaszek, 1993). Reduced calorie intake may effect fetal growth. b) Fasting also leads to reduced glucose level in the blood and this may also lead to reduced fetal growth and lower birth weight (Scholl et al., 2001; ter Braak et al., 2002). c) Maternal fasting may also lead to a set of bio-chemical changes known as "accelerated starvation". "Accelerated starvation" is associated with diminished cognition and neurological impairment (Metzger et al., 1982; Moore et al., 1989; Rizzo et al., 1991).

We build on earlier studies in economics that have shown long run effects of pregnancies overlapping with Ramadan. Using data from Michigan, Uganda and Iraq, Almond and Mazumder (2011) shows that the overlap of Ramadan with the pregnancy leads to lower birth weight, less number of male children, increased learning disability. In another study using data on academic performance for children of Bangladeshi and Pakistani families in England, Almond et al. (2015) finds the overlap of pregnancy with Ramadan reduces the academic outcomes at age 7. Van Ewijk (2011) finds individuals who were exposed to Ramadan in utero are more likely to report poorer general health and Majid (2015) finds individuals who were exposed to Ramadan in utero score less on cognitive and math test and also work fewer hours.[3] In this paper, we do not study the direct effects of fasting during Ramadan on human capital formation. Instead, we focus on the subsequent parental investment responses to better understand the behavioral response and coping strategies of parents to endowment shocks on their children.

[3]Majid et al. (forthcoming) shows that Ramadan exposure in utero leads to adverse effects that are particularly pronounced in the lowest quantiles of the outcome distributions.

TABLE A1: DESCRIPTIVE STATISTICS

	Mean	Std. Dev.	Min	Max	Observations
All Routine Vaccinations Completed	39.72728	48.93345	0	100	214943
All DPT Vaccinations Completed	55.65593	49.67919	0	100	218399
Polio Vaccinations (1-3) Completed	57.8217	49.38453	0	100	219153
BCG Vaccination Complete	71.46469	45.15835	0	100	219090
Measles Vaccination Complete	55.85267	49.6564	0	100	216978
Ramadan Exposure	.9061575	.2916101	0	1	220039
Child Age (Years)	1.938184	1.461027	0	4	220039
Female Child	.4961757	.4999865	0	1	220039
Survey Year	2004.978	8.414285	1986	2017	220039
Birth Year	2002.582	8.539393	1981	2017	220039
Number of children per biological mother in sample	2.186453	.4237203	2	6	220039
Birth order	1.591877	.6130551	1	5	220039
Natural Log of GDP per capita (PPP) in birth year	8.028068	.7697773	6.150892	9.876315	186387
Mother's Education: Below Primary	.7527939	.4313886	0	1	213947

Notes: The sample includes Muslim children with at least one sibling ever born from 126 Demographic and Health Surveys in 50 countries. These children are consists of two groups: those who were fully exposed to Ramadan in utero and those who were not exposed at all.

FIGURE A1: VACCINATION RATES ARE LOW BUT IMPROVING

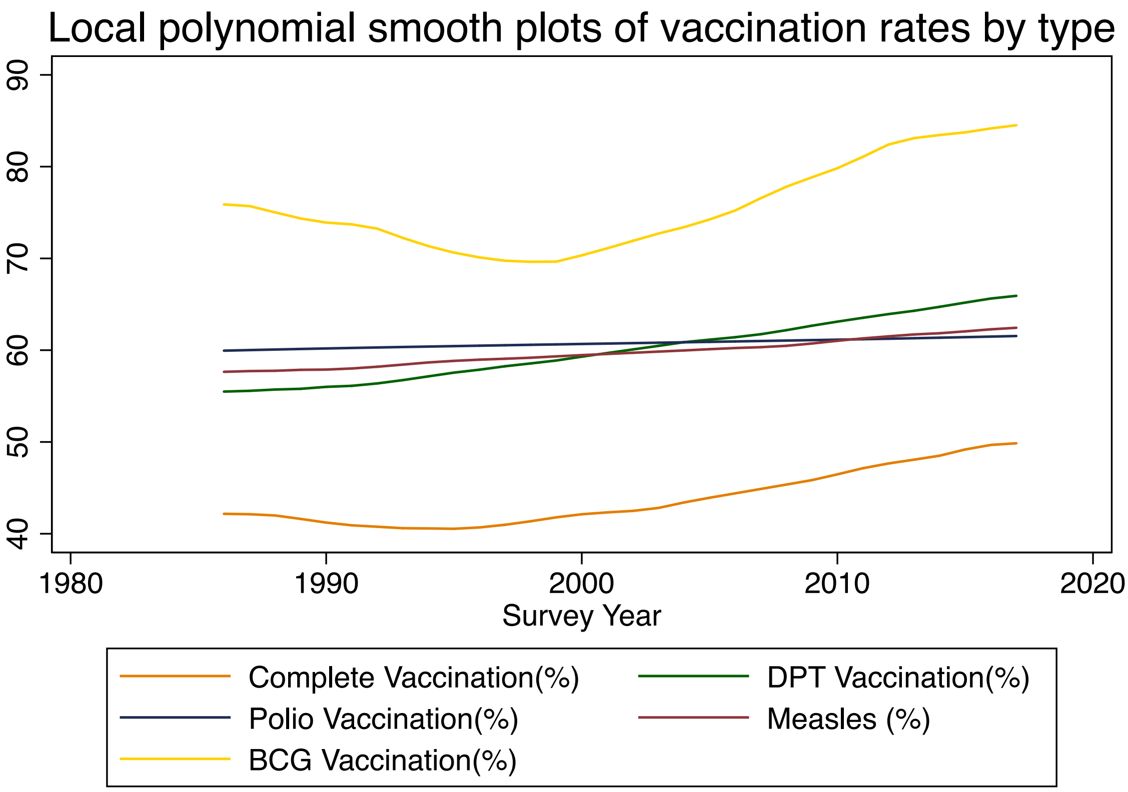

Table A2: Robustness for main estimates of Table 2: Muslims vs Non-Muslims

VARIABLES	(1) All Vaccines	(2) DPT Vaccines	(3) Polio Vaccines	(4) Measles Vaccines	(5) BCG Vaccines
Muslim x Ramadan Exposure	-0.249	-2.089	-2.424	-0.212	-0.594
	(0.858)	(0.925)	(0.993)	(0.940)	(0.598)
Ramadan Exposure (Non-Muslims)	0.189	0.932	1.479	0.551	0.605
	(0.622)	(0.758)	(0.830)	(0.732)	(0.471)
Observations	338,709	346,246	347,657	343,041	347,899
R-squared	0.744	0.767	0.732	0.768	0.800

Notes: Robust multi-way clustered standard errors in parentheses at country x month and mother level. Estimates from models controlling for mother fixed effects and country x month fixed effects, limited to Muslims who are either fully exposed to Ramadan in utero or not at all. This model replicates the model in Table 1 but relaxes the restriction for Muslims only to include non-Muslims as well. It fully interacts model in Table 1 with a dummy variable indicating Muslim vs. non-Muslim status. Hence, we include controls for age, age squared, gender, birth order of the child, and their interactions with the Muslim dummy. We also control for dummies for Muslim.

Table A3: Robustness for main estimates of Table 2: No clustering

VARIABLES	(1) All Basic Vaccines	(2) All DPT Vaccines	(3) All Polio Vaccines	(4) Measles Vaccines	(5) BCG Vaccines
Ramadan Exposure	-0.388	-1.908	-1.594	0.0685	-0.260
	(0.508)	(0.485)	(0.516)	(0.493)	(0.393)
Observations	149,280	153,014	153,750	151,367	153,724
R-squared	0.758	0.781	0.748	0.776	0.825

Notes: Robust standard errors (not clustered) in parentheses. Estimates from models controlling for mother fixed effects and country x month fixed effects, limited to Muslims who are either fully exposed to Ramadan in utero or not at all. Controls for age, age squared, gender, birth order of the child.

Table A4: Robustness: OLS w/o mother fixed effects in Table 1's sample

VARIABLES	(1) All Basic Vaccines	(2) All DPT Vaccines	(3) All Polio Vaccines	(4) Measles Vaccines	(5) BCG Vaccines
Ramadan Exposure	-2.827	-4.231	-3.544	-1.942	-3.937
	(2.517)	(1.828)	(1.886)	(1.840)	(2.457)
Observations	149,280	157,315	158,050	155,663	158,052
R-squared	0.224	0.249	0.197	0.292	0.193

Notes: We use the same sample and model as in Table 1, with the exception that we drop mother fixed effects to conduct a simpler ordinary least squares (OLS) regression.

Table A5: Robustness: OLS w/o mother fixed effects in full sample of all families

VARIABLES	(1) All Basic Vaccines	(2) All DPT Vaccines	(3) All Polio Vaccines	(4) Measles Vaccines	(5) BCG Vaccines
Ramadan Exposure	-1.670	-3.061	-3.077	-0.997	-2.604
	(2.074)	(1.648)	(1.686)	(1.755)	(1.911)
Observations	382,099	387,864	389,132	385,475	389,117
R-squared	0.245	0.262	0.206	0.311	0.219

Notes: We use the same sample and model as in Table 1, with the exception that we relax the restriction to include families with two or more children. Furthermore, we drop mother fixed effects to conduct a simpler ordinary least squares (OLS) regression.

Table A6: Parental Response: DPT Vaccine and GDP

VARIABLES	(1) All DPT Vaccines	(2) >All DPT Vaccines	(3) All DPT Vaccines	(4) All DPT Vaccines
Ramadan Exposure x Log GDP	-1.296	-0.470	-1.068	-1.757
	(1.531)	(2.870)	(1.746)	(1.186)
Ramadan Exposure x GDP(>0 SD)		13.39		
		(27.46)		
Ramadan Exposure x GDP (>0 SD) x Log GDP		-1.654		
		(3.560)		
Ramadan Exposure x GDP (>+1.5 SD)			49.59	
			(38.20)	
Ramadan Exposure x GDP (>+1.5 SD) x Log GDP			-5.484	
			(4.552)	
Ramadan Exposure x GDP (<-1.5 SD)				-55.54
				(36.38)
Ramadan Exposure x GDP (<-1.5 SD) x Log GDP				7.519
				(4.589)
Observations	127,582	127,582	127,582	127,582
R-squared	0.791	0.791	0.791	0.791

Notes: Robust clustered standard errors in parentheses at country level. Estimates from models controlling for mother fixed effects and country x month fixed effects, limited to Muslims who are either fully exposed to Ramadan in utero or not at all. Controls for linear, quadratic cubic trends in birth year, age, age squared of child , gender, birth order of the child. Log GDP is natural log of GDP per capita in PPP.Terms GDP(>0 SD), GDP(>+1.5 SD), and GDP (<-1.5 SD) designate knots/dummies to indicate whether GDP deviates positively more than 1.5 SD from its trends or less than 1.5 SD from its trends. In the model estimated in column (1) we control for Ramadan Exposure and for Log GDP; in (2) in addition to controls in (1) we control for GDP(>0 SD), and for interactions: GDP(>0 SD) x Log GDP; in (3) in addition to controls in (1) we control for GDP(>+1.5 SD), and for interactions: GDP(>+1.5 SD) x Log GDP; ; in (4) in addition to controls in (1) we control for GDP(<-1.5 SD), and for interactions: GDP(<-1.5 SD) x Log GDP.

TABLE A7: PARENTAL RESPONSE: POLIO VACCINE AND GDP

VARIABLES	(1) All Polio Vaccines	(2) >All Polio Vaccines	(3) All Polio Vaccines	(4) All Polio Vaccines
Ramadan Exposure x Log GDP	-0.981	0.465	-0.521	-1.638
	(1.564)	(2.905)	(1.770)	(1.267)
Ramadan Exposure x GDP (>0 SD)		24.23		
		(28.86)		
Ramadan Exposure x GDP (>0 SD) x Log GDP		-2.922		
		(3.734)		
Ramadan Exposure x GDP (>+1.5 SD)			90.67	
			(28.90)	
Ramadan Exposure x GDP (>+1.5 SD) x Log GDP			-10.41	
			(3.377)	
Ramadan Exposure x GDP (<-1.5 SD)				-81.64
				(30.87)
Ramadan Exposure x GDP (<-1.5 SD) x Log GDP				10.52
				(3.826)
Observations	128,307	128,307	128,307	128,307
R-squared	0.753	0.753	0.753	0.753

Notes: Robust clustered standard errors in parentheses at country level. Estimates from models controlling for mother fixed effects and country x month fixed effects, limited to Muslims who are either fully exposed to Ramadan in utero or not at all. Controls for linear, quadratic cubic trends in birth year, age, age squared of child , gender, birth order of the child. Log GDP is natural log of GDP per capita in PPP.Terms GDP(>0 SD), GDP(>+1.5 SD), and GDP (<-1.5 SD) designate knots/dummies to indicate whether GDP deviates positively more than 1.5 SD from its trends or less than 1.5 SD from its trends. In the model estimated in column (1) we control for Ramadan Exposure and for Log GDP; in (2) in addition to controls in (1) we control for GDP(>0 SD), and for interactions: GDP(>0 SD) x Log GDP; in (3) in addition to controls in (1) we control for GDP(>+1.5 SD), and for interactions: GDP(>+1.5 SD) x Log GDP; ; in (4) in addition to controls in (1) we control for GDP(<-1.5 SD), and for interactions: GDP(<-1.5 SD) x Log GDP.

TABLE A8: PARENTAL RESPONSE: MEASLES VACCINE AND GDP

VARIABLES	(1) Measles Vaccine	(2) Measles Vaccine	(3) Measles Vaccine	(4) Measles Vaccine
Ramadan Exposure x Log GDP	2.849	5.228	2.961	2.728
	(1.446)	(1.776)	(1.540)	(1.448)
Ramadan Exposure x GDP (>0 SD)		34.52		
		(19.91)		
Ramadan Exposure x GDP (>0 SD) x Log GDP		-4.678		
		(2.611)		
Ramadan Exposure x GDP (>+1.5 SD)			9.658	
			(22.40)	
Ramadan Exposure x GDP (>+1.5 SD) x Log GDP			-1.542	
			(2.592)	
Ramadan Exposure x GDP (<-1.5 SD)				-10.83
				(19.06)
Ramadan Exposure x GDP (<-1.5 SD) x Log GDP				2.217
				(2.254)
Observations	126,547	126,547	126,547	126,547
R-squared	0.788	0.788	0.788	0.788

Notes: Robust clustered standard errors in parentheses at country level. Estimates from models controlling for mother fixed effects and country x month fixed effects, limited to Muslims who are either fully exposed to Ramadan in utero or not at all. Controls for linear, quadratic cubic trends in birth year, age, age squared of child , gender, birth order of the child. Log GDP is natural log of GDP per capita in PPP.Terms GDP(>0 SD), GDP(>+1.5 SD), and GDP (<-1.5 SD) designate knots/dummies to indicate whether GDP deviates positively more than 1.5 SD from its trends or less than 1.5 SD from its trends. In the model estimated in column (1) we control for Ramadan Exposure and for Log GDP; in (2) in addition to controls in (1) we control for GDP(>0 SD), and for interactions: GDP(>0 SD) x Log GDP; in (3) in addition to controls in (1) we control for GDP(>+1.5 SD), and for interactions: GDP(>+1.5 SD) x Log GDP; ; in (4) in addition to controls in (1) we control for GDP(<-1.5 SD), and for interactions: GDP(<-1.5 SD) x Log GDP.

TABLE A9: PARENTAL RESPONSE: BCG VACCINE AND GDP

VARIABLES	(1) BCG Vaccine	(2) BCG Vaccine	(3) BCG Vaccine	(4) BCG Vaccine
Ramadan Exposure x Log GDP	-0.758	0.252	-0.439	-0.693
	(0.789)	(0.921)	(0.743)	(0.756)
Ramadan Exposure x GDP (>0 SD)		16.16		
		(8.175)		
Ramadan Exposure x GDP (>0 SD) x Log GDP		-2.024		
		(0.989)		
Ramadan Exposure x GDP (>+1.5 SD)			48.27	
			(21.31)	
Ramadan Exposure x GDP (>+1.5 SD) x Log GDP			-6.014	
			(2.591)	
Ramadan Exposure x GDP (<-1.5 SD)				9.142
				(16.78)
Ramadan Exposure x GDP (<-1.5 SD) x Log GDP				-1.018
				(1.975)
Observations	128,352	128,352	128,352	128,352
R-squared	0.829	0.829	0.829	0.829

Notes: Robust clustered standard errors in parentheses at country level. Estimates from models controlling for mother fixed effects and country x month fixed effects, limited to Muslims who are either fully exposed to Ramadan in utero or not at all. Controls for linear, quadratic cubic trends in birth year, age, age squared of child , gender, birth order of the child. Log GDP is natural log of GDP per capita in PPP.Terms GDP(>0 SD), GDP(>+1.5 SD), and GDP (<-1.5 SD) designate knots/dummies to indicate whether GDP deviates positively more than 1.5 SD from its trends or less than 1.5 SD from its trends. In the model estimated in column (1) we control for Ramadan Exposure and for Log GDP; in (2) in addition to controls in (1) we control for GDP(>0 SD), and for interactions: GDP(>0 SD) x Log GDP; in (3) in addition to controls in (1) we control for GDP(>+1.5 SD), and for interactions: GDP(>+1.5 SD) x Log GDP; ; in (4) in addition to controls in (1) we control for GDP(<-1.5 SD), and for interactions: GDP(<-1.5 SD) x Log GDP.