Ramadan and the Timing of Fertility: Evidence from Indonesia

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Abstract

Fasting during pregnancy has adverse effects on fetal and adult health of the offspring. In the case of Ramadan, the Islamic month of fasting, these effects can be avoided through mothers timing pregnancy to avoid Ramadan during the gestation period. This paper examines whether mothers time pregnancy to avoid Ramadan, and the mechanisms behind the avoidance behaviour. Using fertility data from the Indonesian Family Life Survey, I find strong evidence of Ramadan avoidance in the timing of contraceptive use. The probability of using 3-month injectable contraceptives increases by 0.6 percentage points two months before Ramadan to ensure return to fertility during the optimal time to conceive. I also find a 0.2 percentage point increase of in the likelihood of conception after Ramadan. Moreover, my results suggest that expansion of Indonesia's Village Midwife Program allowed mothers to use contraceptives, specifically birth control injections, to avoid Ramadan.

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1 Introduction

The prenatal period is critical to human development. Evidence shows that the time spent *in utero* has an impact throughout the lifecycle – it influences school performance during childhood, as well as health and labour market outcomes in adulthood.[1] Even relatively slight changes in the prenatal environment can have repercussions for the offspring. In particular, recent work uses fasting by Muslim mothers during the month of Ramadan to identify mild but commonplace changes in maternal nutrition during pregnancy. During Ramadan, adult Muslims are required to fast from sunrise until sunset: they abstain from eating, drinking, smoking, sexual intercourse, oral and intravenous medication. Comparing pregnancies that were *in utero* during Ramadan to pregnancies that were not, studies find that exposure to Ramadan early in the gestation period leads to an increase in fetal death (Almond and Mazumder, 2011), worse academic performance during childhood (Almond, Mazumder and Van Ewijk, 2011; Greve, Schultz-Nielsen and Tekin, 2015; Majid, 2015), increase in both mental and physical disabilities, and other health problems in adulthood (Almond and Mazumder, 2011; Van Ewijk, 2011). Additionally, exposure late in the pregnancy is associated with poor labour market outcomes (Schultz-Nielsen, Tekin and Greve, 2014). Pregnancies exposed to Ramadan result in lower birthweight, regardless of the trimester of exposure (Almond and Mazumder, 2011).[2]

The finding that exposure to Ramadan *in utero* leads to negative consequences raises two questions. First, do women time pregnancy to avoid Ramadan, given that Ramadan is

[1] For example, Almond (2006); Almond, Edlund and Palme (2009); Banerjee et al. (2010); Barreca (2010); Chen and Zhou (2007); Jürges (2013); Kelly (2011); Lee (2014); Nelson (2010) and Sotomayor (2013) all find long-term consequences of events that took place during the prenatal period. Almond and Currie (2011*b*) provide an overview of the literature.

[2] Typically, evidence on the impact of *in utero* events on outcomes later in life relies on exploiting changes in fetal health caused by severe but infrequent events, such as famines or outbreaks of an infectious disease. These types of events are not under control of the mother or easily addressed by policy, and thus offer few lessons on how to improve prenatal health. In contrast, fasting during pregnancy is not only a harmful event that is preventable by the mother, but it is also a common practice in several populations. There are currently 1.2 billion Muslims who were potentially exposed to Ramadan *in utero*. Fasting is a common ritual of many other religions besides Islam, such as Hindu, Catholic, and Eastern Orthodox. Fasting for non-religious reasons is also prevalent. For example, in the United States as many as one in four women report having missed a meal during pregnancy (Siega-Riz et al., 2001).

a predictable event? Second, if the avoidance behaviour exists, what are the mechanisms behind this behaviour? To answer these questions, I study fertility decisions of women in Indonesia, the world's largest Muslim country. Specifically, I look for evidence of mothers planning pregnancy to avoid Ramadan by analyzing the timing of birth control use and the timing of conception.

My analysis of mothers' fertility behaviour uses data from the Indonesia Family Life Survey (IFLS). Indonesia is the fourth most populous country in the world and almost 90 percent of the population of 250 million people follow Islam, making it the largest Muslim country and a fitting setting for this study. I begin by studying patterns in birth control use from a calendar that retroactively documents women's contraceptive use for the years 1984-1998. My results suggest that mothers in Indonesia plan pregnancy to avoid Ramadan. I find an increase in the use of contraceptives two months before Ramadan cycle begins. The trend in overall contraceptive use is largely driven by the trend in the use of 3-month birth control injections. This finding is consistent with results from Weaver et al. (2013) who find that women in Indonesia switch to using injectable contraceptives when they are available. Use of 3-month injectable contraceptives two months before Ramadan reflects the need to use such contraceptives early to ensure return to fertility during the optimal conception period (in the first two months after Ramadan). I find a 0.6 percentage point increase in use of injections in two months before Ramadan and an increase in the likelihood of conception of 0.2 percentage points in two months after Ramadan. I also find a drop in conceptions one month before Ramadan. This result is consistent with Ahsan (2015) who finds that women in Bangladesh are less likely to give birth 8-9 months after Ramadan after introduction of a family planning program. However, as the study also finds an increase in conceptions 2-5 months before Ramadan, it is suggestive of an unintentional shift in conceptions due to improvements in fetal health, rather than intentional timing of pregnancy by mothers.[3] Aside from the fact

[3]For example, if pregnancies conceived 2-5 months before Ramadan which would have ended in a pregnancy loss during Ramadan are more likely to survive, then we will observe an increase in conception during this period. Conversely, continuation of the first pregnancy during Ramadan prevents conception of the second pregnancy during Ramadan, so that pregnancies conceived 2-5 months before Ramadan displace the

that the time of conception observed in the data is influenced by selection on pregnancy survival, which makes interpretation of observed patterns more ambiguous, I argue that a mother has much more control over the timing of contraceptive use, compared to the timing of conception, and therefore the timing of contraceptive use is a better indicator of mother's intentions and avoidance behaviour.

Having documented the extent of avoidance in the Indonesian population, I also shed light on the potential mechanisms behind this fertility behaviour. Consistent with prior work documenting parents timing births in response to tax subsidies or school entry cutoff date (LaLumia, Sallee and Turner, 2015; Shigeoka, 2015), I find that the timing behaviour I observe in the data is driven by the mothers timing second and higher-order pregnancies, suggesting that mothers may gain information through pregnancy experience.

As a complement to this learning mechanism, I also examine whether access to modern methods of birth control in Indonesia influences the timing behaviour in mothers. Indonesia's family planning program is cited as one of the reasons for a rapid reduction in birth rate since the 1970s.[4] Prior to the introduction of family planning programs, awareness of modern methods of contraception was low.[5] The National Family Planning Coordinating Board (BKKBN) was established in 1970 and provided birth control pills and condoms to rural communities (Chernichovsky, 1991; Gertler and Molyneaux, 1994). In 1989, a Village Midwife Program (VMP) was also introduced to serve as a family planning resource and address a high rate of maternal mortality and poor early childhood health. In particular, one of the goals of the program was to act as a complement to community posts established by BKKBN. In addition to supplying pills and condoms, these locations were used to provide access to birth control injections and clinical contraceptive methods such as implants and IUDs (Weaver et al., 2013). The midwife program is credited with an improvement in maternal and child health outcomes (Frankenberg et al., 2009; Frankenberg and Thomas, 2001; Frankenberg,

pregnancies conceived during Ramadan.

[4]Total fertility rate fell from 5.6 in 1970 to 3.2 in 1985 (Gertler and Molyneaux, 1994).

[5]A 1968 survey of married men and women in Jakarta revealed that 75 percent of them have not heard of any method of family planning (McNicoll and Singarimbun, 1983).

Suriastini and Thomas, 2005). However, the program did not increase the overall use of family planning methods, but rather lead to women substituting away from oral contraceptives in favour of injections (Weaver et al., 2013).

I present evidence that the introduction of the program in 1989 enabled women to effectively time pregnancy to avoid Ramadan. Specifically, prior to the introduction of the VMP I observe no increase in injection use before Ramadan, nor increase in conception after Ramadan. It is only after the program began that I observe the patterns in birth control use and conception consistent with Ramadan avoidance. Finally, I also show that more educated women are more likely to conceive after Ramadan, although I find no difference in the likelihood of using injections before Ramadan by educational attainment suggesting that pregnancies exposed to Ramadan are adversely selected.

I contribute to several strands of literature. My study adds to the existing body of research on how the timing of conception responds to incentives that vary over time, such as tax subsidies tied to the year of birth or foregone labour earnings that change in a systematic way across seasons (Artadi, 2005; Dickert-Conlin and Chandra, 1999; Kureishi and Wakabayashi, 2008; LaLumia, Sallee and Turner, 2015; Shigeoka, 2015; Shirlee, 2014).

I also add to the existing literature on the consequences of the Indonesia's Village Midwife Program. The program is associated with an improvement in maternal and child health outcomes (Frankenberg et al., 2009; Frankenberg and Thomas, 2001; Frankenberg, Suriastini and Thomas, 2005). In addition, Weaver et al. (2013) finds that the program led to women increasing use of birth control injections, without an increase in overall use of contraceptives. My research indicates that the Village Midwife Program, by providing mothers with injectable contraceptives, enabled mothers to plan pregnancy to avoid Ramadan exposure. Given that Ramadan exposure *in utero* has been shown to have negative effects on the health of the child, avoidance of Ramadan exposure through the use of injectable contraception may partially account for the improvement in child health associated with the program.

Finally, my study also relates to the research on health behaviours in low-income coun-

tries.[6] I present suggestive evidence that women respond to information when making fertility decisions. My results are consistent with the experimental work of Dupas (2011*a*), who finds that teenage girls in Kenya adjust their sexual behaviour in response to information about their partners' relative risk of HIV infection.

My findings have a clear policy implication. The results suggest a previously unexplored channel through which family planning programs in developing countries may improve child health. Month of birth is strongly tied to infant mortality and child outcomes because of seasonal variation in the burden of infectious diseases and availability of nutrition (Lokshin and Radyakin, 2012). Regularly-occurring shocks to fetal health allow mothers to time conception to avoid such shocks. Therefore, family planning programs that enhance the ability to time pregnancy may also work by allowing a mother to simply shift conception to a more favourable period. This also implies that an evaluation of a family planning program that considers total fertility or intervals between pregnancies as outcomes may miss an important effect and understate the benefits of the program for child welfare.

2 Data and methodology

To study pregnancy timing I use data from the Indonesian Family Life Survey (IFLS). The IFLS is a longitudinal survey which collects extensive information on individual and household characteristics, and is representative of 83 percent of the Indonesian population (Frankenberg and Karoly, 1995*b*). One feature of the IFLS makes it particularly well suited for analysis of fertility behaviour is that it collects data on monthly contraceptive use. This data allows me to study the intended timing of conception, which may differ from the realized timing of conception.[7]

[6] See Dupas (2011*b*) for an overview of issues and a summary of results from empirical studies in health behaviours in the developing world.

[7] An additional advantage of the IFLS is that interviews with female respondents were conducted by female interviewers as it is in line with cultural conventions that questions about pregnancy and contraception are asked by women. Females were part of the interview team for this purpose, suggesting that care was taken to ensure that accurate information was collected about fertility behaviour (Frankenberg et al., 1995, 2000; Strauss et al., 2004).

I use data from the fertility calendar module in the IFLS to study whether mothers time pregnancy to avoid Ramadan by analyzing patterns in birth control use and pregnancy. The calendar module retroactively collects information on a month-by-month basis on contraceptive use, pregnancy, and marriage. Respondents are asked whether they used birth control in the first month of the calendar period, the month they stopped using it, and the month they resumed its use. This information is used to develop an indicator for contraception coverage in a given month. Unlike contraceptive use, pregnancy and marriage entries were derived from pregnancy history and marriage history modules. In these modules information is collected about the start and end of each pregnancy or marriage, after respondent reports the number of times she has been pregnant or married.

Data for the contraceptive calendar is collected in two waves, covering 5-10 years before the survey.[8] For respondents whose first marriage occurred more than ten years ago before the survey, the calendar begins in January 1989 for wave 1 (IFLS1) and in January 1992 for wave 2 (IFLS2). For respondents whose first marriage occurred between 1984 and 1994 for IFLS1 (or between 1987 and 1997 for IFLS2), the calendar begins with the first month of the first marriage. For this subsample of women, I observe complete fertility history on a monthly basis. Therefore, I differentiate between the main calendar sample, which includes all respondents, and the complete calendar sample, which includes respondents with complete fertility history documented in the calendar.

I select respondents who are Muslim, at least 15 years old in the first year of the calendar, have a record of at least one pregnancy, do not report improbable information,[9] and have no missing values for control variables. Descriptive statistics for mothers in two calendar

[8]The calendar questionnaire was administered in the first three waves of the IFLS, however IFLS3 calendar data is corrupt and therefore dropped from the study (confirmed via email communication (Peterson, 2014)).

[9]Specifically, I drop mothers who report gestation longer than eleven months, or report a live birth for a pregnancy shorter than seven months. Although probability of a live birth at 26-27 weeks of gestation (or about six months) is about ninety percent, the studies on which these numbers are based use data from developed countries since 1989 (ACOG, 2002; Luke and Brown, 2006; Tyson et al., 2008). I impose a minimum of seven months, or approximately 30 weeks, to account for the context in the developing country, where fetal viability is likely lower than in developed countries, especially during the earlier years in the sample. Pregnancies which end in a live birth and are between six and seven months old account for about 1.4 percent of the total sample and are reported by 1.9 percent of women.

samples are shown in Columns 1 and 2 of Table 1. There are 2,288 respondents in the calendar sample, reporting 1.6 pregnancies during the calendar, and more than half have no more than elementary school education. Although three quarters live in a house with electricity, fewer than one in six have access to running water. 1,358 respondents in the restricted sample are about 2.5 years older, have 0.2 more pregnancies during the calendar period, are somewhat less educated, and have a higher share living in rural areas (although the differences are not statistically significant).

Table 1: Descriptive charcteristics

	(1) Calendar		(2) Complete calendar	
Birth year	1966.425	(6.544)	1963.939	(6.085)
Married	0.967	(0.177)	0.971	(0.167)
Number of pregnancies	1.612	(0.856)	1.843	(0.959)
No education	0.108	(0.310)	0.138	(0.345)
Elementary school	0.566	(0.496)	0.629	(0.483)
Jr. High school	0.138	(0.345)	0.118	(0.323)
Sr. High school	0.155	(0.362)	0.097	(0.296)
Post-secondary school	0.033	(0.180)	0.018	(0.135)
Urban	0.331	(0.471)	0.294	(0.456)
Very healthy	0.159	(0.366)	0.178	(0.383)
Fairly healthy	0.779	(0.415)	0.760	(0.428)
Poor health	0.061	(0.240)	0.061	(0.239)
Very sick	0.001	(0.027)	0.001	(0.032)
Electricity	0.739	(0.439)	0.684	(0.465)
Tap water	0.132	(0.338)	0.114	(0.318)
Observations	2288		1358	

Notes: For respondents who are present in both waves, I use measures collected in wave 1.

Summary statistics for monthly fertility calendar are presented in Table 2. In a given month, more than one third of respondents are using some form of contraceptives, and 3-month injections are the most popular method. Notably, the patterns of birth control use are virtually identical between the two groups.

I obtain the start and end date for each month of Ramadan for the 1984-1998 period

Table 2: Summary statistics for monthly fertility calendar

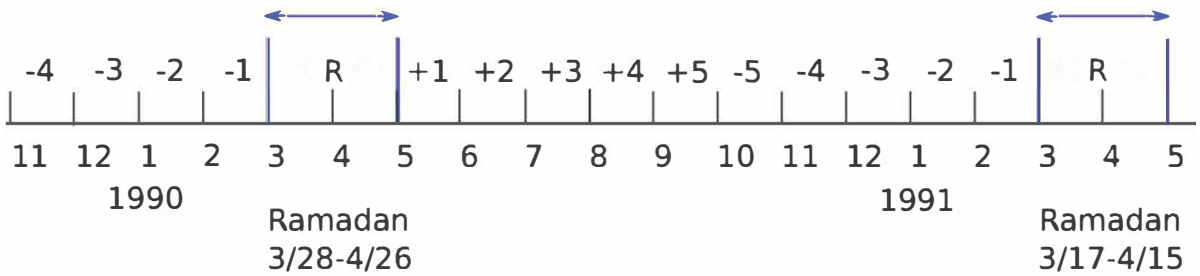
	(1) Calendar		(2) Complete calendar	
Pregnancy	0.149	(0.356)	0.148	(0.355)
Birth control use	0.357	(0.479)	0.389	(0.488)
3-month injection	0.164	(0.370)	0.168	(0.374)
Birth control pill	0.103	(0.304)	0.118	(0.323)
Implant	0.024	(0.153)	0.025	(0.156)
IUD	0.048	(0.213)	0.056	(0.230)
Condom	0.002	(0.042)	0.002	(0.045)
Traditional birth control use	0.011	(0.105)	0.013	(0.113)
Observations	222059		150259	

from the Institute of Oriental studies at the University of Zurich, following Almond and Mazumder (2011).[10] I use data at the year-month level to match monthly records from the IFLS. Figure 1 shows an example of how I construct monthly Ramadan timing measures in years 1990-1991. In 1990 Ramadan began on March 28 and ended on April 26. In a typical year Ramadan overlaps with two calendar months. I refer to the period which spans over these two months as the Ramadan cycle, in the context of the monthly data. Similarly, in 1991 Ramadan fell between March 17 and April 15, therefore the Ramadan cycle is composed of March and April.

To study whether women plan pregnancy to avoid Ramadan, I first examine whether the timing of conception responds to the timing of Ramadan, using calendar data for the years 1984-1998. I regress an indicator for whether a respondent reports conception in a given month on a set of Ramadan timing measures, which are created as follows. As shown in Figure 1, a Ramadan cycle consists of two months. I construct a dummy variable t^R equal to one in the first and the second month of the Gregorian calendar exposed to Ramadan. Similarly, variables t^{-1} - t^{-4} capture months 1-4 before Ramadan and t^{+1} - t^{+4} capture months 1-4 after Ramadan. Variable $t^{+/-5}$ denotes the remaining period since the number of

[10] The database is hosted at http://www.oriold.unizh.ch/static/hegira.html.

Figure 1: Ramadan timing measures. Example using years 1990-1991.



complete calendar months between two successive Ramadan cycles varies between 9 and 10, so that in some years there is overlap between months -5 and $+5$. Because of its equatorial location, Indonesia experiences little annual variation in daylight hours, making the duration of daytime fasting constant, regardless of the time of the year that Ramadan takes place.

I estimate the following regression:

$$p_{imy} = \sum^{k} t^{k}_{my} + \gamma_m + \delta_y + \alpha_i + \theta X_{imy} + u_{imy}, \tag{1}$$

where $p_{imy} = 1$ if respondent i conceives in month m of year y, and zero otherwise, $\sum^{k} t^{k}_{my}$ denotes the sum of Ramadan timing measures, as defined above, δ_y is a set of year fixed effects, which absorb year-to-year changes in the likelihood of conception that are common to all respondents (such as an outbreak of disease or famine caused by drought that reduces fecundity), γ_m is a set of month dummies which control for seasonality in fertility,[11] α_i is a set of mother-specific fixed effects, X_{imy} is a set of mother's characteristics in month m of year y,[12] and u_{imy} is the error term. Because of its equatorial location, Indonesia experiences little annual variation in daylight hours, making the duration of daytime fasting constant, regardless of the time of the year that Ramadan takes place.

[11]The seasonality in fertility may be driven both by exogenous environmental factors outside of maternal control and by mothers timing pregnancy for certain seasons.

[12]This term varies over time only for panel respondents for whom these characteristics change between two waves.

The point estimates of coefficients on Ramadan timing measures from Equation 1 describe how the likelihood of conception changes relative to Ramadan over the course of a calendar year, net of variation due to seasonality, annual changes in fertility common to all respondents, or the change in observable characteristics. However, they do not formally test whether fertility after Ramadan deviates from the rest of the period. For a woman who plans pregnancy to avoid Ramadan there is a limited time window of two months immediately after one Ramadan cycle ends within which she can conceive and give birth before the next cycle begins. Therefore, if women time pregnancy in order to avoid Ramadan, I expect to see an increase in the probability of conceiving in months 1-2 after Ramadan compared to the rest of the period. To that end, I estimate another regression:

$$p_{imy} = \beta^{POST} POST + \gamma_m + \delta_y + \alpha_i + \theta X_{imy} + u_{imy}, \tag{2}$$

where all terms are defined the same as in Equation 1 but the Ramadan timing measures $\sum^k t^k_{my}$ are replaced with a single dummy variable $POST$ which takes on a value of one if t^{+1} or t^{+2} are equal to one, and zero otherwise. Given that this variable omits the post-Ramadan period in the second calendar month that overlaps with Ramadan,[13] I expect that β^{POST} is a lower bound on the change in conception after Ramadan.

In order to identify causal effects of Ramadan on the timing of conception, both specifications above implicitly rely on the assumption that Ramadan timing measures are not correlated with unobservables that influence conception, conditional on controls included in the model. In particular, if Ramadan timing measures are correlated with seasonal effects, the coefficients on Ramadan measures will also capture the seasonality in fertility, rather than just the effects of Ramadan. As shown in Figure 1, each time Ramadan moves forward by approximately 11 days on to the Gregorian calendar, taking 32 years to cycle through the entire year. Therefore, the estimates derived from the calendar sample where I observe only

[13]For example, in 1991 cycle April 16-30 is excluded from the post-Ramadan period.

13 years of data[14] are subject to a concern that seasonal bias may still remain. One potential strategy to deal with an insufficient number of years is to use a comparable reference group of non-Muslims, which is subject to the same seasonal variations in pregnancy as Muslims, but not subject to Ramadan restrictions. In Indonesia, Muslims account for 88 percent of the population. Using non-Muslims as a reference group requires that the effect of living in a predominantly Muslim society on non-Muslims is inconsequential. If non-Muslims also suffer disruptions in their life during the month of Ramadan, while living in a Muslim society, then they are an inappropriate reference group. Therefore, following Van Ewijk (2011) I report results for non-Muslims living in provinces where more than half of the population is non-Muslim. As an additional check, I estimate main regressions separately for rural and urban respondents. Urban women may be less subject to seasonal fluctuations in fecundity that arise from nutritional availability or demand for labour that may affect women in agricultural production (Artadi, 2005; Dorélien, 2016); they may also be more wealthy and more able to mitigate the effects of temperature and other environmental factors.[15]

I use the timing of the first trimester as an alternative measure of the timing of pregnancy. Month of conception is likely reported with error in the calendar data. While the same holds true for the first trimester measure, constructed from the reported month of conception, I expect that it is reported more accurately (e.g. if a respondent incorrectly reports that conception occurred one month later, the first trimester constructed from her response still correctly captures 2/3 of the first trimester).

Yet another source of measurement error in the data is unreported pregnancies. In the calendar data, the share of pregnancies which end in a miscarriage or a stillbirth is 6.79 percent, significantly below the 15-20 percent figure reported in the medical literature (Fortner et al., 2007), indicating that pregnancies which ended in fetal death are less likely to be recorded in the calendar. The finding that prenatal Ramadan exposure increases the risk

[14]Calendar data entries span January of 1984 to March of 1998, but for majority of IFLS2 respondents were surveyed in 1997, which is when their calendar entries end.

[15]For these reasons, urban women may also have less incentive to time pregnancy to avoid seasonal variation in fecundity and prenatal health.

of fetal death (Almond and Currie, 2011*a*) suggests that pregnancies that overlap with Ramadan may be more likely to be missing from the data. In the extreme case, it is possible that selective reporting of pregnancies may lead to a pattern in conception that is consistent with avoidance, even in the absence of such behaviour.[16] In a more mild scenario, estimates of Ramadan timing measures will be biased because they will capture variation in conception due to timing *and* Ramadan-induced pregnancy loss. Birth control use, however, is not subject to the same concern. An additional advantage of using birth control data is that the timing of birth control use, unlike the timing of conception, is under the mother's control (subject to supply-side constraints). Therefore, measure of Ramadan avoidance based on the timing of conception captures *successfull* Ramadan avoidance. Given that the goal of this paper is to document avoidance behaviour, birth control use may be considered to more accurately represent the intended fertility decisions of the mother.

3 Results

First, I present and discuss results from estimating Equation 1 on measures of fertility using the main calendar sample. Figure 2, which plots estimates of Ramadan effects $\sum^k t^k_{my}$ on the probability of conception, reveals a clear pattern. The lowest number of conceptions is in the month before Ramadan is the month, while the highest number of conceptions takes place the second month after Ramadan.[17] The difference in the likelihood of conception between month $+1$ and month -1 is 0.7 percentage points. Although small, this number represents a 41 percent change in the likelihood of conception in the span of three months.[18] The probability of the first trimester follows the same pattern, but it suggests a smaller

[16]Suppose mothers do not time their pregnancy, all pregnancies exposed to Ramadan end in a fetal death and are not reported in the data, leaving only pregnancies conceived immediately after Ramadan. In this case, the resulting pattern may be incorrectly interpreted as evidence of mothers timing pregnancy to avoid Ramadan.

[17]The positive and statistically significant coefficient on month $+/-5$ likely arises because in most years this measure captures pregnancies conceived during two calendar months, and not one.

[18]Mean probability of conception during the calendar period is 0.017. The difference between coefficient estimates is statistically significant at 1 percent level with an F statistic of 13.88.

change in fertility around Ramadan of 23 percent relative to the mean.[19] Though the change in conception around Ramadan is evident, it is less clear whether it constitutes evidence of pregnancy timing for the purpose of Ramadan avoidance. Notably absent is a sharp increase in the likelihood of conception immediately after Ramadan; however, first trimester results are consistent with pregnancy timing, as women whose first trimester falls on months +1-+4 end their pregnancy before next Ramadan cycle begins. The decline in conception before Ramadan is consistent with pregnancy loss due to Ramadan exposure early in the pregnancy, but it is also consistent with mothers timing pregnancy to avoid exposure specifically in the second half of the first trimester and shifting pregnancy until after Ramadan.[20]

Figure 2 also shows estimates of coefficients on Ramadan timing measures on contraceptive use. As may be expected, they follow a pattern opposite to that of conception: contraceptive use peaks in months 1-2 before Ramadan, declines until the second month after Ramadan, and then remains stable. Separately estimating the Ramadan timing effects by birth control type shows that use of 3-month injections drives the results.[21] The women using injectable contraceptives are technically only partially protected during Ramadan, as they have contraceptive coverage in months -2, -1, and the first calendar month that overlaps with Ramadan, but not the second. In reality, the return to fertility after the use of injectable contraceptives is not immediate: median time to conception is estimated at 9-10 months since the last injection and cumulative probability of conception 3 months after stopping (or 6 months after the last injection) is estimated to be 10-15 percent (Pardthaisong, 1984; Pardthaisong, Gray and Mcdaniel, 1980; Schwallie and Assenzo, 1974), suggesting that only a small share of women receiving injections 2 months before Ramadan will become pregnant in the first two months after Ramadan. The slow return to fertility after use of injections is consistent with the gradual increase in conception after Ramadan, and peak

[19] Mean probability of the first trimester is 0.05. Testing the difference between point estimates of coefficients on t^{-1} and t^{+1} gives an F-statistic of 8.68, indicating that the difference is statistically significant at 1 percent level.

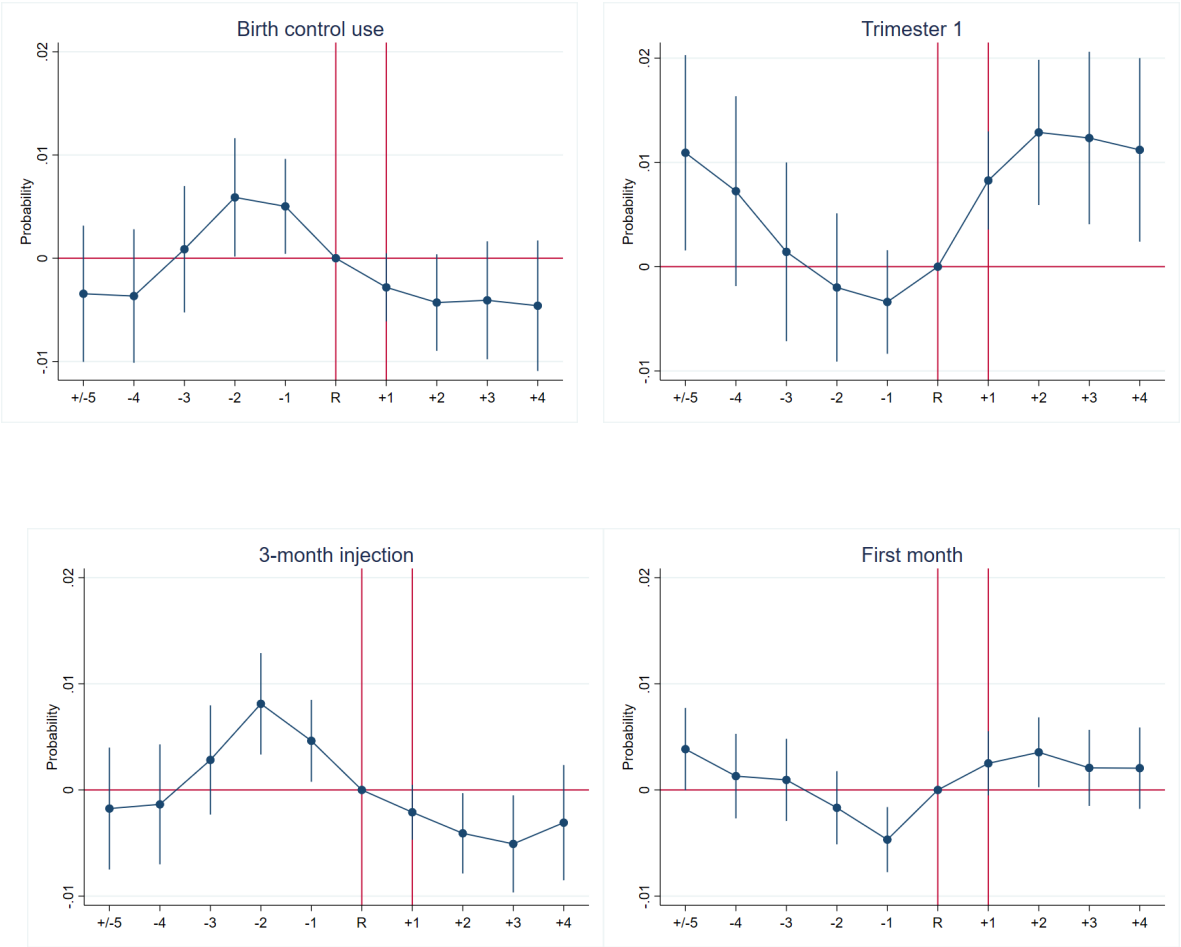
[20] If the goal is to avoid exposure to Ramadan in the first trimester entirely, then I expect the likelihood of conception is the same during Ramadan as it is in one month before Ramadan.

[21] The estimates of Ramadan effects on use of other types of birth control are shown in the Appendix.

conception occurring in month +2, rather than immediately after the fast ends.

Figure 2: Ramadan effects on fertility and contraceptive outcomes

(1) Contraceptive use (2) Fertility



Notes: This figure shows estimates of coefficients on Ramadan timing measures from Equation 1, using main calendar sample for years 1984-1998. Standard errors are clustered at mother level. 95 percent confidence intervals are used.

Separating the sample into women who do and do not use injections[22] reveals substantial heterogeneity in fertility behaviour between the two groups (Figure 3). While the decline in conception before Ramadan is evident in both groups, injection non-users show no evidence of an increase in conceptions after Ramadan. Conversely, there is a pronounced increase in conception after Ramadan for the users. Trends in the first trimester show similar patterns.

[22] I define an injection user as a respondent who reports having used 3-month injectable contraceptives at least once during the calendar period

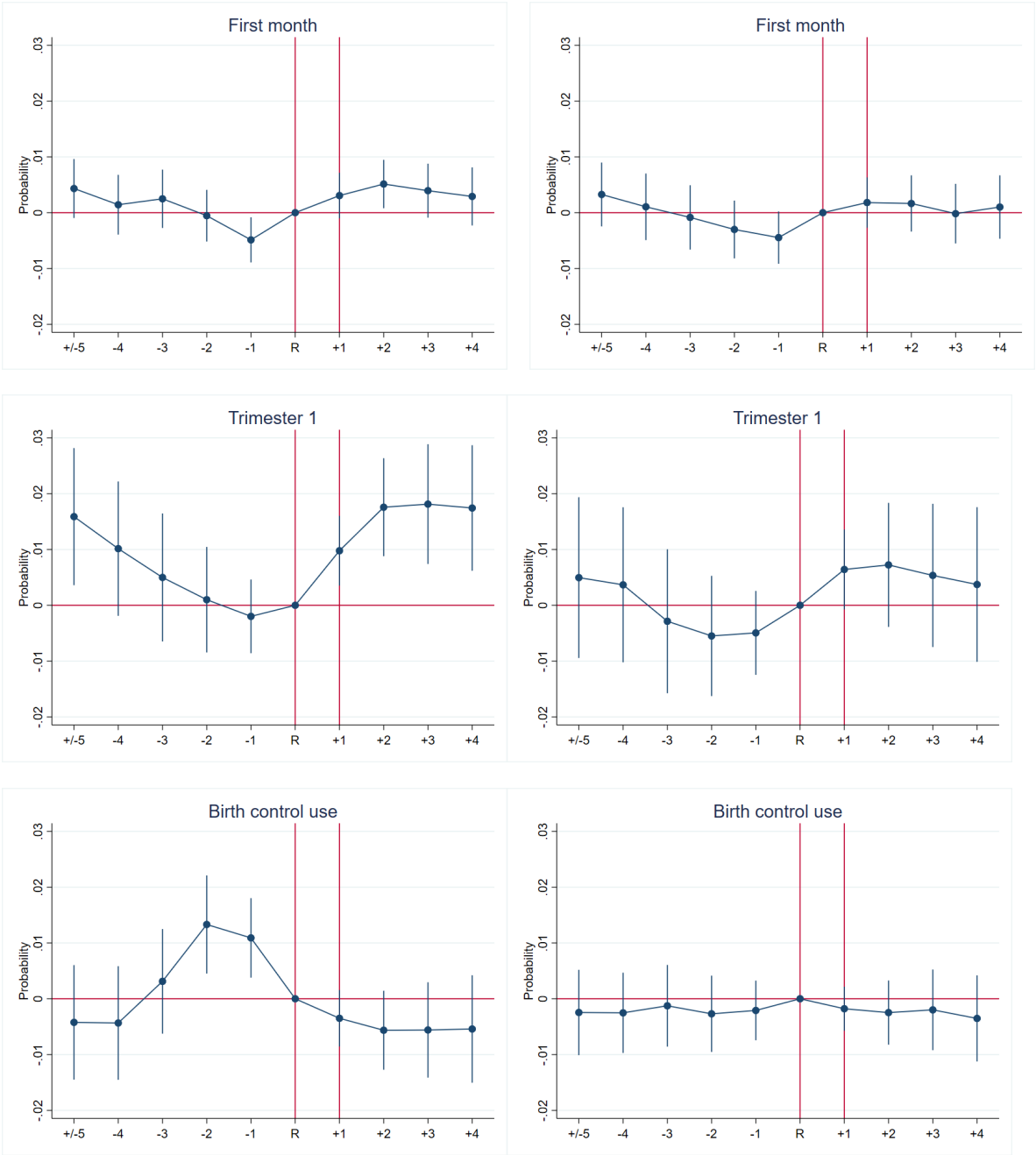
Notably, non-users do not rely on other contraceptives to time pregnancy relative to Ramadan (bottom panel). It remains unclear whether the drop in conception before Ramadan is intentional or an artifact of selection in reported pregnancies. It is possible that it is a result of different mechanisms for different groups of women: it may reflect intentional shift in conceptions from before Ramadan to after Ramadan by the users and an increase in fetal deaths for non-users. However, it is also possible that both users and non-users experience pregnancy loss, or both groups intentionally avoid conception during this period, with non-users simply forgoing pregnancy altogether, rather than shifting it to a later period.

Next, I estimate Equation 2, which allows me to formally test whether the fertility behaviour in the period immediately following Ramadan deviates from the remaining period, with results presented in Table 3. Column 1 reports the estimates of β^{POST} from the most parsimonious specification, where I include no other controls except for the indicator variable denoting the period of two months after Ramadan. This correlation includes the variation in fertility behaviour after Ramadan that includes variation due to seasonal effects, age, and other covariates. The top panel reports results using the indicator for the month of conception as a dependent variable. The point estimate is negative and insignificant. In Column 2 I add month fixed effects, which absorb the variation due to seasonal fluctuation in conception. The point estimate on the $POST$ dummy is 0.0023 and statistically significant at 5 percent level. The change in coefficient estimates from the specification in Column 1 to Column 2 indicates that controlling for seasonal variation in conception is important, and that the bias from seasonal effects pushes the point estimate downwards. The point estimates in Column 3, where I include controls for year fixed effects, and Column 4 where I include the full set of controls, remain relatively stable at 0.0021. These results suggest that the probability of conception is 0.2 percentage points higher 2 months after Ramadan compared to the rest of the period. In other words, in the two months after Ramadan, there is a 12 percent increase in conceptions that cannot be accounted for by the set of covariates used in specification 2.

Estimates of coefficients on Ramadan timing measures $\sum^k t^k_{my}$ indicate a drop in con-

Figure 3: Ramadan effects on fertility and injection use

(1) Injection users (2) Injection non-users



Notes: This figure shows estimates of coefficients on Ramadan timing measures from Equation 1, using main calendar sample for years 1984-1998. Standard errors are clustered at mother level. 95 percent confidence intervals are used.

Table 3: Ramadan effects on fertility and injection use

	(1)	(2)	(3)	(4)	(5)
			Month of conception		
POST	-0.0009	0.0023**	0.0021**	0.0021**	0.0019*
	(0.0008)	(0.0011)	(0.0011)	(0.0011)	(0.0011)
PRE					-0.0038***
					(0.0011)
			First trimester		
POST	-0.0006	0.0054***	0.0048***	0.0047**	0.0045**
	(0.0018)	(0.0019)	(0.0018)	(0.0018)	(0.0018)
PRE					-0.0048***
					(0.0019)
			3-month injection		
POST	-0.0030***	-0.0025***	-0.0017*	-0.0012	-0.0009
	(0.0009)	(0.0009)	(0.0009)	(0.0009)	(0.0009)
PRE					0.0058***
					(0.0017)
Month FE		X	X	X	X
Year FE			X	X	X
Full set of covariates				X	X
Observations	222059	222059	222059	222059	222059

Notes: This table presents estimates of Equation 2. Robust standard errors are in parenthesis, and clustered at the mother level. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

ception before Ramadan, and I cannot rule out that this drop is unintentional. Therefore, without explicitly controlling for the two months before Ramadan, it is included in the reference period and leads to an upward bias in the estimate of a change in conception post-Ramadan. In the final specification, reported in Column 5, I include an additional covariate PRE, which takes on a value of one when t^{-1} or t^{-2} are equal to one, and zero otherwise. As expected, the coefficient estimate on the PRE dummy is negative and statistically significant. However, what is important is that the estimate of β^{POST} remains virtually unchanged between specifications, pointing to the fact that even after controlling for the period with much lower conception rates, there is a small, but statistically significant increase in conception after Ramadan relative to the rest of the period. First trimester results, reported in the

second panel of Table 3 are very similar, suggesting a 9 percent increase in conceptions after Ramadan.

The bottom panel reports the results with an indicator for use of 3-month injectable contraceptives as the dependent variable. The estimates with and without controlling for month fixed effects are very close (-0.003 vs. -0.0025), suggesting that the extent of seasonality bias in the estimates is much smaller compared to the seasonal bias in the timing of pregnancy. Adding year effects reduces the magnitude of the estimate to 0.0017, while the magnitude of the standard error remains the same. Including the full set of covariates reduces the estimate further to 0.0012, and it is also no longer statistically significant. The lack of a change in the use of injections after Ramadan is not surprising given the results shown in Figure 2. The main variation in use of injections takes place before Ramadan, reflecting the need to use such contraceptives early to ensure return to fertility during the optimal conception period for Ramadan avoidance. Adding the control for the pre-Ramadan period produces a precisely estimated coefficient of 0.0058 in the PRE dummy, while the coefficient on the $POST$ dummy is -0.009 but the confidence interval still includes 0. The proportional change in birth control use before Ramadan (of 4 percent relative to the mean, confidence interval is 3-5 percent) is smaller compared to the proportional change in conception after Ramadan (9-12 percent of the mean, confidence interval is 5-18). On the one hand, this difference may indicate that the extent of timing behaviour is understated when looking strictly at birth control use because this measure excludes the women who do not rely on contraceptive use to time pregnancy. On the other hand, it is possible that the coefficients are simply imprecisely estimated given the overlap in confidence intervals.

4 Discussion

4.1 Non-Muslims

I investigate the comparison between Muslims and non-Muslims in Table 4. The sample of non-Muslims is selected based on the same rules as the sample of Muslims for the main analysis. Out of the sixteen provinces in which the IFLS respondents reside, there are only two provinces where the share of Muslims is below fifty percent: Bali, where 11 percent of the population is Muslim, and North Sumatra, where 47 percent of the population is Muslim. I estimate Equation 2, including an additional control for the pre-Ramadan period. Column 1 reports coefficient estimates on $POST$ and PRE variables for the Muslims living in the two provinces. Although most of the point estimates are not statistically significant, they have the same sign and are of comparable to magnitudes to the estimates derived from estimating Equation 2 on the full sample.[23] Column 2 reports the estimates for non-Muslims: in case of the month of conception and the first trimester, estimates on the Ramadan dummies are the same sign as in the Muslim sample, although generally about twice as large. In the case of injectable contraceptive use, the results for non-Muslims indicates essentially no change in use prior to Ramadan (the estimate is close to zero but not precisely estimated), but a statistically significant decline in use after Ramadan.

Based on this comparison, it is not immediately clear that fertility behaviour of non-Muslims relative to Ramadan differs from fertility behaviour of Muslims. Given that the two provinces have substantially different Muslim population shares and one province is just below the somewhat arbitrary cutoff of fifty percent, I disaggregate the analysis by province. Column 3 indicates that the patterns in the timing of pregnancy and the timing of birth control use for Muslims living in low-Muslim provinces are qualitatively the same as in the main sample. Notably, non-Muslims in the low-Muslim province do not exhibit any evidence of the timing of pregnancy changes around Ramadan: coefficient estimates on the PRE and

[23] The one exception is use of birth control injections, where the estimate of β^{POST} from this restricted sample of Muslims is twice the magnitude of the estimate from the full sample.

Table 4: Ramadan effects on fertility and injection use, comparison between Muslims and non-Muslims

	(1)	(2)	(3)	(4)	(5)	(6)
	Pooled		Low Muslim share		High Muslim share	
	Muslims	Non-muslims	Muslims	Non-muslims	Muslims	Non-muslims
			Month of conception			
POST	0.003	0.006	0.013	-0.001	0.002	0.010
	(0.005)	(0.005)	(0.013)	(0.005)	(0.005)	(0.008)
PRE	-0.006	-0.006	-0.007	-0.005	-0.006	-0.007
	(0.005)	(0.005)	(0.015)	(0.005)	(0.005)	(0.007)
			First trimester			
POST	0.004	0.010	0.008	-0.005	0.004	0.021
	(0.008)	(0.008)	(0.022)	(0.008)	(0.008)	(0.014)
PRE	-0.005	-0.010	0.019	-0.002	-0.006	-0.015
	(0.007)	(0.007)	(0.015)	(0.008)	(0.007)	(0.010)
			3-month injection			
POST	0.002	-0.005**	-0.002	-0.009**	0.002	-0.001
	(0.002)	(0.002)	(0.008)	(0.004)	(0.002)	(0.001)
PRE	0.012**	0.002	0.029*	0.005	0.011**	-0.002
	(0.005)	(0.003)	(0.015)	(0.006)	(0.005)	(0.001)
Observations	12730	16694	1338	10395	11392	6299

Notes: This table presents estimates of Equation 2, with an additional control for two months in pre-Ramadan period, *PRE*. Robust standard errors are in parenthesis, and clustered at the mother level. All regressions include the full set of controls. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

POST dummies are the same sign. Although in the case of injection use, the signs on the two dummies are the same across samples, the magnitudes are markedly different. Notably absent is the increase in use of injectable contraceptives among non-Muslims: estimate of β^{PRE} is 0.005 with a standard error of 0.006, compared to the Muslim sample where estimate of β^{PRE} is 0.029 with a standard error of 0.015. The only significant coefficient in the sample of non-Muslims is on the *POST* dummy variable, indicating a decline in the use of birth control injections. Comparing Muslims and non-Muslims in the high-Muslim province shows similar patterns in the timing of pregnancy, although estimates from the non-Muslim sample are much larger in magnitude. The similarity in the coefficients - at least in terms of their

signs - may indicate that the changes in fertility observed around Ramadan in the Muslim population is due to insufficient seasonal controls. This explanation seems unlikely because if the coefficient estimates in the non-Muslim sample capture seasonal effects, and the incentive to time produces variation in the same direction as the seasonal effects, I would expect the estimates in the Muslim population to be biased upwards. However, the point estimates in Column 5 are consistently smaller in magnitude than the estimates in column 6.

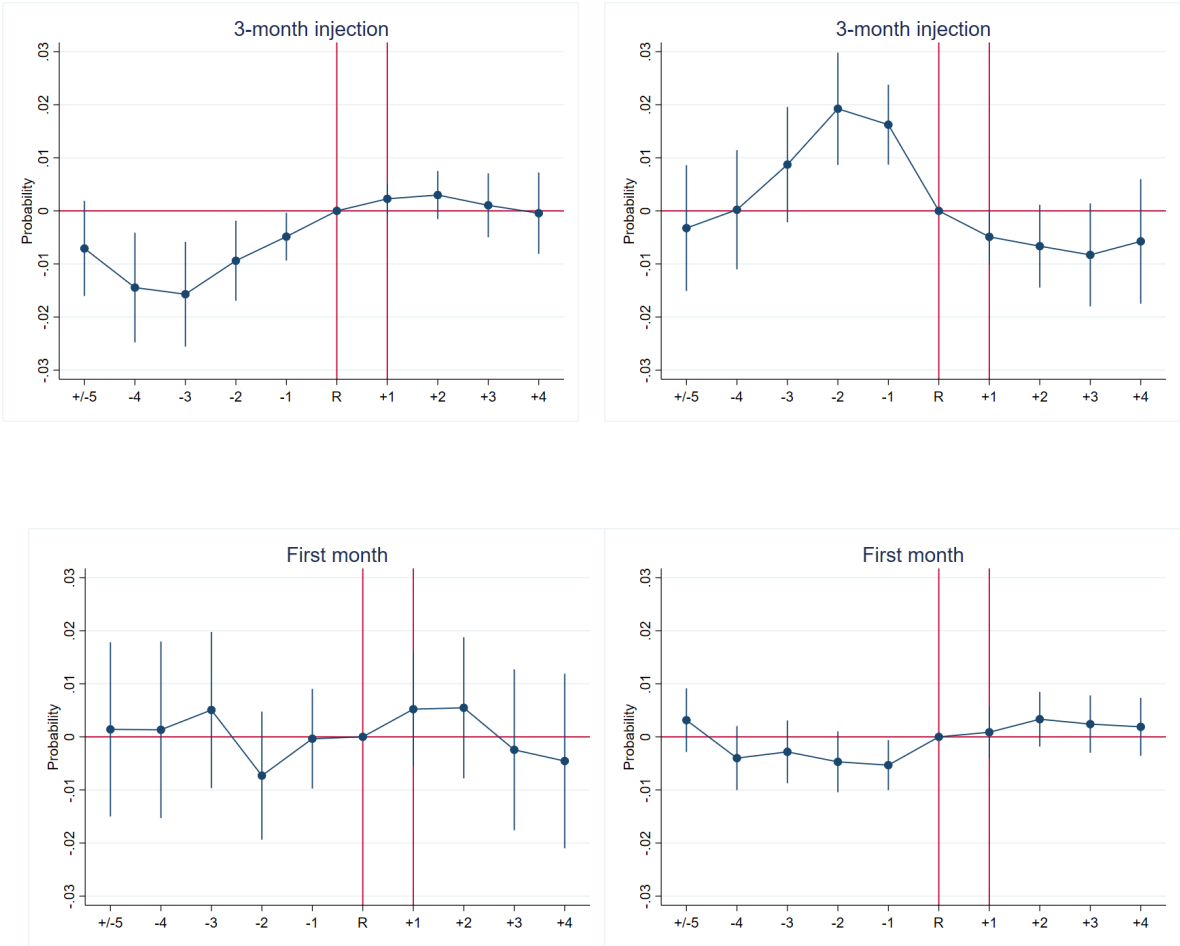
Although this comparison is hampered by small sample sizes, it nonetheless provides suggestive evidence that the patterns documented above for the main sample of Muslims are not an artefact of insufficient seasonality controls, but rather capture intentional behaviour by the mothers.

4.2 Heterogeneity

Next, I turn my attention to heterogeneity in fertility responses to Ramadan. Other papers studying the determinants of the timing of births note that the timing behaviour is more likely for second and higher-order pregnancies (LaLumia, Sallee and Turner, 2015; Shigeoka, 2015). I investigate whether I observe the same pattern in this context. For this analysis, I focus on the subsample of women who report two or more pregnancies during the calendar period. I separate the calendar into two time periods: before the end of the first pregnancy (up to and including the last month in which a woman reports being pregnant), and after the end of first pregnancy. Estimates of Equation 1 on two subsamples are plotted in Figure 4. First, although the trends in the month of conception are not precisely estimated, both subsamples show a drop in conceptions before Ramadan. Second, the timing of injection use between the two periods is very different. Before the end of the first pregnancy, the use of injections is the lowest 3-4 months before Ramadan, while after the first pregnancy I observe the peak in injection use in month -2 seen in the main calendar sample.

Figure 4: Ramadan effects on use of 3-month injectable contraceptives and the month of conception by birth order, using complete calendar sample

(1) Before the end of first pregnancy (2) After the end of first pregnancy



Notes: This figure shows estimates of coefficients on Ramadan timing measures from Equation 1, using complete calendar sample for years 1984-1998. Standard errors are clustered at mother level. 95 percent confidence intervals are used.

Column 1 shows that there is no evidence of a change in the likelihood of using of injections around Ramadan - coefficients on PRE and $POST$ dummies are not statistically significant. In contrast, the coefficients on the Ramadan dummies estimated using the period after the first pregnancy are virtually identical to the coefficients from the main calendar (Table 3, Column 5), indicating that it is the use of injections after the first pregnancy that drives the results I observe in the data. The difference in estimated coefficients by pregnancy

order also points to the low likelihood of seasonal bias in the contraceptive use estimates, as there is no immediately obvious reason why seasonally bias would differ by pregnancy order.[24] Estimates of β^{POST} and β^{PRE} are much larger in magnitude for the first pregnancy subsamples compared to later pregnancies, although the standard errors are also large.

Table 5: Ramadan effects on fertility and injection use, comparison between first and later pregnancies

	Injection		Month of conception	
	Before	After	Before	After
	(1)	(2)	(3)	(4)
	3-month injection	3-month injection	First month	First month
POST	0.0012	-0.0011	0.0067*	0.0006
	(0.0009)	(0.0014)	(0.0039)	(0.0012)
PRE	-0.0014	0.0057**	-0.0052	-0.0024*
	(0.0014)	(0.0028)	(0.0039)	(0.0013)
Conf. interval for $\beta_2^{POST} - \beta_1^{POST}$	(-0.0088 -0.0006)		(-0.0138 0.0022)	
Conf. interval for $\beta_2^{PRE} - \beta_1^{PRE}$	(0.0011, 0.0144)		(-0.0055 0.0104)	
Observations	39029	111230	39029	111230

Notes: This table presents estimates of Equation 2, with an additional control for two months in pre-Ramadan period, *PRE*. Robust standard errors are in parenthesis, and clustered at the mother level. All regressions include the full set of controls. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

I also briefly examine whether there are differences by education or urban status. I interact two Ramadan timing dummies with an indicator for living in urban area (or having high educational attainment)[25] I find no difference between urban and rural respondents (columns 2 and 4), not in conception use nor the use of birth control.

Columns 2 and 3 report the results from investigating heterogeneity by education status. Although women with high education are not more likely to use birth control injections before Ramadan compared to low education women, they are 0.5 percentage points more likely to conceive in two mothers after Ramadan, while low education women do not show an increase in conception after Ramadan. My results suggest that although more educated women are not any more likely to use contraceptives before Ramadan to avoid conception, they are

[24] Unless the seasonal bias stems from mothers timing pregnancy to avoid seasonal fluctuations in prenatal health, and the timing behaviour differs by parity - in this case, the seasonal bias will also differ by parity.

[25] I define low educational attainment as elementary education or lower, and high educational attainment as having education above elementary level.

more likely to successfully conceive after Ramadan compared to low education women. It may because they receive injections early in month -2 so that they experience a shorter delay to fertility after Ramadan, or it may be that they are more healthy and fecund.

Table 6: Heterogeneity in effects of Ramadan

	Injections		Month of conception	
	(1)	(2)	(3)	(4)
	3-month injection	3-month injection	First month	First month
PRE	0.0054**	0.0058***	-0.0060***	-0.0042***
	(0.0023)	(0.0015)	(0.0021)	(0.0012)
POST	-0.0017	-0.0011	-0.0032	0.0021*
	(0.0018)	(0.0010)	(0.0021)	(0.0012)
PRE x high education	0.0004		0.0014	
	(0.0022)		(0.0022)	
POST x high education	0.0013		0.0052**	
	(0.0020)		(0.0021)	
PRE x urban		-0.0003		-0.0015
		(0.0018)		(0.0015)
POST x urban		0.0013		-0.0015
		(0.0015)		(0.0015)
Observations	222059	222059	222059	222059

Notes: This table presents estimates of Equation 2, with an additional control for two months in pre-Ramadan period, *PRE*. Robust standard errors are in parenthesis, and clustered at the mother level. All regressions include the full set of controls. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

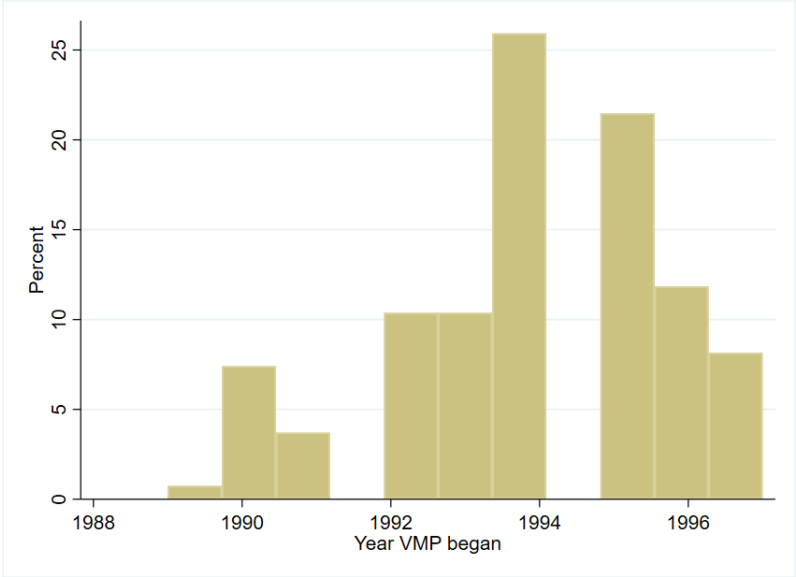
4.3 Birth control access

As mentioned before, modern methods of family planning were introduced to Indonesia starting in the 1970s. Low awareness of modern contraception in the absence of the family planning program suggests that variation in the coverage of the family planning program provides an exogenous source of variation in access to contraceptives. Therefore, comparing fertility response to Ramadan before and after the introduction of family planning can provide evidence on whether the availability of birth control affects Ramadan avoidance behaviour.

As the Village Midwife Program increased the prevalence of birth control injections (Weaver et al., 2013), and my results indicate that the injectables are the most popular method of birth control used to time pregnancy to avoid Ramadan, I investigate whether

this program influenced timing behaviour. Here I take advantage of the rich community-level data collected in the IFLS, which includes interviews with village leaders. Village leaders provided information on whether a midwife is present in the village, and in which year she began practice. I restrict the sample to mothers for whom community information is available. Based on this data, I construct a measure of availability of a village midwife in a given community in a given year. Distribution of the first year of the VMP is shown in Figure **??**, for the 5 communities ever receive a VMP. The roll-out of the program is slow, peaking mid-nineties, after which it declines. From the 298 communities with non-missing information on VMP (out of 313), just under half report having ever had a VMP. For the calendar subsample where I observe complete fertility history for 1,368 respondents, 1,183 have non-missing VMP data and 222 respondents experienced a change in VMP during the calendar.

Figure 5: Distribution of the first year VMP began among communities.

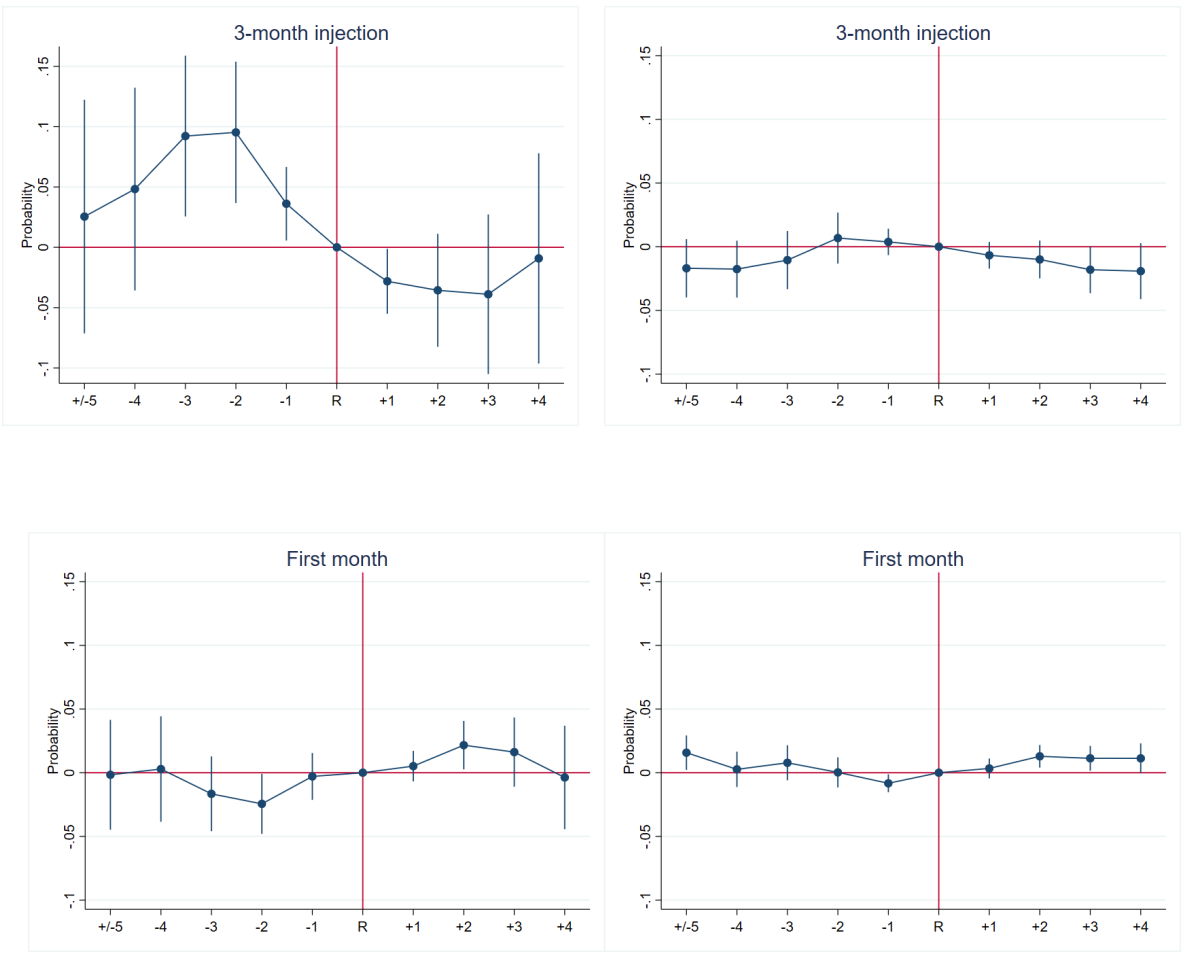


I then estimate Equation 2 separately for individuals living in communities that ever received a VMP before and after the program began, focusing on the period after the first pregnancy where I expect to observe timing behaviour. The results, shown in Figure 6,

indicate that although both trends peak around month −2, the estimated trend for the no-VMP sample is quite flat. It is notable that the trends injection use are much less precisely estimated in the no-VMP sample, despite much larger sample size. Before introduction of VMP conception did not increase after Ramadan, although we still observe a decline in reported conceptions in month −1. After introduction of VMP, we observe a clear increase in conception in month +2, consistent with Ramadan avoidance.

Figure 6: Ramadan effects on use of 3-month injectable contraceptives and the month of conception, after first pregnancy, using complete calendar sample, by presence of VMP

(1) VMP (2) No VMP



Notes: This figure shows estimates of coefficients on Ramadan timing measures from Equation 1, using the period after the first pregnancy from the complete calendar sample for years 1984-1998. Standard errors are clustered at mother level. 95 percent confidence intervals are used.

The decline in conception before Ramadan is present in both sub-samples, but the point estimate is more than five times as large as the estimate using the non-VMP period. One the one hand, given that VMP lesd to improvements in maternal and child health (Frankenberg et al., 2009; Frankenberg and Thomas, 2001; Frankenberg, Suriastini and Thomas, 2005), I expect that VMP also led to improvements in prenatal health and fetal viability (which in turns affects the likelihood of being reported in the data). Therefore, if the decrease in conception before Ramadan is due to selection on pregnancy survival in the data, I expect the magnitude to shrink as fetal health improves with VMP. However, another potential mechanism is that VMP also provided mothers with contraceptives enabling them to successfully shift conception from before Ramadan until after Ramadan, exacerbating the existing patterns in conception. This ambiguity in interpretation of the estimates using the data on reported pregnancies further highlights the advantage of including birth control use in the analysis.

5 Conclusion

I find evidence that women in Indonesia time pregnancy to avoid Ramadan. I also find that family planning methods play an important role in Ramadan avoidance in Indonesia. In particular, I find strong effects of Ramadan on the timing of contraceptive use. Probability of using 3-month injectable contraceptives increases by 0.6 percentage points or 4 percent relative to the mean probability of using injectables in any month. I find less precisely estimated effects on the timing of conception, which suggest that the probability of conceiving in the first two months after Ramadan increases by 0.2 percentage points, or there is a 12 percent increase in the likelihood of conception after Ramadan relative to the likelihood of conception in an average month. My results also suggest that mothers learn from their prior experience of pregnancy during Ramadan, as I find that the timing behaviour is absent in the first pregnancy, and only apparent in later pregnancies.

My findings imply that, at least in the context of Indonesia, some mothers do time pregnancy to avoid Ramadan. However, the extent of Ramadan avoidance is relatively small and avoidance behaviour is concentrated in the period of expansion of the Village Midwife Program. I do find some evidence of adverse selection into exposure as mothers with higher educational attainment are more likely to conceive during the optimal conception period for Ramadan avoidance (although they are not more likely to use injections). Overall, the implication of my findings for research on Ramadan exposure is that even if the assumption of avoidance does not hold in Indonesia, the extent of this behaviour is small so it is not likely to bias the results of earlier studies, which assume that mothers do not systematically select into Ramadan exposure during pregnancy.

I also find that family planning programs which were implemented in Indonesia influenced Ramadan avoidance behaviour. Specifically, I find no evidence of avoidance before the introduction of the Village Midwife Program. The result that mothers use birth control injections to plan pregnancy to avoid Ramadan points to a new interpretation of earlier literature on the consequences of the Village Midwife Program in Indonesia. The combination of findings that the program led to an improvement in child outcomes, and a higher share of women switching to injectable contraception, suggests a possibility that use of birth control to avoid predictable adverse conditions during pregnancy may have been partially responsible for the positive change in child health.

More generally, my results suggest a previously unexplored channel through which access to contraceptives may improve children's health outcomes. Infant mortality and child health are strongly correlated with the season of birth in developing countries. Provided a mother can observe a correlation between season of birth and child outcomes (or learn about it through other channels) or if she is simply less comfortable being pregnant during less favourable seasons, then she has an incentive to time pregnancy to avoid an adverse seasonal variation in the prenatal environment. Alternatively, my findings also point to a potential way to enhance family planning programs. My work implies that educating women about

seasonal variation in pregnancy health and the potential of using contraceptives to avoid such damage may improve child health in developing countries.

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