The Missing Men: Combined Micro and Macro Evidence in Relation to Prenatal Fasting

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Abstract

In contrast to the recognized problem of the 100 million "missing" women due to gender discrimination, the problem of the "never-born" men due to religious fasting has so far been neglected. In the attempt to quantify the magnitude of the latter, I combine micro- and macro-level evidence showing that Ramadan fasting among pregnant women distort the sex ratio of their offspring in favor of females. From this, I estimate that around two million men are missing simply due to the practice of prenatal fasting. This might in turn have consequences for the actual number of missing women.

Keywords: Sex ratio, missing women, missing men, selective mortality, fasting, Ramadan.
JEL: I12, J16, O15, Z12.

1 Introduction

An abundant economic literature has provided evidence that stress-related events in utero have negative impacts on later in life outcomes, such as health, education, and earnings (for comprehensive reviews, see e.g. Almond & Currie 2011*a*, Almond & Currie 2011*b*). However, not only do such adverse events affect human development in the long term, they also influence which of the exposed fetuses are born alive as well as whom of the these children survive until adulthood. Thus, it is also well-established that maternal stress can skew the sex ratio in favour of females, as male fetuses are more fragile (e.g. Almond, Edlund, Li & Zhang 2010, Almond & Mazumder 2011, Kraemer 2000, Roseboom, Van Der Meulen, Ravelli, Osmond, Barker & Bleker 2001).

At the same time, it a well-known problem that Asia and North Africa have a deficit of approximately 100 million women (Sen 1990). Strong gender preferences result in excess female mortality in childhood largely due to unequal access to healthcare and increasingly in sex-selective abortions (Klasen & Wink 2003, Ebenstein 2010). However, a factor which, at the same time, might mitigate the distortion of the sex ratio is the vulnerability of male fetuses to adverse shocks in utero and has yet not been considered in the missing women literature.

One paper has previously attempted to explain the missing women problem from a medical point of view (Oster 2005), claiming that hepatitis B carriers are more likely to conceive males. This, in turn, could explain 45 percent of the 100 million missing women. However, the conclusion has been widely criticized (e.g. Gupta 2006, Ebenstein 2010), and Oster, Chen, Yu & Lin (2010) show that hepatitis B cannot explain the excess of males in China. In contrast to this dispute, this paper is based on the well-established knowledge on fragility of male fetuses in response to adverse events in utero (e.g. Catalano & Bruckner 2006, Kraemer 2000).

The source of intrauterine stress considered in this paper is prenatal Ramadan fasting among Muslims. However, the same issue might also be relevant for fasting according to other beliefs (e.g. Orthodox Christians), exposure to famine, or simply due to breakfast skipping or morning sickness during pregnancy. The only difference is that Ramadan fasting is a widespread and recurrent event among the world's 1.6 billion Muslims (Grim & Hsu 2011). Since the majority of these live in countries suffering under the missing women problem, the repeated occurrence of prenatal fasting might have some important implications for the extent of the problem.

A recent focus in the fetal origin literature regards the adverse event of maternal Ramadan fasting during pregnancy for Muslims (Almond & Mazumder 2011, Almond, Mazumder & Ewijk 2014, van Ewijk 2011, van Ewijk, Painter & Roseboom 2013). During the Ramadan, which is shifted 11 days each year due to the Islamic lunar calender, Muslims are obligated to fast from sunrise to sunset. Although pregnant women can be exempted from this religious obligation, the fact that they often have to pay a compensation and fast alone afterwards means the vast majority of pregnant women do fast during Ramadan. Thus, Ramadan exposure during gestation is considered a natural experiment of exposing the mother's body to stress.

Two studies examine potential selection effects due to prenatal Ramadan fasting by looking at the sex composition predominantly among adults (Almond & Mazumder 2011, van Ewijk 2011). Both find a negative impact on the share of men. A weakness of these papers is, however, that they only use cross-sectional data and are thus not able to control for potential omitted variables or endogenous timing of conception.

Consequently, my first contribution is to document that, controlling for maternal fixed effects, the sex ratio is distorted at the time of birth for multiple developing countries over a time period of 32 years. I do this by applying detailed data on all recent births and not only on those children remaining alive at the time of the interview. For this micro-level analysis, I apply DHS data from Bangladesh, Egypt, Indonesia, Jordan, Morocco, Pakistan, and Turkey from 1987 to 2013.

If a change in the sex composition is a general consequence of prenatal Ramadan fasting during certain stages of gestation, Muslim countries suffering under the acknowledged problem of missing women might in fact also be affected by a completely neglected problem of missing men. In case of this, we should be able to observe country-wide effects for Muslim populations both as a comparison between Muslim and non-Muslim countries as well as within countries due to differences in the share of Muslims across regions and time. Based on this, my second contribution is to show that there is a positive relationship between the share of females and Muslims across countries and within provinces. In other words, Muslim populations have generally more women than other societies in Asia and Africa with similar son preferences.

Finally, I contribute to the literature by combining the micro- and macro-level evidence, thereby estimating the number of missing men to be between 1.22 and 3.05 million men across the 61 considered Asian and African countries. Compared to the approximately 100 million women missing due to gender discrimination, roughly two million "never-born" male fetuses, due to their fragility to adverse events in utero, might seem to be a small problem. However, in the absence of religious fasting, the latter problem would imply that the sex ratio would be skewed even more, meaning that the extent of the former problem might in fact yet be larger than our existing estimates.

The rest of this paper is organized as follows: Section 2 provides a background for the medical literature in relation to prenatal fasting. Section 3 presents the micro-level analysis, while section 4 provides comparisons of sex ratios across countries and provinces. Thereafter, section 5 combines the micro and macro analysis, providing an estimate of the number of missing men caused by Ramadan fasting. Finally, section 6 concludes.

2 Literature Background

2.1 Ramadan Fasting

2.1.1 The Settings around the Ramadan

During the holy month of Ramadan, all adult Muslims are obligated to fast during the hours from sunrise to sunset, prohibiting any intake of food or drinks during this time span. Typically, each evening during this month, the fast is disrupted with sweet food and drinks as part of a social event where family and friends meet. Further, the meal before dawn is usually comprised by fat-rich food. Generally, people reduce their overall physical activity during Ramadan (Alkandari, Maughan, Roky, Aziz & Karli 2012). Some groups are, though, exempted from this religious obligation, such as persons, for whom it may have negative health consequences. However, for each day a Muslim misses fasting, he or she has to fast another day when it becomes possible and often has to pay a penalty to feed the poor (van Ewijk 2011).

Pregnant women are exempted from fasting if they believe it will harm their own health or the one of their fetus. According to van Ewijk (2011), some Muslims interpret this as an obligation to fast during pregnancy except in case there is a specific health reason for skipping fasting. On the other hand, other Muslims understand the regulation as a dispensation from fasting. Nevertheless, the latter group most often chose to fast anyway. This explains why studies across countries find that between 70 and 90 percent of all pregnant Muslim women do in fact fast at least partly during Ramadan; these studies cover Iran, Singapore, Yemen, Gambia, Pakistan, and the United States (Arab & Nasrollahi 2001, Joosoph, Abu & Yu 2004, Makki 2002, Mubeen, Mansoor, Hussain & Qadir 2012, Prentice, Prentice, Lamb, Lunn, Austin et al. 1983, Robinson & Raisler 2005).

2.1.2 Direct Health Effects of Prenatal Fasting

Normally, the body's main source of metabolic fuel is glucose; when fasting, the glucose level falls significantly, which is called hypoglycaemia or low blood sugar (van Ewijk 2011). As a normal response to a shortage of glucose, the body compensates for this by switching to the fat metabolism. This increases the ketone level in blood by destroying proteins, which in itself can have severe effects for the mother, such as tissue damage, organ failure, and death. The greatest problems arise, nevertheless, for the fetus as intrauterine death is often caused by elevated levels of ketone. This process is also what happens during starvation.

Metzger, Vileisis, Ravnikar & Freinkel (1982) found that pregnant women skipping breakfast already after this prolonged time of nocturnal fasting experienced signs of starvation in contrast to non-pregnant women, calling it *accelerated starvation*. Furthermore, signs of accelerated starvation occur faster when fasting during the day due to higher energy demands while being physically active (Meis, Rose & Swain 1984). Also, Mirghani, Weerasinghe, Smith & Ezimokhai (2004) find significant correlations between the number of fasted days and the glucose level, suggesting a cumulative effect of glucose level during maternal fasting. In short, the medical literature suggests metabolic changes during fast among pregnant women, thereby showing a clear connection between fasting and accelerated starvation (for comprehensive reviews of the biological literature, see Almond & Mazumder 2011, Hoffmann 2014, van Ewijk 2011).

2.2 The Sex Ratio

Within the medical literature, there is agreement that severe fetal stress is associated with a larger proportion of female births, as male fetuses tend to be more affected by intrauterine stress (Kraemer 2000). Based on this, the literature suggests two potential mechanisms, skewing the sex ratio in favor of females in situations of maternal stress, referred to as culling and scarring (Catalano & Bruckner 2006). In this framework, it is assumed that fetal survivability follows a normal distribution and that the mean for males is lower than that for females. Moreover, the mother is able to spontaneously abort the fetus when fetal health falls below a certain threshold. The culling mechanism is in accordance with the Trivers-Willard hypothesis, stating that the threshold increases when experiencing an adverse environment, thereby leaving a positively selected cohort. In contrast, the scarring mechanism argues that the fetal health distributions are negatively affected by adverse shocks, whereby the cohort is left negatively selected. Common for both mechanisms is that due to inferior health of males, maternal stress induces the abortion of more male than female fetuses, distorting the sex ratio.[1]

In favor of the Trivers-Willard hypothesis, Mathews, Johnson & Neil (2008) find a strong positive relationship between maternal nutrient intake in the lead up to conception and the incidence of male fetuses. In particular, they find that eating breakfast prior to pregnancy is strongly correlated with fetal gender. This indicates that skipping breakfast and, thereby, extending nocturnal fasting causes the body to perceive the environment as being hostile.[2]

Another study of maternal nutrition is Villamor, Sparén & Cnattingius (2008), examining inter-pregnancy weight gain between the first prenatal visit for respectively the first and second pregnancy. This study provides evidence that those mothers having reduced their BMI with more than one unit are 1.4 percent more likely to give birth to a girl than those mothers who had an absolute change of less than one unit.

Furthermore, in the context of prenatal Ramadan fasting, Almond & Mazumder (2011) and van Ewijk (2011) find effects of prenatal Ramadan exposure during the time in utero on the share of men. For the Ugandan and Indonesian samples (only containing retrospective data) of these two studies, they both find effects throughout the whole period of pregnancy. More precisely, among Ugandan Muslim adults, the probability of being male decreases with 2.0 percentage points if the person was exposed to a Ramadan nine months prior to birth (Almond & Mazumder 2011). Similarly, for Indonesian Muslims, there are indication that those exposed to a Ramadan at some point during gestation are 2.6 percentage points less likely to be male (van Ewijk 2011). The largest estimate when decomposing the timing of exposure for the latter sample is found for persons born during Ramadan, being opposite to what would have been expected. In contrast, for the sample of Arab children born in Michigan (Almond & Mazumder 2011), exposure to an average Ramadan during the first gestational month reduces the probability of being male with 4.9 percentage points.

Consequently, it is a well-established fact that the male fetus is more vulnerable than the female and is at greater risk of death and damage during gestation (e.g. Kraemer 2000). On one hand, less males are conceived when adverse event are taking place. On the other hand, also less male fetuses survive until the time of birth. As a result, it is predicted that less males will be conceived during and

[1]Hoffmann (2014) studies the culling and scarring effects in relation to prenatal Ramadan fasting.

[2]The weaknesses of this study are, however, the small sample size (N=740) and that breakfast status might be associated with other more important but unobserved characteristics.

shortly after a Ramadan, and that those being conceived are more likely not to survive until birth.

3 Micro-Level Analysis: Ramadan Fasting and the Sex Ratio

3.1 Data

I use comparable data from the Demographic and Health Surveys (DHS) from Bangladesh, Egypt, Indonesia, Jordan, Morocco, Pakistan, and Turkey between 1987 and 2013.[3] Data is on the individual woman's birth history the five years prior to the time of interview, covering 35 different surveys. Table 1 reports the distribution of observations by year and country.[4]

The advantage of using DHS data is that it is comparable over time and across space since all surveys contain the same questions on birth history. Moreover, a favourable property obtained from pooling data is that it creates more variation in Ramadan exposure in terms of its timing over the year. This makes it possible to consider a shorter recall period than from having only considered one survey round or one country as well as to control for seasonal patterns affecting the outcomes of interest but not stemming from Ramadan exposure. Also, making use of different locations from equator creates further variation in exposure, as the number of daylight hours and hence length of fasting varies across the countries' geographical location.

On the other hand, one might argue that these seven countries are somewhat different despite their religious similarities and that, even within each country, parents might endogenously affect the prenatal Ramadan exposure of their children. Therefore, I apply fixed effects at the maternal level in order to difference out potential omitted variables, such as the quality of the health system, genetics, and different attitudes towards timing of conception. As long as these potentially omitted variables are constant for the same mother across all her pregnancies during the chosen time period, and as long as the impact of Ramadan fasting biologically is comparable across space, it should not be a problem to use observations from different countries or survey periods.

[3]These countries are chosen as they are predominantly Muslim, have had at least three survey rounds over a period of at least ten years, and had a considerably large number of observations.

[4]Appendix Tables 6 and 7 present some descriptive statistics and correlations between maternal characteristics and prenatal exposure.

Table 1: Observations by Country and Year

Year of Interview	BD	EG	ID	JO	MA	PK	TR	Total
1987	0	0	3,478	0	2,821	0	0	6,299
1988	0	4,995	0	0	0	0	0	4,995
1989	0	126	0	0	0	0	0	126
1990	0	0	0	6,502	0	866	0	7,368
1991	0	0	5,851	0	0	3,143	0	8,994
1992	0	5,020	0	0	3,298	0	0	8,318
1993	1,267	166	0	0	0	0	1,469	2,902
1994	1,959	0	5,872	0	0	0	0	7,831
1995	0	6,734	0	0	0	0	0	6,734
1996	1,465	177	0	0	0	0	0	1,642
1997	1,336	0	4,943	4,723	0	0	0	11,002
1998	0	0	0	0	0	0	1,574	1,574
1999	1,216	0	0	0	0	0	0	1,216
2000	1,656	2,010	0	0	0	0	0	3,666
2002	0	0	2,439	3,920	0	0	0	6,359
2003	0	697	1,875	0	1,878	0	498	4,948
2004	2,695	0	0	0	700	0	1,462	4,857
2005	0	6,562	0	0	0	0	0	6,562
2006	0	0	0	0	0	3,883	0	3,883
2007	2,133	0	4,440	6,599	0	1,632	0	14,804
2008	0	4,881	0	0	0	0	0	4,881
2009	0	0	0	5,991	0	0	0	5,991
2011	2,454	0	0	0	0	0	0	2,454
2012	0	0	523	6,228	0	5,484	0	12,235
2013	0	0	0	0	0	2,202	0	2,202
Total	16,181	31,368	29,421	33,963	8,697	17,210	5,003	141,843

Note: the country columns BD–TR are grouped under the spanning header "Country".

I only consider singleton births with exact information on month and year of birth and only those of Muslim women. Hence, I do not follow some of the previous literature using non-Muslims as a comparison group since the latter group might not be that easily comparable with Muslims despite both groups are exposed to the same external factors, such as price shocks and holidays. The reason is that non-Muslims are minorities in the studied countries and thus most likely distinguish themselves in other ways than solely religious affiliation, like educational level and living standards.

In the case of Morocco and Pakistan, there is no information on religion. However, since respectively 99 percent of the former and 96 percent of the latter country's population is Muslim according to the World Factbook, all Moroccans and Pakistanis are assumed to be Muslim. Moreover, after 1997 the Jordanian surveys do not contain information on religion. Though, since 98 percent in the 1990 and 1997 samples are Muslim, all Jordanians without religious information are assumed to be Muslims. In contrast, at the regional level, Egypt, Indonesia, and Turkey are not as homogeneous in terms of religion and thus, only individuals without information on religion living in regions with at least 98 percent Muslims are assumed to be so.[5]

Compared to previous studies on prenatal Ramadan exposure, a further advantage of the data used for this sex composition analysis is that it contains *all* births, having occurred within 60 months prior to the time of interview. Hence, despite its nature of being retrospective data, the considered period is still quite close in time. Moreover, the questionnaire contains different types of questions concerning dates unique for each child. From this, it is possible to assess the completeness of the answers (e.g. Rutstein & Rojas 2006). Based on these assessments, less than 1.4 percent of all reported births less than five years back in time suffer from incomplete information, while the number is 2.6 percent for those five to six years back in time and 9.6 percent for those six to ten years back.

3.2 Measure of Ramadan Exposure

A person's exact prenatal Ramadan exposure is determined from the date of conception. However, only month and year of birth is observed and hence the determination of exposure might be somewhat blurry. Therefore, I term it *exposure before birth* rather than *after conception*.

For the main specification, the exact measure of Ramadan exposure is measured as the number of Ramadan days multiplied by the average hours of daylight during the particular month in the specific country and then divided by the average number of daylight hours during an average Ramadan of 30 days.[6] [7] In other words, Ramadan exposure is measured as the relation between total fasting hours during the specific month and the average fasting hours during an average Ramadan. In this way, the countries' different geographic distances to equator and thus differences in length of fasting during the year are taken into account, which might be relevant as the effects of fasting might be cumulative. This is in line with the approach used for the Michigan sample in Almond & Mazumder (2011).

In addition to this principal measure of Ramadan exposure, which I will refer to as the *daylight* measure, the sensitivity checks also use two other measures.

[5]This is, in particular, relevant for Indonesia 2012, for Egypt 2002 and 2003, and Turkey 1993 and 2003. Although 99.8 percent of all people in Turkey are Muslim according to the World Factbook, there is one region in my Turkish sample with relatively more non-Muslims.

[6]For the determination of Ramadan exposure by year and month of birth, I have used data (and updated it with the most recent years) provided by Almond & Mazumder (2011), accessed through the *American Economic Journal: Applied Economics*.

[7]Data on daylight hours per day by month and country (capital city) is found from http://www.timeanddate.com/worldclock/.

First, the *percent* measure uses the fraction of Ramadan days during the specific month without accounting for the differences in day length. Hence, the focus of this measure is the number of days with fasting rather than the length of fasting. Second, the *dummy* measure is a binary variable indicating the earliest months of pregnancy coinciding with a Ramadan[8]. This latter more rough measure is though less favourable due to its nature of only taking two values.

In terms of the interpretation of the estimates of Ramadan exposure, the estimates should be seen as an intention-to-treat (ITT) since actual fasting status is not observed. However, this is not a problem since the purpose of this analysis is to quantify the extent of missing men in section 5 for the Muslim population as a whole and not only for those actually fasting. Moreover, as previously mentioned, most pregnant women chose to fast and greater observance of fasting in early stages of pregnancy seems to be reasonable. Therefore, estimates of exposure in early months of pregnancy might be close to the real effect and in any case be conservative.

3.3 Empirical Specification

For the empirical specification, f is the outcome of interest, i.e. a dummy for being female, and R_{istc} represents the vector of Ramadan exposure by months before birth for child i. As mentioned above, Ramadan exposure is determined by month (s), year (t), and country (c) of birth. Each individual will be exposed to maximum two subsequent months of Ramadan while being in utero and no more than 30 days. Therefore, those individuals not exposed to any month of Ramadan during gestation will form the control group.

Due to the uncertainty of the exact time of conception and birth (as only month of birth is known and not day), I control for Ramadan exposure in the month of birth through the ninth month before birth. Hence, as a normal pregnancy lasts nine months, the Ramadan exposure during month of birth and month nine before birth is in fact only experienced by half of those being imposed this status of exposure. Therefore, it is worth keeping in mind that observing no effect for these two months might be due to too much noise rather than actual no impact.

The equation to estimate is:

$$f_{imstc} = \alpha + \sum_{j=0}^{9} \beta_j R_{istc} + \gamma_s + \delta_{tc} + X_i'\epsilon + \zeta_m + \eta_{imstc}, \tag{1}$$

where X is a vector of birth order dummies, γ_s represents month of birth dummies,

[8]However, if less than half of the month was Ramadan nine months before birth, this dummy is set to zero and the dummy for month eight is one if it contained some Ramadan days.

and δ_{tc} is a vector of country-specific year of birth dummies. By including interactions between country and year of birth, I allow for different time trends across countries in terms of, for instance, changes in the health system. At the same time, I do not include country specific month effects as the combination of birth year and birth month country-specific dummies would in some cases almost be a clear predictor of the assignment of Ramadan exposure. Lastly, ζ_m represents maternal fixed effects, which I remove by within-transformation in the empirical analysis, and finally η_{imstc} is the error term. Consequently, all estimations use the linear fixed effects probability model.

3.4 Results

Table 2 presents the results on gender composition, where Models (1) and (2) use the daylight measure of Ramadan exposure, Models (4) and (5) use the percent measure, and the remaining two models use the dummy measure. Models (1), (3), and (5) use the whole sample of children born within 60 months prior to the interview, whereas the remaining models restrict the sample to the last two births.

There is strong evidence that fewer boys are born eight months after Ramadan. The preferred model, i.e. Model (1), suggests that exposing the fetus to an average Ramadan eight months before birth increases the likelihood for being female with 2.5 percentage points. This is a very consistent finding across all models, giving estimates in the range between 1.7 and 2.6 percentage points, being in line with the findings in Almond & Mazumder (2011) and van Ewijk (2011).

Consequently, as the eighth month before birth for a reasonable share of the sample is the actual month of conception, this supports the theory that accelerated starvation due to fasting negatively affects the probability that the conceived embryo is male. Moreover, as probably not all the effect stems from the gender determination at the time of conception, the results also support the medical knowledge that male fetuses are more vulnerable to negative shocks, especially shortly after conception.[9]

3.5 Robustness Checks

As robustness checks of the results in the previous subsection, Appendix Table 8 replicates Models (1) and (3) from Table 2 restricting the sample in four ways: only children of mothers actively reporting that they are Muslim; those whose mother has at the most completed primary school (i.e. six years of education or less);

[9] This is studied more in depth in Hoffmann (2014).

Table 2: Impacts of Prenatal Ramadan Exposure on the Probabilty of Being Female, Controlling for Maternal Fixed Effects

Measure:	– Daylight –		– Percent –		– Dummy –	
Sample:	All	Last	All	Last	All	Last
Months prior		2 births		2 births		2 births
to birth	(1)	(2)	(3)	(4)	(5)	(6)
Birth	0.017	0.013	0.017	0.013	0.018*	0.019*
	(0.011)	(0.011)	(0.011)	(0.011)	(0.010)	(0.011)
1	-0.005	-0.013	-0.006	-0.013	0.001	-0.003
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.011)
2	0.017*	0.014	0.018*	0.015	0.011	0.006
	(0.010)	(0.011)	(0.010)	(0.011)	(0.010)	(0.011)
3	-0.006	-0.006	-0.005	-0.005	0.006	0.007
	(0.010)	(0.011)	(0.010)	(0.011)	(0.010)	(0.011)
4	0.000	-0.007	0.001	-0.005	0.001	0.001
	(0.010)	(0.011)	(0.010)	(0.011)	(0.010)	(0.011)
5	0.006	0.004	0.005	0.003	0.008	0.004
	(0.010)	(0.011)	(0.010)	(0.011)	(0.010)	(0.011)
6	-0.002	-0.005	-0.002	-0.005	0.001	0.002
	(0.010)	(0.011)	(0.010)	(0.011)	(0.010)	(0.011)
7	0.005	-0.002	0.003	-0.003	0.004	-0.001
	(0.010)	(0.011)	(0.010)	(0.011)	(0.010)	(0.011)
8	0.025**	0.021**	0.026***	0.023**	0.020**	0.017*
	(0.010)	(0.011)	(0.010)	(0.011)	(0.009)	(0.010)
9	0.003	-0.003	0.002	-0.004	0.004	0.003
	(0.011)	(0.011)	(0.011)	(0.011)	(0.009)	(0.010)
R-sq	0.004	0.004	0.004	0.004	0.004	0.004
N	141843	131286	141843	131286	141843	131286
Female share	0.493	0.490	0.493	0.490	0.493	0.490

Note: Robust standard errors, clustered at the enumeration area level, are shown in parentheses: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All regressions control for month of birth dummies, year of birth dummies by country, and birth order dummies. Only singleton children born within 60 months prior to the interview and who have a sibling fulfilling the same criteria are used. Models (2), (4), and (6) further restrict the sample to the last two births.

those living in rural areas; and lastly, only those children of mothers with at most primary education living in rural areas. This is done in order to check the sensitivity of the results for certain sub-groups. From this, the finding of a positive impact of Ramadan exposure eight months before birth on the likelihood of being female is robust.

These estimates are slightly larger than the ones in Table 2, though not significantly different. This is most likely because the estimates might be closer to the actual treatment effect in terms of fasting. For instance, one would expect larger effects in families with less resources, as they might be less able to compensate for the adverse effects by consulting a doctor, among others. Also, to the degree that women have to pay a penalty for not abstaining from fasting, those from poorer households might tend to fast more often than more resourceful families, and thus, the ITT-estimate might be closer to the real effect. Also, less educated women might to a larger degree be unaware of negative health effects and hence be more likely to fast.

Moreover, Appendix Table 9 estimates Model (1) from Table 2 excluding one or two countries at a time. This exercise does not change the results.

Finally, another concern might be that the estimated models assume linearity despite the binary nature of the dependent variable. Therefore, Appendix Table 10 reports the mean, minimum, and maximum of the predicted values of the dependent variable for each regression as well as the number of predicted values lying out of the interval between zero and one. Generally, only few predicted values are out of range. Thus, it does not seem to be a problem to use the fixed effects OLS model for the analysis.

4 Macro-Level Analysis: Aggregate Comparisons of Sex Ratios

Asian and North African countries are, in general, known to have preferences for sons (Sen 1990). In particular, the severity of these cultural preferences were highlighted and quantified by Nobel laureate Amartya Sen, initiating the debate on the 100 million missing women in *New York Review of Books* in 1990 (Sen 1990). By refining the estimation method and making use of new data, Klasen & Wink (2003) estimate the total number of missing women to have been about 89 million in 1990, corresponding to 6.5 percent of all women in the affected countries. In contrast, one decade later, this number had increased in absolute terms to about 101 million missing women, though decreased in relative terms to 5.7 percent.

These male preferences are found across religions; for instance, the predominantly Hindu country India and the mainly Muslim country Pakistan both miss women corresponding to nearly eight percent of the actual number of women in each of these countries (Klasen & Wink 2003). On this basis and the evidence on the fragility of the male fetus, a difference in the gender composition by religiosity might be observable at an aggregate level. This would be the case if prenatal Ramadan exposure is such an adverse event that substantially fewer males are conceived during Ramadan and a greater share of those male than female fetuses terminate in death before birth. Potentially, this distortion of the sex ratio might even be amplified after birth if the individuals exposed to prenatal fasting are scarred, leaving them with a worse health endowment and therefore at greater risk of early death. Thus, effects of fasting during Ramadan might be detectable on the share of women alive between countries or regions. To illustrate this point, I first present correlations between the proportion of Muslims and the share of females at the country level and thereafter between 139 provinces in four countries.

4.1 Across Countries

For the first analysis, data on the share of Muslims comes from the World Factbook, run by the Central Intelligence Agency.[10] In terms of the share of women in the population as a whole, I use data from the World Bank for 61 countries over 53 years (1960-2012)[11]. Hence, it is worth noting that this aggregate measure of the sex ratio does not take into account potential variations due to different age compositions across countries and time, in contrast to the province analysis below.

Table 3: Associations between the Share of Muslims and Females Across Countries, 1960-2012

Independent variables	Dependent variable: Female Share (1)	(2)	(3)
Share of muslims	0.0109***	0.0109***	0.0136***
	(0.0000)	(0.0000)	(0.0000)
Share of muslims * trend		-0.0003***	-0.0003***
		(0.0000)	(0.0000)
Share of muslims * trend sq			0.0000***
			(0.0000)
Controls:			
Country dummies	X	X	X
Year dummies	X		
Country dummies * trend		X	X
Country dummies * trend sq			X
R-sq	0.787	0.922	0.969
N	3233	3233	3233

Note: Clustered standard errors at the country level are shown in parentheses: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All regressions control for an intercept. The trend is demeaned.

From the cross-country comparison in Table 3, a positive relationship between the proportion of Muslims in a country and the share of females is apparent. These

[10] One drawback of this data is, though, that I need to assume that the share of Muslims has been constant throughout the considered period.

[11] Appendix Table 11 shows the countries contained in the sample.

correlations suggest that a 100 percent non-Muslim country would, ceteris paribus, have an increase in its share of women of 1.1 percentage point had the same country been 100 percent Muslim. In other words, these correlations indicate that Muslim countries have a greater share of women compared to non-Muslim countries, sharing strong son-preferences. This relationship is fairly constant across specifications, also when including country-specific trends.

The negative estimate of the interaction between the share of Muslims and the time trend indicates a decrease in the correlation over time in Models (2) and (3). This seems reasonable as the health systems and nutritional status of the populations have generally improved considerably over time in the considered countries. However, it is important to stress that all associations in Table 3 are only suggestive and should be seen as indications of a positive relationship across these 61 countries.

4.2 Within Provinces

To further explore this relationship between the observance of Muslims and the sex ratio, I use the variation over time and age groups within 139 provinces and states in respectively Indonesia, Thailand, India, and Malaysia. Data is provided by the IPUMS-International database[12], covering extracts from 21 population censuses in the period between 1970 and 2010. I only consider individuals of age zero to 19 years and divide them into three age groups: 0-4, 5-9, and 10-19. This is in order to observe the sex ratio as close to birth as possible as well as potential changes during childhood and adolescence. For each age group and province, I take the mean of females and Muslims at the province level, excluding aggregates with fewer than 100 individuals and those, for which the sex ratio falls outside the interval between the 5th and 95th percentiles.

A great advantage of the province analysis is its panel structure, making it possible to control for province fixed effects and still have variation in the proportion of Muslims within the same province over time. Table 4 displays the association between the share of Muslims and the one of females at the province level. Despite not including other time-varying controls than the share of Muslims and some time trends, this association is a good candidate for a causal relationship. At least, it seems implausible that the effect would be reverse, i.e. that the female share should affect the share of Muslims. However, if can of course not be ruled out with certainty that no other time-varying variable is both correlated with the share of Muslims and girls, although it is hard to think about one.

[12]Minnesota Population Center. Integrated Public Use Microdata Series, International: Version 6.2 [Machine-readable database]. Minneapolis: University of Minnesota, 2014.

Table 4: Associations between the Share of Muslims and Females Across Provinces, Controlling for Province Fixed Effects, 1970-2010

Independent variables	Dependent variable: Female Share (1)	(2)	(3)	(4)	(5)
Share of muslims 0-19 years	0.0175***	0.0166***	0.0166***	0.0129*	0.0122
	(0.0054)	(0.0057)	(0.0059)	(0.0069)	(0.0117)
Share of muslims 5-9 years	-0.0015	-0.0015	-0.0015	-0.0017	-0.0017
	(0.0011)	(0.0011)	(0.0011)	(0.0011)	(0.0011)
Share of muslims 10-19 years	0.0046***	0.0045***	0.0045***	0.0043**	0.0042**
	(0.0016)	(0.0016)	(0.0016)	(0.0017)	(0.0018)
Share of muslims * trend		0.0000	0.0000	0.0012	-0.0002
		(0.0001)	(0.0002)	(0.0007)	(0.0012)
Share of muslims * trend sq			0.0000		-0.0001
			(0.0000)		(0.0001)
Controls:					
Province fixed effects	X	X	X	X	X
Year dummies	X				
Country dummies * trend		X	X		
Country dummies * trend sq			X		
Province dummies * trend				X	X
Province dummies * trend sq					X
R-sq	0.041	0.037	0.037	0.129	0.220
N	1810	1810	1810	1810	1810

Note: Robust standard errors are shown in parentheses: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All regressions control for an intercept. The trend is demeaned.

Consequently, from Table 4, we see that increasing the share of Muslims within a province increases the share of girls aged 0-19 years. Models (1) to (3) include similar controls as the corresponding models in Table 3. In contrast, Models (4) and (5) control for province-specific trends (and not only country-specific trends), giving rise to larger standard errors. The estimates are in line with the country analysis, though somewhat larger in magnitude. Thus, these estimates suggest that raising the share of Muslims from zero to 100 percent would increase the share of females by around 1.7 percentage points.

Distinguishing between the age groups, the share of Muslims among 5-9 years old children does not significantly change the sex composition compared to the whole sample; the estimated sign is even negative. Meanwhile, for the oldest age group (10-19 years), the estimate of the proportion of Muslims gives rise to an enhanced impact, adding approximately 25 percent of the magnitude to the effect for all age groups. This might point to some scarring effects, resulting in higher mortality rates among males due to their vulnerability to intrauterine stress. The difference seems though quite large to solely be explained as a scarring effect, as the impact of the younger age group (5-9 years) does not differ.

To sum up, across countries generally favouring boys, the evidence from the cross-country and within-province analyses indicates that Muslim countries have a slightly greater share of females. This is a very interesting result, as it might point to macroeconomic consequences of Ramadan fasting, which is discussed more in the next section.

5 Implications for the Missing (Wo)Men

So far, I have provided micro-level evidence that if pregnant women did not fast during Ramadan, they would on average give birth to more boys. Additionally, I have presented positive associations between the proportion of Muslims and females at the macro-level. Combining the findings of these two analyses suggests that a substantial number of male fetuses are lost (or never conceived) each year due to religious fasting. This, we might refer to as the missing men. On this basis, this section attempts to quantify the extent of the problem.

Quantifying the actual number of missing men in the countries considered in the cross-country analysis in section 4 is not completely straightforward. However, under certain assumptions it is still possible to provide some rough estimates to get an impression of the magnitude.

First, I assume that the number of women would stay constant in a scenario without fasting during pregnancy. This might only be an approximation since one could imagine that in absence of fasting the total number of pregnancies would not equal the sum of the ones already taking place and those miscarriages being prevented, as it is likely that many women compensate a miscarriage by a subsequent pregnancy. Thus, instead of assuming an increase in the total number of live births, it might stay constant. Another scenario is where the quantity of live births would even diminish as a dynamic consequence of a greater probability of giving birth to a son. This could be the case, as women (or the couples) in these societies with strong son-preferences might have a desired number of sons and not only of total number of children. Thereby, it might be that when this goal of sons is reached, they would terminate their birth history. Nevertheless, as the probability of getting a son, in absence of fasting, would not increase substantially from the viewpoint of the individual couple, it might be fair to assume that the overall fertility level would at least not decline.

Another issue is whether girls would be treated as badly as today if parents on average got more boys. As was evident from the country and province comparisons of sex ratios, non-Muslim populations have fewer women relatively, pointing to discrimination against daughters no matter the biological probability of giving birth to males. Therefore, it seems reasonable to assume that the attitude against females would not change. On this basis, only the sex ratio at birth would be affected by Ramadan fasting.

Finally, it is assumed that the never-born men should have followed a similar mortality pattern as the non-missing women. The sex ratio at birth is not necessarily the same as the sex ratio in the population as a whole, as mortality rates may differ by gender. For populations in which women and men are treated equally in terms of access to nutrition and healthcare, age-specific mortality rates are higher for men than women, typically throughout all ages (Sen 1990). This is, however, a much less pronounced feature in societies favouring sons, as their problem in its core is excess female mortality. Therefore, when comparing differences in life expectancy at birth between women and men, only 12 of the 61 countries experience a difference of four years or more (Lopez, Organization et al. 1999); for a comparison, the difference is 5.9 and 6.7 years in respectively the U.S. and Japan. Thus, even it might seem to be a strong assumption, it might be a fair approximation.

Based on these assumptions, Table 5 provides four cases, estimating the number of missing men, depending on the severity of male fragility in utero. Cases A and B are based on the estimates from the micro-level analysis on gender selection, finding a decreased probability of being male of two to three percentage points when exposed to prenatal fasting during the month of conception and closely thereafter. Similarly, case C might be seen as an upper bound estimate of five percentage points, which was found for the Michigan sample in Almond & Mazumder (2011).

As approximately one Ramadan takes place each year, this finding corresponds to a decline in males ever born of $\frac{2}{12}$ to $\frac{5}{12}$ percentage points each year for the Muslim share of the population, compared to a situation without this religious custom. Thus, a rough estimate of the number of missing men is calculated as:

$$Missing\ men = Muslim\ men * \frac{0.0x}{12}, \tag{2}$$

where

$$Muslim\ men = population * (1 - share\ of\ women) * share\ of\ Muslims \tag{3}$$

and x is the estimate of male vulnerability. Projecting this to the Muslim population as a whole, the total number of missing men across these 61 countries in Asia and Africa (including the Middle East) amounts to between 1.22 and 3.05 million males.

Table 5: Quantifying the Number of Missing Men, 2012

	Population (millions)	Percentage of Women	Muslims	# of Missing Men (millions) for Case A: 2/12	B: 3/12	C: 5/12	D: Macro
Middle East	**320.72**	**49.87**	**95.30**	**0.26**	**0.38**	**0.64**	**0.47**
Egypt	80.72	49.79	90.00	0.06	0.09	0.15	0.11
Iran	76.42	49.63	99.40	0.06	0.10	0.16	0.12
Turkey	74.00	50.89	99.80	0.06	0.09	0.15	0.11
Iraq	32.58	49.44	97.00	0.03	0.04	0.07	0.05
Yemen	23.85	49.58	99.10	0.02	0.03	0.05	0.04
Syria	22.40	49.04	87.00	0.02	0.02	0.04	0.03
Asia	**3661.44**	**48.72**	**22.08**	**0.68**	**1.03**	**1.71**	**1.27**
China	1350.70	48.19	1.80	0.02	0.03	0.05	0.04
India	1236.69	48.28	13.40	0.14	0.21	0.36	0.27
Indonesia	246.86	49.69	87.20	0.18	0.27	0.45	0.34
Pakistan	179.16	48.64	96.40	0.15	0.22	0.37	0.27
Bangladesh	154.70	49.35	89.50	0.12	0.18	0.29	0.22
Uzbekistan	29.77	50.26	88.00	0.02	0.03	0.05	0.04
Malaysia	29.24	51.49	60.40	0.01	0.02	0.04	0.03
Africa	**645.33**	**49.78**	**51.63**	**0.28**	**0.42**	**0.70**	**0.52**
Nigeria	168.83	49.12	50.00	0.07	0.11	0.18	0.13
Tanzania	47.78	50.00	35.00	0.01	0.02	0.03	0.03
Algeria	38.48	49.44	99.00	0.03	0.05	0.08	0.06
Sudan	37.20	49.83	70.00	0.02	0.03	0.05	0.04
Morocco	32.52	50.73	99.00	0.03	0.04	0.07	0.05
Total	**4627.49**	**48.95**	**31.28**	**1.22**	**1.83**	**3.05**	**2.27**

Note: Data is from the World Bank and is for year 2012. The aggregate regions include all countries from the respective region used for the macro analysis in Table 3 (however, countries in the Middle East are not included in the other categories); displayed countries are selected due to their size. Cases A, B, and C assume that during each year x/12 percentage points more men would have been born in absence of Ramadan fasting. Case D assumes that the sex ratio would have been equal across Muslim and non-Muslim countries, accounting for the estimates of the Muslim share and its interaction with the trend in Model (2) in Table 3, corresponding to 3.71/12 percentage points.

Case D represents the estimate of the relation between the female share and proportion of Muslims at the country level in the cross-country analysis. Here, Model (2) from Table 3 is used, resulting in a reduced share of men in the Muslim population by $\frac{3.71}{12}$ percentage point[13]. This corresponds to a deficit of 2.27 million men, meaning that the suggestive evidence from the macro-level analysis supports the estimates based on the micro-level analysis quite well. Thus, the cross-country estimate indicates a shortage of men, supporting case B and C, i.e. the micro-level estimates in the high end. Consequently, it seems reasonable to propose that around two million men are missing, and this is within the sense that they are actually missing physically speaking since they would have been born had it not

[13]This is calculated as $0.0109 - 0.0003 * 26$ since the trend takes the value 26 for year 2012.

been for prenatal fasting.

Overall, the assumptions made for this rough calculation of the total number of missing men in the considered countries seem reasonable from what was argued above. Thus, from both the macro- and micro-level analyses, the results suggest that, as a direct consequence of Ramadan fasting among women in the child-bearing ages, around two million males would have been alive today but have never been born. Thus, even though this number of missing men is not at the same level as the one of missing women, it is still a substantial deficit, especially when taking into account that parents, in general, actually prefer this gender.

The presence of this missing men problem could in turn also have some implications for the true magnitude of the problem of the missing women. In the situation as it is today *with* fasting, we already proportionally observe too many men. So if there would have been even more men in those countries in the situation where Muslim women would not fast around the time of conception and during early pregnancy, it might imply that yet more women are missing. It is, however, difficult to estimate the number of additional missing women, as such calculations have to rely on even more assumptions and it is difficult to disentangle which effects might dominate at the aggregate level. However, it is reasonable to conclude that more women might actually be missing than what our previous estimates suggest.

6 Conclusion

This paper has examined the extent of the distortion in the sex ratio as a consequence of maternal fasting during pregnancy, relating it to the missing (wo)men problem. Using DHS data, I document an increase in the probability of a female birth eight months after Ramadan for multiple Muslim countries over a period of 32 years. The advantage of this dataset compared to previous studies is that I observe all children ever born by each woman, making it possible to remove maternal fixed effects and thereby potential problems, such as timing of conception and access to healthcare.

An important implication of the findings of a distorted sex ratio due to prenatal fasting is that a substantial number of male fetuses would have been born had it not been for religious fasting. From a cross-country as well as a within-province comparison over time of societies sharing son-preferences, I provide evidence of a positive association, supporting the micro-level findings.

Combining the estimates of fewer males born when exposed to Ramadan in utero and a greater share of women in Muslim countries from respectively the micro- and macro-level analyses, I quantify the number of missing men. This is done for the 61 countries considered in the country-level analysis, representing the vast majority of the World's Muslims. This gives an estimate of between 1.22 and 3.05 million missing men, meaning that roughly two million men are missing merely because they were never born due to a combination between religious fasting and biology. Compared to the 100 million women missing due to discrimination, two million missing men is of course not an equivalent problem. However, it is still relevant to consider the extent of the never-born males, as it is a problem which could be prevented simply by encouraging pregnant women not to fast or at least to be aware of adverse health symptoms during Ramadan and encouraging those women who might be pregnant to test whether they are so just before the Ramadan month begins.

Finally, a potentially more severe result of this number of missing men is that it might have implications for the "true" number of missing women. As the considered countries already today suffer from gender discrimination, resulting in excess female mortality, the problem of missing men might in fact imply that more women are missing than we originally thought. An estimation of this is, however, out of the scope of this paper, as it at the same time might have ambiguous effects on the total number of births and the degree of discrimination against girls and women, among others.

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A Appendix

Table 6: Descriptive Statistics

	N	Mean	SD	Min	Max
Child Characteristics					
Female	141843	0.493	0.500	0	1
Age in months	141843	30.308	17.936	0	60
Year of birth	141843	1997.5	8.100	1982	2013
Exposed 9 to 1 months BB (dummy)	141843	0.762	0.426	0	1
Daylight exp 1 trimester BB	141843	0.251	0.399	0	1.176
Daylight exp 2 trimester BB	141843	0.248	0.398	0	1.176
Daylight exp 3 trimester BB	141843	0.257	0.402	0	1.176
Maternal/Household Characteristics					
Age in years	141843	28.512	5.745	13	49
# of children	141843	4.048	2.265	2	19
Years of education	141796	5.623	5.247	0	23
Primary	141820	0.515	0.500	0	1
Rural	141843	0.593	0.491	0	1
Primary & rural	141843	0.379	0.485	0	1
Has electricity	130994	0.771	0.421	0	1
Has radio	130343	0.515	0.500	0	1
Has TV	138791	0.622	0.485	0	1

Note: BB is abbreviation for "before birth".

Table 7: Correlations between Maternal Characteristics and child prenatal Ramadan exposure

	Child exposure			
	Exposed 9 to 1	– Daylight exposure –		
	months BB (dummy)	1 trimester BB	2 trimester BB	3 trimester BB
Maternal Characteristics				
Age in years	-0.0014	0.0062	0.002	0.0015
# of children	-0.0034	0.0059	0.0029	0.0094
Years of education	0.0173	-0.0048	0.009	-0.0078
Primary	-0.0201	0.0024	-0.0156	0.0072
Rural	-0.0074	-0.0027	-0.0124	0.0047
Primary & rural	-0.0165	-0.0007	-0.0172	0.0078

Note: BB is abbreviation for "before birth".

Table 8: Robustness Checks of Impacts of Prenatal Ramadan Exposure on the Probabilty of Being Female, Controlling for Maternal Fixed Effects

Sample:	Reported Muslim		Max Prim.		Rural		Max Prim. & Rural	
Measure:	Dayl.	Perc.	Dayl.	Perc.	Dayl.	Perc.	Dayl.	Perc.
Months prior to birth	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Birth	0.017	0.016	0.025*	0.027*	0.018	0.018	0.029*	0.029*
	(0.014)	(0.014)	(0.014)	(0.015)	(0.014)	(0.014)	(0.017)	(0.017)
1	-0.014	-0.013	0.003	0.003	-0.006	-0.006	0.003	0.003
	(0.013)	(0.012)	(0.013)	(0.013)	(0.013)	(0.013)	(0.015)	(0.016)
2	0.022*	0.022*	0.020	0.021	0.017	0.018	0.021	0.021
	(0.013)	(0.013)	(0.014)	(0.014)	(0.013)	(0.013)	(0.016)	(0.016)
3	-0.003	-0.001	0.005	0.006	-0.003	-0.001	0.006	0.009
	(0.013)	(0.013)	(0.014)	(0.014)	(0.013)	(0.014)	(0.017)	(0.017)
4	0.011	0.011	-0.000	0.001	0.015	0.016	0.022	0.022
	(0.013)	(0.013)	(0.014)	(0.014)	(0.013)	(0.013)	(0.016)	(0.016)
5	-0.006	-0.007	0.024*	0.023	0.002	0.000	0.021	0.019
	(0.013)	(0.013)	(0.014)	(0.014)	(0.014)	(0.014)	(0.016)	(0.017)
6	-0.011	-0.010	-0.002	-0.002	0.007	0.008	0.007	0.008
	(0.013)	(0.013)	(0.014)	(0.014)	(0.013)	(0.013)	(0.016)	(0.017)
7	-0.004	-0.005	0.016	0.015	0.009	0.008	0.018	0.017
	(0.013)	(0.013)	(0.014)	(0.014)	(0.013)	(0.013)	(0.016)	(0.016)
8	0.027**	0.028**	0.037***	0.040***	0.026**	0.028**	0.043***	0.045***
	(0.013)	(0.013)	(0.014)	(0.014)	(0.013)	(0.013)	(0.016)	(0.016)
9	-0.003	-0.005	0.016	0.016	0.007	0.006	0.021	0.019
	(0.013)	(0.013)	(0.015)	(0.015)	(0.014)	(0.014)	(0.017)	(0.017)
R-sq	0.003	0.003	0.006	0.006	0.006	0.006	0.008	0.008
N	90341	90341	73046	73046	84046	84046	53817	53817
Female share	0.492	0.492	0.494	0.494	0.492	0.492	0.495	0.495

Note: Robust standard errors, clustered at the enumeration area level, are shown in parentheses: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All regressions control for month of birth dummies, year of birth dummies by country, and birth order dummies. Only singleton children born within 60 months prior to the interview and who have a sibling fulfilling the same criteria are used. Models (1) and (2) restrict the sample to children of mothers who actively report themselves as Muslim; Models (3) and (4) only include children of mothers with at most primary (six years of) education; Models (5) and (6) only include children living in rural areas; Models (7) and (8) only include children of mothers with at most primary education living in rural areas.

Table 9: Robustness Checks of Impacts of Prenatal Ramadan Exposure on the Probabilty of Being Female, Controlling for Maternal Fixed Effects

Sample ex.:	EG	ID	JO	MA & TR	BD & PK
Measure:			– Daylight –		
Months prior to birth	(1)	(2)	(3)	(4)	(5)
Birth	0.008	0.017	0.022*	0.019	0.020
	(0.012)	(0.012)	(0.012)	(0.011)	(0.012)
1	0.002	-0.007	-0.000	-0.011	-0.011
	(0.011)	(0.011)	(0.011)	(0.010)	(0.011)
2	0.010	0.014	0.016	0.025**	0.019
	(0.011)	(0.011)	(0.012)	(0.011)	(0.012)
3	-0.013	-0.005	-0.000	-0.008	-0.002
	(0.011)	(0.012)	(0.012)	(0.011)	(0.012)
4	-0.004	-0.014	0.004	0.007	0.008
	(0.011)	(0.011)	(0.012)	(0.011)	(0.012)
5	0.005	0.016	-0.000	0.004	0.003
	(0.012)	(0.012)	(0.012)	(0.011)	(0.012)
6	-0.010	-0.005	0.000	0.001	0.004
	(0.011)	(0.011)	(0.012)	(0.011)	(0.012)
7	-0.008	0.012	0.001	0.005	0.009
	(0.012)	(0.011)	(0.012)	(0.011)	(0.012)
8	0.026**	0.020*	0.027**	0.029***	0.024**
	(0.011)	(0.011)	(0.012)	(0.010)	(0.012)
9	-0.009	0.006	0.009	0.008	0.001
	(0.012)	(0.012)	(0.012)	(0.011)	(0.012)
R-sq	0.004	0.004	0.003	0.004	0.004
N	110475	112422	107880	128143	108452
Female share	0.491	0.496	0.492	0.493	0.493

Note: Robust standard errors, clustered at the enumeration area level, are shown in parentheses: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All regressions control for month of birth dummies, year of birth dummies by country, and birth order dummies. Only singleton children born within 60 months prior to the interview and who have a sibling fulfilling the same criteria are used. The daylight measure is used for all regressions. *Sample ex.* specifies which country(ies) is (are) excluded from the respective regression.

Table 10: Predicted Values of Dependent Variable

	Mean	Minimum	Maximum	Out of Range
Table 2				
Model (1)	0.493	-0.760	0.874	7
Model (2)	0.490	-0.888	0.915	1081
Model (3)	0.493	-0.762	0.875	7
Model (4)	0.490	-0.894	0.912	1101
Model (5)	0.493	-0.774	0.888	7
Model (6)	0.490	-1.015	0.922	51
Table 8				
Model (1)	0.492	-0.549	0.818	4
Model (2)	0.492	-0.551	0.818	4
Model (3)	0.494	-0.454	1.048	226
Model (4)	0.494	-0.454	1.047	209
Model (5)	0.492	0.023	0.989	0
Model (6)	0.492	0.022	0.990	0
Model (7)	0.495	-0.058	1.189	702
Model (8)	0.495	-0.059	1.187	696
Table 9				
Model (1)	0.491	-0.783	0.809	12
Model (2)	0.496	-1.155	1.001	418
Model (3)	0.492	0.074	0.863	0
Model (4)	0.493	-0.667	0.772	4
Model (5)	0.493	-0.676	0.863	6

Note: Descriptive statistics of the predicted value of the dependent variable for the respective regressions. *Out of Range* refers to the number of predicted values falling outside the interval between zero and one.

Table 11: Countries Used for the Cross-Country Comparison

Algeria	Hong Kong	Mali	Sri Lanka
Azerbaijan	India	Mauritania	Sudan
Bangladesh	Indonesia	Mongolia	Syria
Benin	Iran	Morocco	Tajikistan
Burkina Faso	Iraq	Nepal	Tanzania
Cambodia	Jordan	Niger	Thailand
Cameroon	Kazakhstan	Nigeria	Timor-Leste
Chad	Kenya	Pakistan	Togo
China	Korea	Papua New Guinea	Tunisia
Cote d'Ivoire	Kyrgyz Republic	Philippines	Turkey
Egypt	Lebanon	Senegal	Turkmenistan
Fiji	Liberia	Sierra Leone	Uganda
Gambia	Libya	Singapore	Uzbekistan
Ghana	Malawi	Somalia	Vietnam
Guinea	Malaysia	South Sudan	Yemen
Guinea-Bissau			

Note: Observations used for Table 3. Data is from the World Bank and covers the period 1960-2012.