Ramadan fasting, sex-ratio at birth, and birth weight: no effects on Muslim infants born in Germany

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October 7, 2015

Abstract

Recent economic studies have shown negative effects of intrauterine exposure to Ramadan on birth outcomes and long-term economic outcomes. I examine the effect of Ramadan fasting on birth weight and the fraction of male births in Germany, which has large and diverse Muslim communities. Using data on 1 million births to Muslim mothers from 1996 to 2010, I find virtually no effect of Ramadan exposure on either outcome. Earlier results from other countries based on smaller samples can therefore not be generalized.

JEL classification: I12, J13, Z12

Keywords: Fasting, Ramadan, birth weight, sex ratio

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1 Introduction

Intrauterine influences on later life outcomes have recently gained attention among economists (e.g. Almond and Currie, 2011; Chen and Zhou, 2007; Jürges, 2013). One focus is on wars or famines with large exogenous reductions in nutritional intake during pregnancy. Related studies analyze the effect of a mild form of malnutrition – daytime fasting during Ramadan (Almond and Mazumder, 2011; Schultz-Nielsen et al., 2014; Van Ewijk, 2011). Using data from Michigan, Almond and Mazumder (2011) (AM in short) exploit cross-year and cross-religious differences in Ramadan exposure to find negative effects on birth weight of on average 18g, and negative effects on the fraction of male births of 6 percentage points for Ramadan exposure close to conception. Since their data do not contain information on Ramadan observance, the estimates are intention-to-treat effects and the causal effects of fasting could be larger. Diverging opinions exist on whether fasting is mandatory for pregnant women. Worldwide, estimates of the proportion of pregnant women fasting in pregnancy range from 50% to 90% (Cross et al., 1990; Joosoph et al., 2004; Robinson and Raisler, 2005).

I analyze the effect of Ramadan exposure on birth weight and sex-ratio using all births in Germany 1996 to 2010. The data have two advantages compared to AM's data. First, mother's religion is coded explicitly. In contrast, AM code Arabs in counties where the majority of Arabs are Muslims as Muslims. This neither excludes non-Islamic Arabs nor captures all Muslims. The true effect of intrauterine Ramadan exposure might thus be underestimated due to measurement error. Second, my data contain more than 1m births to Islamic mothers, allowing more precise estimates.

My data also have drawbacks. First, Ramadan observance is unknown, thus my estimates must also be interpreted as ITT. Second, German birth registers are less informative on covariates such as education and on outcomes such as gestational age. Lack of covariates also precludes analyzing potential selectivity of Ramadan births directly. Health-conscious mothers who believe that Ramadan fasting affects infant health might avoid pregnancies that cover Ramadan. I address this issue in alternative specifications that restrict the sample to pregnancies covering Ramadan and exploiting differences in Ramadan exposure due to seasonal and regional differences in the number of fasting (i.e., daylight) hours for identification.

2 Data and Methods

The data are derived from official German birth statistics 1996 to 2010, covering all births in Germany. They contain 10m births to non-Islamic and 1m births to Islamic mothers, who are mostly of Turkish, North African or Middle Eastern origin. To estimate the effect of Ramadan exposure, I estimate the following linear regression model by OLS:

$$y_i = \alpha + \beta \mathbf{x}_i + \gamma \mathbf{z}_i + \varepsilon_i \tag{1}$$

where y_i is birth weight in grams or newborn sex (1=boy; 0=girl) and $\mathbf{z}_i$ are covariates: year of birth (1996, ..., 2010), month of birth (Jan, ..., Dec), parity, mother's age and marital status, and newborn sex where appropriate. $\mathbf{x}_i$ measures intrauterine exposure to Ramadan. Similar to AM, I operationalize exposure in several ways:

(a) A dummy variable indicating if Ramadan falls into pregnancy at any time.

(b) A vector of three dummy variables for Ramadan falling into the first, second, or third trimester of pregnancy, respectively. If Ramadan falls into two adjacent trimesters, both pertaining dummy variables are set to one.

(c) A vector of nine dummy variables for Ramadan falling into the first, second, or third month of pregnancy, respectively. Results of this specification are shown only for the fraction of male births as dependent variable.

(d) Since Ramadan follows the lunar calendar, it shifts by approximately two weeks each year. Thus fasting is shorter in winter than in summer. Moreover, it is longer in the North than in the South in summer but shorter in the winter. I computed the number of daylight hours for each day in 1996 to 2010 separately for each federal state capital in Germany. This variable was matched to each newborn by mother's state of residence and number of exposure hours was computed for each pregnancy. To make results comparable across specifications, the number of fasting hours was finally divided by 260, the average number of Ramadan daylight hours per pregnancy in our sample.

Eq. (1) is first estimated only for births to Islamic mothers. Here identification rests on intertemporal variation in exposure. For instance, in specification (a), $\hat{\beta}$ reflects the difference in birth weight between children born to Islamic mothers who were exposed to Ramadan in utero and children born to Islamic mothers who were not exposed. Interpretation of this coefficient as causal requires $\text{Cov}(\mathbf{x}_i, \varepsilon_i) = 0$, which could be violated if more health-conscious mothers try to time pregnancies to avoid Ramadan exposure. AM find hardly any evidence for systematic "selection into treatment" based on observed mother's characteristics. Still, I deal with this concern by restricting the sample to pregnancies that covered Ramadan.

Another identification problem could arise if Ramadan periods systematically differ from non-Ramadan periods in characteristics that may affect birth weight, such as climate, the availability of certain foods, etc. In my data, Ramadan has moved (backwards) by about half a year, from January to August. Thus we do not observe the Ramadan effect in spring. If such characteristics affect births to Islamic and non-Islamic mothers alike, identification can be refined by estimating the difference in the Ramadan effect $\hat{\beta}$ between Islamic and non-Islamic mothers. Following AM, I estimate Eq. (1) for births to non-Islamic mothers and compute the difference between the estimated $\hat{\beta}$s.

3 Results

Results for birth weight are shown in Table 1. Each panel shows estimates for the Ramadan effect separately for Islamic and non-Islamic mothers and their difference. Panel A shows results for the full sample. If Ramadan falls into a pregnancy at any time, babies born to Islamic mothers are on average 2.1g *heavier* than if pregnancy is between Ramadans. Babies born to non-Islamic mothers are 0.2g lighter on average if Ramadan falls into the pregnancy. These differences and the difference between differences are insignificant. When Ramadan exposure is measured by the number of daylight (=fasting) hours during Ramadan, the estimate for Islamic births remains insignificant and positive but the estimate for non-Islamic births turns negative and significant. The difference in differences of about 2.5g is small and insignificant.

This is evidence against any medically or economically relevant effects.

Effects may differ by the trimester of exposure, but Panel A shows only small differences. Point estimates are generally below 5g and given the large sample sizes, statistical significance should not be misinterpreted as substantive significance. Notably, if anything, I find a negative effect of Ramadan exposure in the first trimester on non-Islamic mothers, so that the difference in differences is again positive. Estimates for the effect of Ramadan or daylight hours by month of pregnancy yielded no additional insight and are not reported here.

Panel B shows results when the sample is restricted to normal weight births (>2,500g). This specification serves two purposes. First, since gestational age is not recorded in the birth records, exposure variables are coded assuming full-term pregnancies. While this assumption holds for more than 90 percent of births, Ramadan exposure is likely overestimated among births of low gestational age and thus low birth weight. Restrictions to births >2,500g mitigates this problem. Second, results in Panel B should be better comparable to AM, who also restrict their sample to full-term births.

The restriction to normal weight births does not change the conclusion reached above. Standard errors are smaller, but the point estimates remain so small that they cannot be considered relevant. Moreover, they often have unexpected signs, namely positive effects of Ramadan on birth weights among Islamic mothers but negative effects among the rest.

Another concern might be that Ramadan exposure is endogenous. In additional analyses not shown here, I estimated how the number of births per week varies by Ramadan exposure. Muslim mothers in Germany might time conception so that Ramadan does not fall into their pregnancy (or specific trimesters in which fasting may be deemed particularly burdensome). One should then find fewer births following Ramadan-exposed pregnancies. However, if anything the opposite seems to be true. Ramadan exposure is linked with about 2 percent *more* births (without significant differences across trimesters.)

Panel C shows estimates of the effect of Ramadan exposure at the "intensive margin". Here every pregnancy is exposed and variation in exposure comes from regional and seasonal variation in the number of Ramadan daylight hours. Again, we find no effect among Muslim newborns, and some small significant negative effect among the rest.

Table 1: Effect of Ramadan exposure on birth weight (in grams)

	Exposure dummy			Exposure in daylight hours		
Ramadan falls into ...	Islamic mother	Non-islamic mother	Difference	Islamic mother	Non-islamic mother	Difference
		Panel A: Full sample				
Any time during pregnancy	2.08	-0.22	2.29	0.87	-1.61**	2.48
	(1.51)	(0.49)	(1.59)	(1.41)	(0.46)	(1.48)
First Trimester	1.47	-1.88**	3.35	0.38	-3.70**	4.08*
	(1.81)	(0.59)	(1.90)	(1.74)	(0.56)	(1.83)
Second trimester	0.67	1.35*	-0.68	-0.63	-0.53	-0.09
	(2.01)	(0.66)	(2.12)	(1.85)	(0.60)	(1.94)
Third trimester	3.08	1.08	2.00	1.91	-0.26	2.17
	(1.84)	(0.60)	(1.94)	(1.71)	(0.55)	(1.79)
Observations	1,041,603	9,801,521		1,041,603	9,801,521	
		Panel B: Normal weight births				
Any time during pregnancy	1.27	-0.17	1.43	0.87	-1.69**	2.55*
	(1.20)	(0.39)	(1.26)	(1.12)	(0.37)	(1.18)
First Trimester	1.60	-0.53	2.13	1.62	-2.31**	3.92**
	(1.44)	(0.47)	(1.51)	(1.38)	(0.45)	(1.45)
Second trimester	-0.58	0.15	-0.73	-0.54	-1.33**	0.79
	(1.59)	(0.53)	(1.68)	(1.46)	(0.48)	(1.54)
Third trimester	1.40	0.12	1.28	0.77	-1.35**	2.12
	(1.45)	(0.48)	(1.53)	(1.35)	(0.44)	(1.42)
Observations	972,888	9,150,521		972,888	9,150,521	
		Panel C: Pregnancies covering Ramadan (“intensive margin”)				
Any time during pregnancy				0.62	-1.41**	2.03*
				(0.85)	(0.27)	(0.89)
First Trimester				0.59	-2.20**	2.80**
				(0.94)	(0.30)	(0.99)
Second trimester				0.10	-1.05**	1.15
				(0.93)	(0.30)	(0.97)
Third trimester				0.94	-1.08**	2.01*
				(0.92)	(0.30)	(0.97)
Observations				872,138	8,171,352	

Note: Robust standard errors in parentheses. * p<0.05; ** p<0.01. Control variables: mother’s age (in five year age brackets), newborn sex, parity, mother’s marital status, year of birth and month of birth. Exposure hours are normalized to the empirical average of 260.

Table 2: Effect of Ramadan exposure on fraction male births (in percentage points)

	Full sample			Low birth weight excluded		
Ramadan falls into …	Islamic mother	Non-islamic mother	Difference	Islamic mother	Non-islamic mother	Difference
First month	0.056	0.030	0.027	0.048	0.041	0.008
	(0.205)	(0.066)	(0.216)	(0.212)	(0.069)	(0.223)
Second month	0.121	0.081	0.040	0.044	0.072	-0.028
	(0.214)	(0.069)	(0.225)	(0.221)	(0.072)	(0.232)
Third month	-0.085	0.022	-0.108	-0.145	-0.006	-0.139
	(0.223)	(0.072)	(0.234)	(0.230)	(0.075)	(0.242)
Fourth month	-0.036	0.002	-0.039	-0.069	0.004	-0.073
	(0.230)	(0.075)	(0.242)	(0.238)	(0.077)	(0.250)
Fifth month	-0.602***	0.041	-0.643***	-0.574**	0.078	-0.651***
	(0.230)	(0.075)	(0.242)	(0.238)	(0.077)	(0.250)
Sixth month	-0.011	0.033	-0.044	-0.005	0.042	-0.047
	(0.227)	(0.074)	(0.238)	(0.235)	(0.076)	(0.247)
Seventh month	-0.182	0.074	-0.255	-0.235	0.088	-0.323
	(0.222)	(0.072)	(0.233)	(0.229)	(0.075)	(0.241)
Eighth month	0.013	0.098	-0.084	-0.009	0.083	-0.092
	(0.213)	(0.069)	(0.224)	(0.221)	(0.072)	(0.232)
Ninth month	-0.221	-0.038	-0.182	-0.359*	0.000	-0.359
	(0.205)	(0.066)	(0.216)	(0.212)	(0.068)	(0.223)
Nobs	1,041,603	9,801,521		1,041,603	9,801,521	

Note: Robust standard errors in parentheses. * p<0.1; ** p<0.05; *** p<0.01. Control variables: mother's age (in five year age brackets), parity, mother's marital status, year of birth and month of birth. Coefficients are multiplied by 100, so that a value of one corresponds to a one percent point effect.

Table 2 shows a replication of AM's analysis on the effect of Ramadan exposure on the fraction of male births. Effects are shown separately by month of Ramadan exposure. Again, there is hardly any evidence that the boy-girl ratio is different if pregnancies cover Ramadan. I find significantly lower proportions of boys only if Ramadan falls into the *fifth* month of pregnancy (not the first month as in AM). The point estimate is small (0.7 percentage points; one tenth the size of what AM report for Ramadan covering the first month). I believe this is a false positive result that should not be generalized.

4 Discussion and Conclusion

Using data on 1m births to Islamic mothers, I find no evidence of any medically relevant effect of Ramadan fasting on birth weight and sex ratio at birth in Germany. Findings on birth weight contradict those in the recent economic literature but are in line with an older medical literature (Cross et al., 1990). A limitation of this (and most previous) studies is the lack of information on actual Ramadan observance during pregnancy. Surveys in other countries have shown observance rates of 50% and more. Muslims in Germany are mostly of Turkish origin, and it is unclear whether these rates also apply. Assuming an observance rate in Germany of 50% and using Ramadan exposure as an instrument would yield IV estimates twice the size of the parameters reported in Table 1, which would still be small. Moreover, since the reduced form parameter is positive, the IV estimate would be positive, too, and hence have a theoretically implausible sign.

To conclude: earlier results using the same identification strategy based on smaller samples from other countries must be interpreted with caution. At least with respect to birth weight among Muslims in Germany, Ramadan fasting appears to be a safe practice. However, an important caveat is that birth weight is an unreliable metric of intrauterine damages. There are several examples, such as the Dutch famine and the German food crisis, in which severe malnutrition in the first trimester hardly affected birth weight but had long-term consequences regarding health and educational attainment (Jürges, 2013; Roseboom et al., 2003).

References

Almond, Douglas, and Bhashkar Mazumder (2011) 'Health capital and the prenatal environment: The effect of Ramadan observance during pregnancy.' *American Economic Journal: Applied Economics* 3(4), 56–85

Almond, Douglas, and Janet Currie (2011) 'Killing me softly: The fetal origins hypothesis.' *Journal of Economic Perspectives* 25(3), 153–72

Chen, Yuyu, and Li-An Zhou (2007) 'The long-term health and economic consequences of the 1959-1961 famine in China.' *Journal of Health Economics* 26(4), 659–681

Cross, J H, J Eminson, and B A Wharton (1990) 'Ramadan and birth weight at full term in Asian Moslem pregnant women in Birmingham.' *Archives of Disease in Childhood* 65, 1053–1056

Joosoph, J, J Abu, and Yu SL (2004) 'A survey of fasting during pregnancy.' *Singapore Medical Journal* 45, 583–587

Jürges, Hendrik (2013) 'Collateral damage: The German food crisis, educational attainment and labor market outcomes of German post-war cohorts.' *Journal of Health Economics* 32(1), 286–303

Robinson, Trinka, and Jeanne Raisler (2005) 'Each one is a doctor for herself: Ramadan fasting among pregnant Muslim women in the United States.' *Ethnicity & Disease* 15(1 Suppl 1), S1–99–103

Roseboom, Tessa J., Jan H. P. Van Der Meulen, Anita C. J. Ravelli, Clive Osmond, David J. P. Barker, and Otto P. Bleker (2003) 'Perceived health of adults after prenatal exposure to the Dutch famine.' *Paediatric and Perinatal Epidemiology* 17(4), 391–397

Schultz-Nielsen, Marie Louise, Erdal Tekin, and Jane Greve (2014) 'Labor market effects of intrauterine exposure to nutritional deficiency: Evidence from administrative data on Muslim immigrants in Denmark.' Working Paper 20723, National Bureau of Economic Research

Van Ewijk, R (2011) 'Long-term health effects on the next generation of Ramadan fasting during pregnancy.' *Journal of Health Economics* 30, 1246–1260