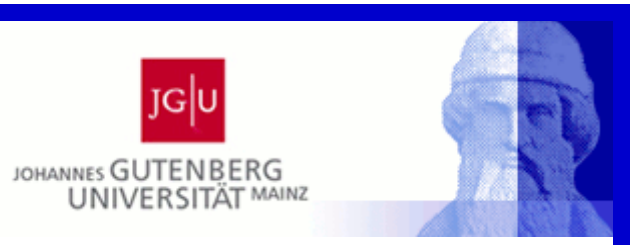

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Ramadan during Pregnancy – Fasting, Nutrition, Sleep Patterns and Offspring Health at Birth

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Abstract

Background

Intrauterine exposure to Ramadan is associated with adverse offspring health outcomes. Yet, the dynamics behind these associations remain largely unexplored. We investigate if maternal intermittent fasting or other lifestyle changes during Ramadan affect birth outcomes, and determine whether nutritional and sleep behavior during non-fasting hours influences the fasting-birth weight association.

Methods

Linear regressions are estimated using OLS to identify the associations between fasting, sleep behavior, sweets consumption and birth weight, 5-minute APGAR score and gestational age. Interaction terms between fasting and other behaviors are included to explore the potential moderating role of behaviors beyond the binary fasting decision. The Oster test statistic is calculated to address the possibility of residual confounding.

Findings

Newborns with intrauterine exposure to fasting had lower birth weights than non-exposed newborns (-161·57g, CI: -295·63; -27·51). No associations with APGAR score (0·02, CI: -0·23; 0·27) and gestational age (0·00, CI: -0·51; 0·51) appeared. Sweet food consumption and sleep reduction themselves are not associated with birth outcomes. However, consuming more sweet and fatty foods mitigates the negative fasting-birth weight association. The Oster test statistic shows that results are not subject to residual confounding.

Interpretation

Fasting seems to be the main driver of the negative fasting-birth weight association, while simultaneous nutritional and behavioral changes appear to influence how the effects materialize. Nutrition is a potential mitigating factor that should be taken into consideration when advising Muslim women of childbearing age on their behavior during Ramadan.

Funding

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Panel: Research in context

Evidence before this study

The starting point of our research were previous studies on Ramadan during pregnancy, with which we mostly were already acquainted due to our earlier research. The available evidence consistently suggests that intrauterine exposure to Ramadan is associated with negative effects on various offspring physical and cognitive health outcomes along the life course while at the same time, fasting rates among pregnant Muslims are found to be high. Yet, the evidence on health at birth effects is inconclusive and many studies report that information on potentially important covariates is lacking. We also searched PubMed with MeSH terms and key word searches using the terms "Prenatal Exposure Delayed Effects", "Prenatal Nutritional Physiological Phenomena", "Embryonic and Fetal Development" or "Pregnancy" with Ramadan and reviewed the economic literature on health and human capital effects of Ramadan during pregnancy. We did not find any study that was able to explore the dynamics behind the detected associations (for instance the roles of nutrition and sleep adaptations during Ramadan, besides maternal fasting) between prenatal Ramadan exposure and later health effects. This is attributed to a lack of data. In survey studies, a further challenge is to deal with the potential bias due to residual confounding, which has not been addressed by innovative methods in previous studies.

Added value of this study

By connecting hospital birth records to survey data on an entire cohort of pregnant Muslims exposed to Ramadan 2017, we are the first to systematically study maternal nutritional patterns beyond the binary fasting decision, as well as sleep behavior, in conjunction with birth outcomes. The main added value of this study is our finding that the fasting-birth weight association appears strongly moderated by further maternal behaviors during Ramadan: particularly increased sweet and/or fatty food consumption seems protective against negative birth weight effects among fasting women. By calculating the Oster test statistic, we are able to demonstrate that the detected effects are not subject to residual confounding.

Implications of all the available evidence

Our results suggest that effects of Ramadan fasting on offspring health might be considerably moderated by maternal nutritional intake during non-fasting hours. Since a large share of Muslims fast during pregnancy, the available evidence calls for more research in order to understand how fasting can be managed safely and how/to what extent adverse consequences for the offspring can be avoided.

INTRODUCTION

Early childhood development, including its earliest stages in utero, has not only been endorsed in the 2030 Sustainable Development Goals, but growing evidence has established links between the intrauterine environment and various health and human capital outcomes. Since almost a quarter of the world population is Muslim, with 75% of Muslim pregnancies overlapping with a Ramadan, the collection of data and research on the health effects of intrauterine exposure to Ramadan is pivotal for health practitioners worldwide. To date, no comprehensive evidence-based guidelines exist on how to advise pregnant Muslims on their behavior during Ramadan, even though the available evidence suggests that Ramadan during pregnancy leads to various adverse health effects.[1-7]

While it is generally assumed that maternal adherence to the diurnal fast during Ramadan drives any health effects in the offspring, there are additional channels that have not yet been investigated. Due to the traditional breaking of the fast after sunset during the 29-30 days of Ramadan, food and drink composition are changed – most notably, sweet foods are traditionally consumed. Additionally, sleep behavior is adjusted. Both behavioral changes can occur independent of the fasting decision, as non-fasting pregnant women often live in households with fasting members and participate in the traditional customs and celebrations.[8] In order for pregnant Muslims to be able to make informed choices on their behavior during Ramadan, it is essential to find out whether the fasting itself or other aspects of Ramadan affect the offspring's health.[9]

This is the first study to systematically record and include maternal behavior beyond the binary fasting decision in analyses on health effects of intrauterine exposure to Ramadan. By applying the Oster method, we moreover use an innovative approach to rule out the possibility of residual confounding. First, we examine how fasting, sleep reduction and sweet food consumption during Ramadan affect offspring health at birth, hypothesizing that fasting is the likeliest source of any association. Second, we test whether among those who fast, altered sleep patterns, food intake compositions - particularly consumption of fatty/greasy food, sweet foods, fruits and vegetables, healthier food - as well as fluid consumption, mitigate or exacerbate the effects of fasting.

METHODS

Study Design

The target population consisted of all Muslim women delivering in Mainz (capital of the German state Rhineland-Palatinate) whose pregnancy overlapped with Ramadan 2017 (May 26 - June 24, 2017) for at least one day. Pregnant Muslims and new Muslim mothers who either delivered their newborn or preregistered for delivery with one of the two obstetric wards in Mainz were approached for participation. Interviews were conducted on three nonconsecutive days per week from May 26, 2017 until April 13, 2018. Interviews using a structured questionnaire were conducted in German, Arabic, Turkish and English, to collect information on behavior during Ramadan as well as demographic information. Upon consent of the interviewed women, survey data was linked to the medical information

of the obstetric wards. Due to the high participation rate among the relevant population (72%), our sample is representative of pregnant Muslim women delivering in Mainz, speaking German, Arabic, Turkish or English well enough to participate in the study (see Figure 1).

Exposure

Exposure to maternal fasting is defined in three ways. First, maternal fasting is defined using a binary indicator for having fasted at least three days during pregnancy. Women who reported fasting one or two days indicated that they had tried fasting, but realized it was too difficult and abandoned fasting immediately. As these women cannot be considered as regularly fasting, we classify them as not having fasted. Exposure to fasting is further differentiated by the pregnancy trimester during which Ramadan occurred, calculated based on gestational age at birth (taken from the hospitals' official birth records). If exposure falls within two trimesters, we assign the observation to the trimester where the number of days of overlap is larger. To explore the role of the intensity of fasting, we separate the fasting indicator into two groups – having fasted partially (3-19 days) versus having fasted fully (20-29 days).

Information on sweet food consumption and sleep behavior was also collected among all participating women. Sleep behavior is adapted during Ramadan as food and drink intake as well as its preparation are shifted to night hours.[10] A woman is considered to have slept less during Ramadan if she reported either going to bed later or getting up earlier (or both) during Ramadan, while not sleeping more during the day. Research on maternal sleep and birth outcomes remains scarce, but the available evidence suggests that lack of maternal sleep or poor maternal sleep quality may be associated with poorer birth outcomes[11]. Data on shifts in sweet foods consumption were collected since both fasting and non-fasting pregnant women often join the traditional celebrations around Ramadan and therefore experience changes in nutritional intake.[8, 12] Diets rich in fats or sugar, have been shown to be negatively associated with offspring health.[13] Women are categorized as having either consumed fewer, the same amount or more sweet foods, according to their self-reported eating behavior, compared to the month prior to Ramadan.

Fasting women were additionally asked to provide more detailed information on their nutrition during Ramadan. They were asked whether they had drunk more, less or the same amount compared to the month before Ramadan. Dehydration during pregnancy has been shown to lead to lower amniotic fluid levels[14]. In order to proxy for changed dietary patterns and sources of nutrient intake, fasting women were also asked whether they had eaten more, less or the same amount of greasy/fatty food and fruits and vegetables compared to the month before Ramadan. We further create a combined consumption measure. A woman is classified as having adjusted her diet to be unhealthier during Ramadan if she reported eating more sweets and/or greasy/fatty foods, and healthier if she consumed more fruits and vegetables while neither consuming more sweets nor more greasy/fatty foods. If none of the above applies, she is classified as having an unchanged food consumption compared to the month prior to Ramadan.

Outcomes of Interest

The outcomes of interest are birth weight (in grams), 5-minute APGAR score (0-10 points) and gestational age (in completed weeks). Birth weight has been shown to have predictive value for a variety of short- and long-term health, education and labor market outcomes.[15-17] Lower APGAR scores are associated with higher mortality in the first year of life as well as a higher prevalence of neurologic disability and lower cognitive function in early adulthood.[18, 19] Shortening of gestation is a cause of infant mortality as well as morbidity and associated with increased risks for morbidity from chronic diseases among adults.[20-22]

Covariates

We adjust for sex of the offspring, gestational week at birth (week and weeks²) and maternal age at birth (age, age² and age³). We further control for several maternal characteristics: employment status prior to parental leave, highest educational attainment, country of birth, nulliparity, indicator for length of stay in Germany (fewer or more than 3 years), degree of religiosity (defined using information on fasting behavior during previous Ramadans when not pregnant and the use of veiling on a day-to-day basis), pre-pregnancy BMI, risky behavior during pregnancy (smoking, alcohol consumption, drug use, and/or consanguinity) and awareness of the pregnancy during Ramadan.

Methods

Linear regressions are estimated using Ordinary Least Squares to identify the associations between fasting, sleep behavior, sweet consumption and birth outcomes. Regressions are adjusted for the covariates described above. To analyze the potential moderating role of other Ramadan-related behavior on the association of fasting with birth outcomes, interaction terms between fasting and nutritional and sleep behavior are included.

We test whether the associations are robust to controlling for unobserved confounders by calculating the Oster test statistic.[23] This novel method allows to assess to what extent residual confounding may have driven the reported associations, which is indispensable due to the potential non-random assignment to the fasting and non-fasting groups. The Oster test statistic compares the raw association between fasting and birth outcome with the adjusted association from the regression analysis. The test statistic describes how important unobserved confounders would have to be in order for them to explain away the reported effect to the point where the hypothesis of a null effect of maternal fasting on birth outcome would no longer be rejected. We assume that the maximum R^2 that is theoretically reachable in a model that would include all observable and unobservable determinants of the birth outcome equals 1·3 times the R^2 from the adjusted regression, i.e. $R_{max} = 1{\cdot}3 * \tilde{R}$, but as a sensitivity analysis, we also use $R_{max} = 1$. [23]

To test the robustness of our results, we additionally run regressions in which we first include women who fasted one or two days in our fasting definition and secondly include them as a separate category.

We also run analyses in which the sample is reduced to full-term pregnancies (≥37 weeks of gestation) and to normal-term pregnancies (≥37 & ≤42 weeks of gestation).

To gain insight into the heterogeneity of the effect, we perform sub analyses by sex. Furthermore, we investigate if the effect is different among offspring to women who have been living in Germany for less than three years. We aim to understand whether a potential negative association is concentrated among the offspring of recent immigrants, since a large number of Muslim refugees arrived in Germany during the European refugee crisis 2015/16. The composition of the group of refugees who arrived during this crisis might differ from the composition of Muslims who have arrived in Germany earlier or who have been born in Germany. For instance, many recent refugees stem from countries with large Muslim populations in which Ramadan observance is generally thought to be higher.

RESULTS

Descriptives

Of the interviewed women, 31% reported having fasted at least three days (Table 1). Half of the fasting women reported having adhered to the fast for at least 20 days (Figure 2), while the fasting rate is highest among women whose pregnancy overlapped with Ramadan in the first pregnancy trimester (Figure 3). Exposure to Ramadan is evenly distributed over pregnancy trimesters (Table 1). The slightly lower number of pregnancies overlapping during the second trimester can be explained by the first and third trimester including women whose pregnancy only partially overlapped with Ramadan, i.e. who either conceived (N=30) or gave birth (N=33) during Ramadan. Excluding these partial exposures leads to an equal distribution over the trimesters.

Maternal fasting and offspring health at birth

As illustrated in Figure 4, offspring to mothers who fasted at least three days had significantly lower birth weights compared to offspring of non-fasting women (-161·57g, CI: -295·63; -27·51). In particular, children of mothers who fasted during the first trimester had significantly lower birth weights than children of mothers who experienced a Ramadan during the first trimester but did not fast (-360·48g, CI: -539·27; -181·69). No differences between birth weights of fasting and non-fasting women are found for Ramadan occurring in the second or third trimester.

Compared to children of non-fasting women, the children of mothers who fasted fully (20-29 days) had lower birth weights, while no difference was found for those fasting partially (3-19 days) (-209·06g, CI: -365·82; -52·30 for exposure to maternal fasting for 20-29 days; -104·91g, CI: -278·62; 68·80 for exposure to maternal fasting for 3-19 days). APGAR score and gestational age were not associated with exposure to maternal fasting.

The results of the Oster test statistic report that it is highly unlikely that residual confounding has driven the reported association between fasting and birth weight. Compared to the raw association (-

59·77g, CI: -240·57; 121·03), adding our set of covariates to the regression model leads to a stronger association between fasting and birth weight. The Oster test statistic shows that residual confounders would not only have to be over ten times as important as the included variables in explaining the outcome variable, but they would have to work in the opposite direction from the included covariates in order to eliminate the detected effects on birth weight ($\delta = -10{\cdot}17$). In the robustness test using the more conservative $R_{max} = 1$ instead of $R_{max} = 1{\cdot}3 * 0{\cdot}40 = 0{\cdot}52$, this test statistic changes to $\delta = -2{\cdot}15$, which would still require the unobservables to be more than twice as important as the included covariates, and to work into the opposite direction. We can thus reasonably expect that the control variables included in our model reflect the most important factors that may influence both behavior during Ramadan and birth outcomes.

Maternal sleeping behavior and sweet food consumption and offspring health at birth

Adding sleep reduction and sweet food consumption to the previously presented regressions does not alter the magnitude of the association between fasting and birth weight (Figure 5). Neither sleep reduction nor sweet food consumption were themselves significantly associated with birth weight. These behaviors were also not associated with APGAR score and gestational age (not shown here).

The impact of sleep and nutrition on the association between fasting and birth outcomes

Investigating the interactive effect of further behavioral changes and fasting shows that the association of in utero exposure to Ramadan with birth weight seems considerably moderated by maternal (nutritional) behavior (Figure 6). The negative association between fasting and birth weight was only significant for women eating less or the same amounts of fatty or sweet foods compared to the preceding month. Correspondingly, there was no association between fasting and birth weight among women who, following conventional ideas, had unhealthier consumption patterns during Ramadan, while fasting and birth weight were negatively related among women with consumption patterns that were unchanged, or became healthier during Ramadan.

Furthermore, the negative association between fasting and birth weight was only significant among women who ate more fruits and vegetables, among women who drank less fluids during Ramadan, and among women who slept less during Ramadan. Fasting-birth weight associations for women with different behaviors on these variables were negative, but not significant. No effects were found for APGAR score and gestational age when interacting fasting with further behaviors.

Robustness and Heterogeneity Analyses

Our findings are robust to including women who reported fasting one or two days in the fasting definition (-116·97g, CI: -250·92; 16·98) as well as to including a separate category for having fasted one or two days (-155·46g, CI: -298·62; -12·30). Results are also robust to reducing the sample to full-term offspring (-188·76g, CI: -319·14; -58·38) and normal term offspring (-188·06g, CI: -318·05; -58·07).

The heterogeneity analyses suggest that the association between fasting and lower birth weight is concentrated among male offspring (male: -222·52g, CI: -404·00; -41·04; female: -25·57g, CI: -175·06; 123·92). The association appears stronger among offspring to mothers who have been living in Germany for more than three years (≥3 years: -140·98g, CI: -296·24; 15·68; <3 years: -62·18g; CI: -253·71; 129·35). There are no subgroups which are significantly affected in terms of APGAR score or gestational age.

DISCUSSION

We find that maternal adherence to fasting during Ramadan is associated with lower offspring birth weight, while we do not find fasting to be associated with APGAR score or gestational age at birth. Sweet food consumption and sleep deprivation per se – two other commonly experienced behaviors during Ramadan, irrespective of fasting – are not associated with birth outcomes.

The strength of the fasting-birth weight association depends on further maternal behavior. Consumption patterns that are generally considered unhealthier (i.e. increased consumption of fatty or sweet foods during Ramadan) eliminated the negative effect of fasting on birth weight. The negative fasting-birth weight association was statistically significant among women who drank less fluids or slept less during Ramadan. While fasting seems to be the main driver of the observed lower birth weights in response to intrauterine exposure to Ramadan, there are important moderator variables, among which particularly nutritional patterns during non-fasting hours seem to play a key role.

While evidence on long-run adverse health effects of prenatal Ramadan exposure is accumulating, data on birth outcomes are scarce and results contradictory.[24] Previous survey studies were not able to control for covariates such as country of birth, maternal BMI, risky behavior or religiosity[25, 26]. Without the inclusion of these controls, we also do not find significant effects on birth weight (-96·77g, CI: -220·71; 27·17). This is due to the fact that factors that are positively correlated with the decision to fast are also positively correlated with birth weight. It might also be that birth weight effects of intrauterine exposure to Ramadan can be found in some populations and not in others due to different cultural and dietary habits.[26]

Several large, register-based studies investigated the effects of intrauterine exposure to Ramadan using intention-to-treat designs, calculating exposure to Ramadan based on birth date and a regular length gestation, without information on maternal adherence to the fasting. Jürges[27] and Savitri et al.[28] found no effects on birth weight for Germany and The Netherlands respectively. In intention-to-treat analyses, all offspring calculated to have been in utero during a Ramadan are considered “treated”, which leads to a bias towards zero since not all mothers fasted. Both studies contained a large share of offspring to Turkish women, among whom only 1 in 5 women in our sample reported fasting. Other intention-to-treat studies found birth weight effects of intrauterine exposure during the first trimester[1]. We find that

fasting rates are highest in the first pregnancy trimester, which might partly explain the results of intention-to-treat studies.

Strengths and weaknesses

A main advantage of our study is the high quality of the data in conjunction with a systematic and representative sampling design and a high response rate of 72%. We cover an entire cross section of Muslims whose pregnancy overlapped with a Ramadan, so that offspring with in utero exposure to Ramadan at all stages of pregnancy are included. While other studies relied on antenatal care visits during later pregnancy, we approached the Muslim mothers in the obstetric wards, where 98% of children in Germany are born.[29] Our sample is thus less selective than previous studies, which tend to oversample women in later stages of pregnancy. The calculation of the Oster test statistic rules out the possibility of residual confounding.[23] Furthermore, while the timing and intensity of fasting as well as other behavioral changes during Ramadan often have been hypothesized as further channels for the health effects, previous literature did not have the necessary data to investigate. We are the first to show that specific nutritional and behavioral choices matter for the manifestation of the effect of Ramadan fasting on the health of the offspring.

Several limitations must be noted. First, we only look at a set of outcomes at birth, but are not able to study the effects of intrauterine exposure to Ramadan on longer-run outcomes. Second, we only have data for one birth cohort. As it has been shown that effects potentially differ by the hours fasted[1], our effect might in part depend on Ramadan 2017 coinciding with the longest potential fasting durations in Germany (up to 18 hours) as well as high temperatures. Third, we do not have exact protocols of maternal nutrition and sleep behaviors of the participants during Ramadan and rely on self-reports. Still, this is more than any previous study has been able to do.

Meaning of the study

Our finding that nutritional and behavioral choices matter for the materialization of the effects of maternal Ramadan fasting on offspring health at birth constitutes the first step on a long avenue of future research. While sleeping behavior and the traditional sweet consumption during Ramadan themselves do not seem to directly affect birth weight, they may moderate the fasting-birth weight relation. A possible explanation is that the actual channel through which fasting affects offspring birth weight could be caloric deficiencies. Earlier studies have shown that pregnant women tend to consume insufficient calories during Ramadan.[30] Since fatty and sweet foods have higher caloric contents, eating what would traditionally be considered more unhealthy food, may lead to pregnant women consuming the required number of calories.

Our study highlights that research on culture-specific habits and traditions are pivotal in order to promote a healthy start to life for all children, independent of their mother's faith. Ramadan during pregnancy is a highly sensitive, religious topic. However, each year millions of Muslim offspring with intrauterine exposure to Ramadan are born. When pregnant women decide to fast, they need to be informed that their

nutritional behavior during Ramadan may have an impact on their offspring's health. An extended body of research on how other behavioral changes during Ramadan – such as nutrition, sleep or stress levels – moderate the health effects of intrauterine exposure to Ramadan will contribute to the development of guidelines that help practitioners in giving advice to their Muslim patients in childbearing age.

Future research is urged to collect more detailed data on maternal nutritional intake during Ramadan. The knowledge on epigenetic effects of maternal nutrition during pregnancy is to date very limited. Whether a diet with increased sweets and fat consumption or other nutritional behavior during Ramadan also prevents adverse long-run effects, and whether more specific nutritional intake patterns during fasting may lead to, or prevent, such effects, remains to be further investigated.

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Declaration of interests:
All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf and declare: F. Pradella, B. Leimer and R. van Ewijk had financial support from the German Research Foundation (DFG grant 260639091) for the submitted work; there are no financial relationships with any organisations that might have an interest in the submitted work in the previous three years and no other relationships or activities that could appear to have influenced the submitted work.

Ethics approval:
The ethics committee of the State Chamber of Medicine in Rhineland-Palatinate (Germany) reviewed and approved this study (837.309.14 (9548)). All participants gave informed consent before taking part in this study.

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Contributorship statement:
F. Pradella and B. Leimer contributed equally to this article. Both developed the data collection process, monitored data collection and cured the data, wrote the statistical analysis plan and methodological approach. They also cleaned, analyzed, validated and visualized the data and wrote the original draft. Both led the revision of the article based on the other co-authors' comments and edited the article. They have verified the underlying data. A. Fruth and A. Queißer-Wahrendorf supported the conceptualization of the study and data curation processes. They contributed to the resources of this project. They revised the draft paper. R. van Ewijk acquired the funding for this article. Together with F. Pradella and B. Leimer, he took over a leading role in the development of the methodology of the project and also contributed to the conceptualization as well as supervision and validation of the study and the study

materials. He further supported the development of the statistical analysis plan and was involved in the writing of the original draft as well as the revision of the draft paper.

Data sharing statement:

Data collected for the study, including individual participant data and a data dictionary defining each field in the data set are available upon reasonable request with investigator support and after approval of a research proposal. The data consist of deidentified participant data, a data dictionary and the survey questionnaire. Furthermore, the informed consent forms are available. Data will be available with publication. Please contact the corresponding author of this article if you wish to access the data (fapradel@uni-mainz.de).

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Figure Legends

Figure 1. Sample Selection

Figure 2. Number of Days Fasted among Women Fasting at Least One Day (N=119)

Figure 1. Fasting Rates by Trimester (N=326).
Note: Fasting is defined as having fasted at least 3 days.

Figure 2. Fasting and Birth Outcomes.
Note: Each panel represents the results of three separate regressions, using the three different fasting definitions. All regressions also control for the covariates listed above. The reference group are non-fasting women. When separating the effect of fasting by trimester, the reference group are non-fasting women whose pregnancy overlapped in the same trimester. Trimester exposure is based on gestational age at birth; if Ramadan occurred during two trimesters, exposure is assigned to the trimester with more exposure days.

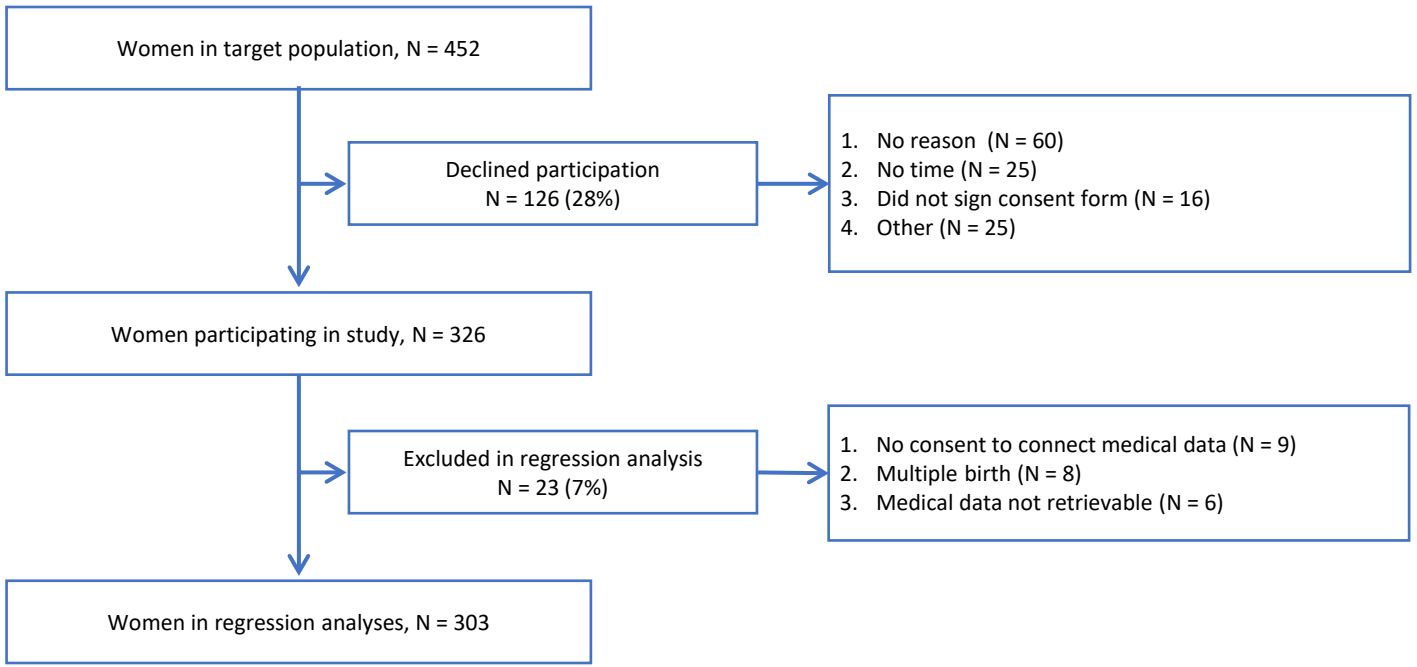
Figure 3. Behavioral Changes and Birth Weight (Fasting and Non-Fasting Women)
Note: Each panel represents the results of a separate regression: the first controls for fasting and having slept less (ref: not sleeping less), while the second regression controls for fasting and sweet food consumption (ref: same amount of sweet food). Both regressions also control for all other covariates listed above.

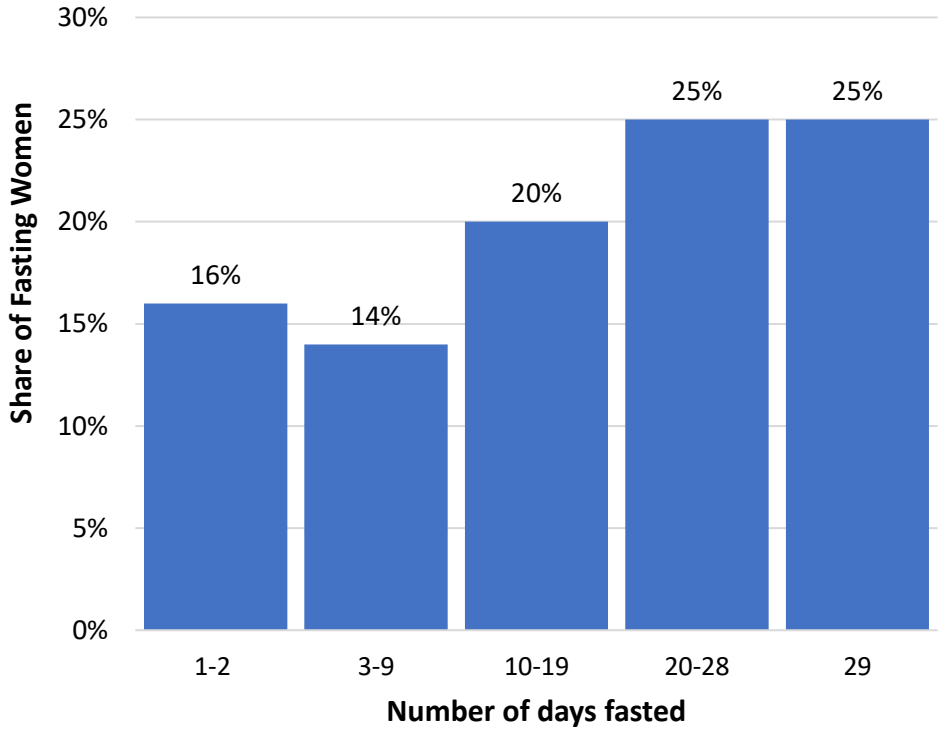
Figure 4. Effect of Fasting on Birth Weight Interacted with Behavioral Changes
Note: The figure shows the effect of fasting interacted with indicators for behavioral changes in the respective categories (decreased, unchanged, increased intake), along with the effect size and 95% confidence interval. The reference group is always the children of mothers who did not fast. Both regressions also control for all other covariates listed above.

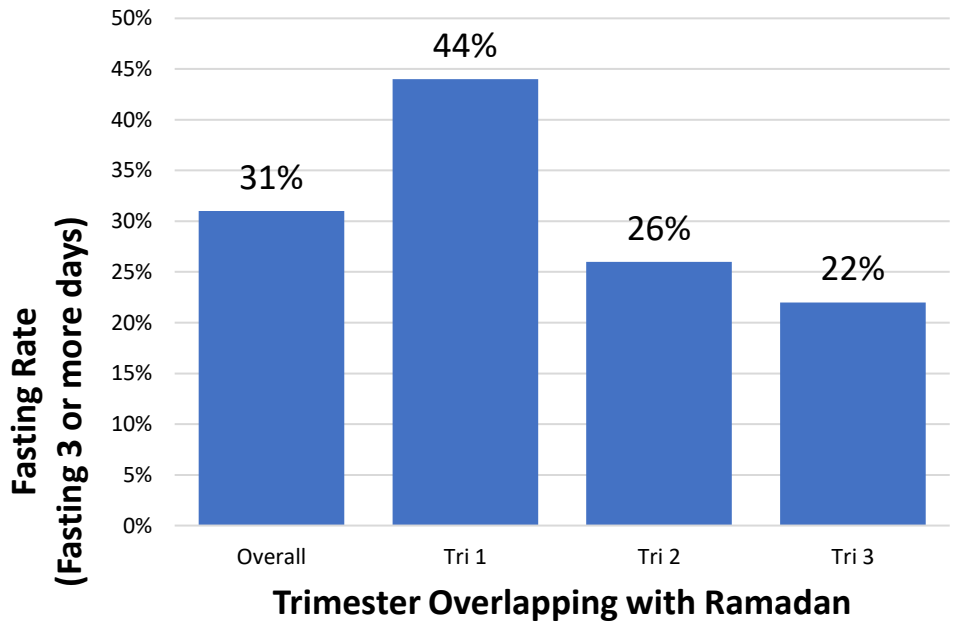
Table 1 Descriptive Statistics

	Obs. Total	Share	Obs. Fasting	Share	Obs. Non-Fasting	Share
Maternal Behavior						
Fasted at least three days	100	31%	100	100%	N/A	N/A
Slept less	124	38%	42	42%	82	37%
Ate less sweet foods	117	37%	43	43%	74	34%
Ate same amount of sweet foods	135	42%	32	32%	103	47%
Ate more sweet foods	68	21%	25	25%	43	20%
Religiosity						
More religious	185	57%	80	80%	105	46%
Trimester of Ramadan Overlap						
Trimester 1	117	36%	51	51%	66	29%
Trimester 2	92	28%	24	24%	68	30%
Trimester 3	116	36%	25	25%	91	40%
Birth Outcomes						
Birth weight[1,2)]	3349	532	3312	509	3367	543
5-minute APGAR score[1,2)]	10	0·9	9·8	1.1	9·6	0·9
Gestational age (in weeks)[1,2)]	39	1·9	38·9	2·2	39·0	1·8
Male child	154	51%	53	55%	101	49%
Maternal Birth Country						
Germany	91	28%	11	11%	80	35%
Syria	52	16%	27	27%	25	11%
Morocco	48	15%	28	28%	20	9%
Turkey	39	12%	7	7%	32	14%
South Asia	28	9%	8	8%	20	9%
Other Arab countries	23	7%	12	12%	11	5%
Somalia	14	4%	3	3%	11	5%
Other	31	10%	4	4%	27	12%
Living in Germany <3 years	90	28%	42	42%	48	21%
Maternal Risk Factors						
Age at birth[1,2)]	30 ·1	5·9	30·2	6·3	30·1	5.7
Pre-pregnancy BMI[1,2)]	24·9	5·3	24·7	4·3	24·9	5.7
Nulliparous	117	36%	33	33%	84	37%
Risky behavior	45	14%	17	17%	28	12%
Pregnancy not known during Ramadan	27	8%	23	23%	4	2%
Household members fast	274	85%	97	97%	177	78%
Maternal Socio-Economic Status						
Partially/fully employed	130	40%	26	26%	104	46%
Technical/university degree	99	30%	28	28%	71	31%
Total N	326		100		226	

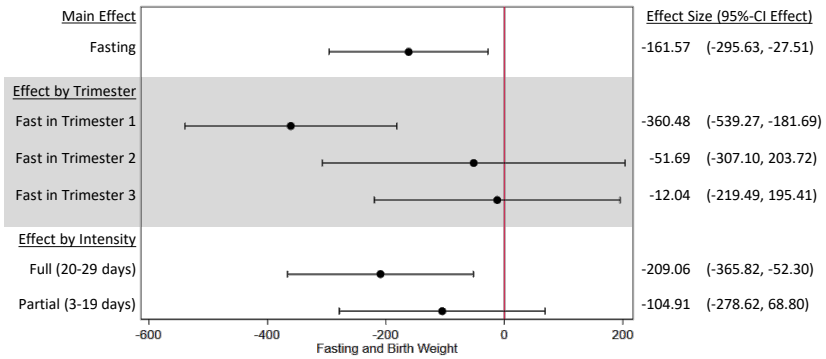
Note: Share refers to the share of the total sample. 1) Average value instead of number of observations. 2) Standard deviation instead of share of the sample. Risky maternal behavior includes smoking, alcohol consumption, drug use and/or consanguinity.



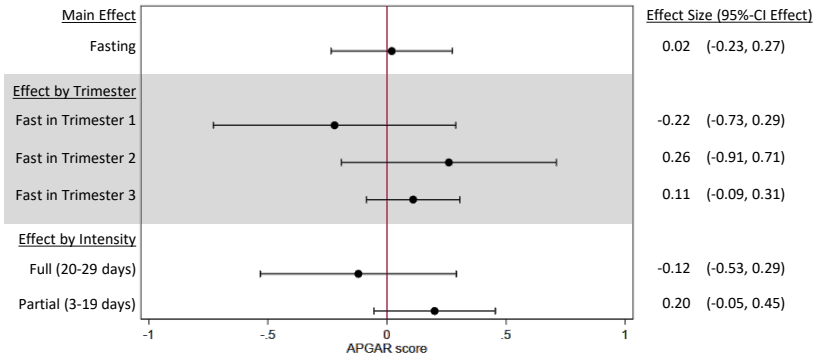




Panel A: Birth Weight



Panel B: APGAR score



Panel C: Gestational Age