Received: 21 April 2020 | Revised: 30 November 2020 | Accepted: 9 December 2020

DOI: 10.1111/mcn.13135

ORIGINAL ARTICLE

Maternal & Child Nutrition WILEY

Women's fasting habits and dietary diversity during Ramadan in rural Bangladesh

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Funding information
Alexander von Humboldt-Stiftung, Grant/Award Number: 3.1-1163387; Bundesministerium für Bildung und Forschung, Grant/Award Number: 01ER1201; Department for International Development, Grant/Award Number: DFI.1836-705713-PRE

Abstract

Little is known about fasting practices and dietary changes during Ramadan in low- and lower-middle-income countries. Although pregnant women are exempt from fasting, they may still fast. This is of interest as dietary habits during pregnancy may affect the development of the unborn child. In a community-based sample of young women in rural Sylhet division, Bangladesh, we described fasting practices and beliefs (n = 852). We also examined reported food group consumption and minimally adequate dietary diversity for women (MDD-W) by Ramadan occurrence (n = 1,895) and by fasting adherence (n = 558) using logistic regression with Hindu women as a seasonal control. During Ramadan in 2018, 78% of pregnant Muslim women fasted every day. Over 80% of Muslim women believe that they should fast during pregnancy and over 50% expect positive health effects on the mother and the unborn child. We found strong evidence that Muslim women have more diverse diets during Ramadan, with higher odds of MDD-W (OR [95% CI]: 5.0 [3.6, 6.9]) and increased consumption of pulses, dairy, fruit, and large fish. Dietary diversity increased to a lesser extent on non-fasting days during Ramadan. Ramadan appears to improve dietary quality in both fasting and non-fasting Muslim women in a rural population in Bangladesh. These results help to interpret findings from studies on Ramadan during pregnancy on later-life outcomes and thus contribute to a better understanding of intrauterine influences of maternal nutrition on healthy child development.

KEYWORDS
diet, fasting, nutrition, population-based cohort, pregnancy, Ramadan, South Asia

1 | INTRODUCTION

During the fasting month Ramadan, Muslims abstain from eating and drinking during daylight hours. There are also changes during Ramadan in relation to what and how much Muslims eat and drink, for example due to the consumption of specific cultural dishes (Shadman et al., 2014). Some studies in high- and upper-middle-income countries suggest that Muslims eat more unhealthy foods high in carbohydrates and fat during Ramadan (Bakhotmah, 2011).

Health effects of Ramadan fasting during pregnancy are attracting increasing scientific interest. Researchers want to establish whether fasting during pregnancy is safe for expecting mothers and their unborn children. More fundamentally, Ramadan is used as a tool to study intrauterine nutritional and environmental influences on healthy development in general (Almond & Mazumder, 2011; van Ewijk, 2011).

Inadequate maternal nutrition during pregnancy can lead to defects and deficits in development that cannot be caught up on later in life (Adair et al., 2013; Victora et al., 2008). Additionally, according to the Barker hypothesis, the fetus adapts to environmental circumstances during pregnancy through fetal programming (Barker, 2007). If environmental circumstances change later in life, this early adaptation can result in increased risk for diseases (Bateson et al., 2004; Gillman, 2005). The field of research on *Developmental Origins of Health and Disease* has identified various negative long-term health impacts of famines (Lumey, Stein, & Susser, 2011). Ramadan is a less extreme but recurring example of altered maternal nutrition.

Few studies on dietary intake during Ramadan have been carried out in low- and lower-middle-income countries, with mixed results. Although a hospital-based study in pregnant women in Indonesia found that fasting women had a lower intake in total energy, protein and vitamin A (Savitri et al., 2018), a population-based study among adolescents in Ghana found increased dietary diversity during Ramadan with higher consumption of milk, vitamin A-rich fruits and other fruits (Ali & Abizari, 2018).

Muslims can be exempted from fasting during Ramadan and instead make up for the missed days during the rest of the year for reasons such as travelling, illness, pregnancy and breastfeeding. Although for these reasons Muslims can take an individual decision whether or not to fast, there are also reasons that strictly exclude Muslims from the Ramadan fast, most notably menstrual bleeding.

Even Muslims who abstain from fasting can experience changes in diet and lifestyle during Ramadan compared to other times of the year. They may participate in *Suhoor/Sehri* (the last meal before fasting starts at sunrise) and *Iftar* (the first meal after fasting ends at sunset), consume similar foods as fasting family members and change their dietary habits in public out of respect for community members. For example, in a study in Indonesia, both fasting and non-fasting women consumed less water within 24 h during Ramadan (Savitri et al., 2018).

There is no clear consensus on health-related effects of Ramadan fasting in healthy adults (Trepanowski & Bloomer, 2010). Ramadan fasting can influence metabolic processes with favourable effects on cardiovascular health (Mirmiran, Bahadoran, Gaeini, Moslehi, & Azizi, 2019; Roky, Houti, Moussamih, Qotbi, & Aadil, 2004), similar to the metabolic benefits of non-religious intermittent fasting (Patterson & Sears, 2017). At the same time, other aspects of Ramadan such as disruption of circadian rhythms (Roky, Houti, Moussamih, Qotbi, & Aadil, 2004), dehydration, discontinued intake of medication (Aadil, Houti, & Moussamih, 2004) and accidents due to decreased alertness (Bener, Absood, Achan, & Sankaran-Kutty, 1992) may be harmful to general health.

Key messages

- Pregnant Muslim women often adhere to fasting during Ramadan despite exemption from fasting during pregnancy by Islamic tradition and rules.
- Ramadan influences dietary habits and lifestyle beyond daytime fasting.
- During Ramadan, dietary diversity can improve for Muslims, even when they do not adhere to fasting.
- The influence of Ramadan on diets likely depends on cultural factors and population characteristics and should be examined in various settings.
- Health effects of Ramadan fasting during pregnancy need to be interpreted in the context of dietary changes in that particular setting.

Concerning fasting in pregnant women, things are more complex as the development of the unborn children could be compromised. These risks are not fully understood. Birth weight appears to be unaffected by Ramadan fasting during pregnancy while data on other perinatal outcomes are insufficient to draw conclusions (Glazier et al., 2018). Few studies have investigated longer-term outcomes, suggesting delayed health risks for individuals who experienced Ramadan *in utero* (Almond & Mazumder, 2011; Karimi & Basu, 2018; Schoeps et al., 2018). A possible mechanism linking Ramadan fasting with fetal development is the phenomenon of *accelerated starvation*: pregnant women have a reduced capacity to maintain blood glucose levels during extended periods of fasting, which might result in limited energy supply to the fetus (Metzger, Ravnikar, Vileisis, & Freinkel, 1982; Prentice, Prentice, Lamb, Lunn, & Austin, 1983). Furthermore, micronutrient needs are particularly high during pregnancy, and reduced food intake could thus lead to deficiencies (Black, 2001; Mousa, Naqash, & Lim, 2019). Although pregnant women can be exempted from fasting during Ramadan, many pregnant women decide to adhere to fasting (Mubeen, Mansoor, Hussain, & Qadir, 2012; Savitri et al., 2018). Fasting habits and beliefs have not been previously studied in Bangladesh.

With this study, we examine dietary changes during Ramadan among women in rural Bangladesh in order to improve the understanding of how Ramadan might affect health in a vulnerable population. We describe Ramadan fasting habits in pregnant, breastfeeding and non-pregnant-non-breastfeeding women and explore their beliefs on Ramadan fasting. We assess consumption of distinct food groups and dietary diversity during and outside Ramadan in Muslim and, as seasonal comparison, non-Muslim women. Additionally, we examine differences in food group consumption and attainment of minimally adequate dietary diversity between fasting and non-fasting Muslim women during Ramadan.

2 | METHODS

We first describe the study population and general data structure. We then describe methods of data collection and statistical analysis separately for each of the two components of the study. For the first component, we describe how we assess dietary habits, behavioural changes and beliefs on fasting during Ramadan using data from a questionnaire survey. For the second component, we describe how we analyse dietary diversity during Ramadan and on fasting and non-fasting days using logistic regression based on repeated assessments of dietary diversity.

2.1 | Study population

We used data collected during the 'Food and Agricultural Approaches to Reducing Malnutrition' (FAARM) cluster-randomized trial which evaluated the impact of a homestead food production program on undernutrition in Habiganj district, Sylhet division, Bangladesh (Wendt, Sparling, Waid, Mueller, & Gabrysch, 2019). Bangladesh has a high prevalence of micronutrient deficiencies. Malnutrition in Sylhet division is particularly high with over 70% of women consuming an inadequately diverse diet (Helen Keller International and James P Grant School of Public Health, 2015). Muslims make up the majority (90%) of the population in Bangladesh, with the remainder being mostly Hindus (Bangladesh Bureau of Statistics, 2014). In Habiganj district, 83% of the population are Muslim (Bangladesh Bureau of Statistics, 2012). The FAARM trial enrolled over 2700 married women aged 30 years or younger after enumeration of households in the study area in 2015, including both Muslim and Hindu women. Detailed information on FAARM study procedures has been published (Wendt, Sparling, Waid, Mueller, & Gabrysch, 2019).

2.2 | Data

We used data from the FAARM trial routine surveillance system (Wendt, Sparling, Waid, Mueller, & Gabrysch, 2019), in which participating women were interviewed every two months from 2015 to 2019 to collect data on impact pathways. Routine data collection included assessment of dietary diversity every two months in pregnant women and every six months in non-pregnant women. Opinions and practices regarding Ramadan fasting were assessed among Muslim participants in an additional surveillance module in 2018. During Ramadan 2019, fasting adherence on the day of dietary assessment was recorded. Participant characteristics, including wealth, education and age, were collected at enrollment.

2.3 | Dietary habits, behavioural changes and beliefs on fasting during Ramadan

2.3.1 | Data collection

Following Ramadan in 2018, all pregnant Muslim women and a random third of non-pregnant Muslim women in the FAARM trial were interviewed about their fasting practices and beliefs (n = 852). We adapted a questionnaire from a previous study in Germany (Leimer, Pradella, Fruth, Queisser, & van Ewijk, 2018) to our study setting (available in the supporting information, Table S1).

2.3.2 | Data analysis

We calculated frequencies and proportions for background characteristics and answer options. We analysed days of fasting, reasons for not fasting and plans to make up for non-fasting days separately for pregnant, breastfeeding and non-pregnant-non-breastfeeding women. Breastfeeding status was defined by the woman saying she breastfed at least one day during Ramadan regardless of the age of the breastfed child.

2.4 | Dietary diversity and food group consumption during Ramadan

2.4.1 | Dietary assessment

Consumption of 21 food groups (Table S3) was collected in a recall of all meals consumed during the day before the interview following FAO recommendations (FAO & FHI 360, 2016) with adaptation to the study setting (Helen Keller International and James P Grant School of Public Health, 2011). A spoonful of foods or a sip of beverages was used to determine the threshold quantity of 15 g. Minimally adequate dietary diversity for women of reproductive age (MDD-W) is defined as the consumption of at least five out of ten standard food groups (Table S3) during the previous day (FAO & FHI 360, 2016). MDD-W is a proxy for adequate micronutrient intake on the population level (Women's Dietary Diversity Project (WDDP) Study Group, 2017). The MDD-W scale only includes 'nutritious' food groups, not other food groups that may be energy dense but are nutrient poor, such as sugary drinks and oils.

2.4.2 | Seasonal control

Dietary patterns and food intake are influenced by seasons (Stelmach-Mardas et al., 2016), therefore the season coinciding with Ramadan in a given year has to be taken into account when studying dietary effects of Ramadan fasting. Our comparison group was selected to represent a season similar to Ramadan by using observations just before and after Ramadan. During the study period (2016–2019), Ramadan occurred between early May and early July (Bengali summer and early rainy seasons). The comparison observations before and after Ramadan thus range from April to August (Bengali late spring, summer and rainy seasons) (Table S2).

We additionally adjusted for residual seasonal influences on food consumption by comparing changes during vs. outside Ramadan in Muslim women with changes during vs. outside Ramadan in Hindu

women in a difference-in-differences analysis. This is necessary because the start and end of Ramadan advance 11 days in the solar calendar each year and therefore fall in similar seasons during consecutive years. This analysis was possible as the FAARM study population comprises both Muslim and Hindu women living in the area.

2.4.3 | Analysis sample

Our analysis included all dietary data collected during Ramadan in the years 2016–2019. For the non-Ramadan comparison group, we included all dietary data collected during the 30 days before and after each Ramadan.

We excluded 31 women with missing covariates, resulting in a final dataset of 1895 unique women (1311 Muslim women and 584 Hindu women) with 2346 observations during Ramadan and 2156 observations outside Ramadan (Table S2). (The term observation refers to an observation unit in the sense of a data point, not in the methodological sense of direct observation of behaviour.) We excluded one observation with incomplete data on fasting adherence from the subsample for the analysis of fasting and non-fasting days during Ramadan, resulting in a subsample of 360 observations during Ramadan and 198 after Ramadan.

2.4.4 | Statistical approach

We calculated proportions for consumption of each of the 21 food groups separately by religion and timing of the interview during or outside Ramadan. We built logistic regression models with consumption of food groups and achievement of MDD-W as outcome variables. Explanatory variables are Ramadan timing (during vs. outside Ramadan), religion (Muslim vs. Hindu) and the interaction of timing with religion (Ramadan*Muslim). The interaction term Ramadan*Muslim gives the coefficient of primary interest of this analysis as it models effects of Ramadan in Muslims over and above general seasonal effects that coincide with Ramadan and can be observed in non-Muslims. This modelling approach has been used in previous population-based studies on effects of Ramadan and corresponds to the econometric term 'difference-in-differences' analysis (Almond, Mazumder, & van Ewijk, 2015; Schoeps et al., 2018).

Models include woman-level random effects to account for intra-individual correlation of repeated measures as well as settlement-level random effects to account for clustering within settlements. Models adjust for wealth, education and age as categorical variables. Variables for adjustment in multivariable analysis were identified by examining candidate variables with regards to their association with exposures (religion and Ramadan occurrence) and outcomes of the main analysis.

Taking into account multiple testing in this dataset, we applied Bonferroni correction and only consider *P*-values below 0.001 as strong evidence for an effect and are cautious about the interpretation of associations with higher *P*-values. We used Stata SE version 14.2 for all data analysis.

2.4.5 | Dietary diversity and food group consumption on fasting and non-fasting days

To explore potential dietary changes in Muslim women also on days during Ramadan when they did not adhere to fasting, we recorded fasting adherence on the day of dietary assessment during Ramadan 2019 for an additional analysis. There are no repeated observations on the same women in this subsample from 2019. We calculated proportions for the consumption of food groups and MDD-W for days outside Ramadan, fasting days during Ramadan and non-fasting days during Ramadan in Muslim women. We compared dietary diversity in observations on days outside Ramadan and on fasting days during Ramadan with observations on non-fasting days during Ramadan using logistic regression. Models include settlement-level random effects to account for clustering. Models adjust for wealth, education and age as categorical variables in line with the difference-in-differences analysis.

2.5 | Ethical considerations

The FAARM protocol was positively reviewed by ethics committees in Bangladesh and Germany and written informed consent was obtained from all study participants before interview (Wendt, Sparling, Waid, Mueller, & Gabrysch, 2019).

3 | RESULTS

3.1 | Dietary habits and behavioural changes during Ramadan

In our sample from rural Bangladesh, two thirds of Muslim women had primary or less education (Table 1; for characteristics of the dietary diversity sample, including Hindu women, see Tables S4a and S4b). Pregnant women were slightly younger than breastfeeding women and non-pregnant–non-breastfeeding women were slightly older.

Almost all Muslim women fasted on at least 1 day during Ramadan. The proportion of women not fasting at all was highest among breastfeeding women with 3%. The proportion of women who fasted every day was highest among pregnant women: 78% of pregnant women, 40% of breastfeeding women and 27% of non-pregnant–non-breastfeeding women fasted the full 30 days of Ramadan. In each group, at least 89% of women fasted 20 days or more. The most commonly reported reasons for not fasting were menstruation among non-pregnant women, and illness, pregnancy and having recently delivered among pregnant women.

Most Muslim women reported changes in their dietary habits during Ramadan (Table 2). Nearly all women reported drinking more liquids. Nine in ten women reported eating more, while one in ten reported eating less. More than three quarters reported eating more fruits, vegetables, sweets and fatty foods during Ramadan. Nearly all women who generally drink caffeinated drinks reported drinking less

TABLE 1 Characteristics and fasting adherence of Muslim women in rural Sylhet division, Bangladesh, who were interviewed about dietary behaviours during Ramadan (*n* = 852)

Totals	Pregnant[a] *n* = 188	Breastfeeding *n* = 361	Non-pregnant–non-breastfeeding *n* = 303
Age at enrollment	***n*=186**	***n* = 357**	***n* = 301**
15–19 years	25.8%	16.5%	9.0%
20–24 years	43.5%	47.3%	33.2%
25–29 years	24.7%	29.1%	36.9%
30 and more years	5.9%	7.0%	20.9%
Woman's education	***n*=188**	***n* = 361**	***n* = 303**
None	16.0%	15.5%	16.2%
Partial primary	26.1%	20.8%	24.4%
Completed primary	26.1%	25.8%	23.4%
Partial secondary	27.1%	32.1%	31.4%
Completed secondary	4.8%	5.8%	4.6%
Husband's education	***n*= 187**	***n* = 357**	***n* = 301**
None	38.0%	39.8%	35.2%
Partial primary	24.1%	18.8%	22.6%
Completed primary	11.8%	17.9%	15.3%
Partial secondary	20.3%	17.6%	21.3%
Completed secondary	5.9%	5.9%	5.6%
Wealth quintile	***n*= 179**	***n* = 344**	***n* = 297**
Poorest	28.5%	23.8%	27.3%
Poorer	19.6%	23.8%	23.6%
Middle	18.4%	19.2%	15.2%
Richer	19.0%	20.3%	17.5%
Richest	14.5%	12.8%	16.5%
Days of fasting	***n*= 188**	***n* = 361**	***n* = 303**
0 days	1.1%	3.0%	0.7%
1–19 days	10.1%	1.9%	1.0%
20–29 days	11.2%	54.6%	71.3%
30 days	77.7%	40.4%	27.1%
Reasons for not fasting[b,c]	***n*= 42**	***n* = 215**	***n* = 221**
Menstruation	9.5%	78.1%	95.9%
Illness	47.6%	12.6%	6.8%
Puerperium (0–40 days after birth)	21.4%	7.4%	0.0%
Pregnancy	30.0%	0.0%	0.6%
Breastfeeding	2.4%	1.4%	0.0%
Travelling	0.0%	0.0%	0.0%
Other	11.9%	2.8%	1.4%
Making up for missed fasting days[b]	***n* = 42**	***n* = 215**	***n* = 221**
No intention	54.8%	36.7%	38.5%
Already made up at least part	2.4%	8.4%	10.9%
Sometime soon	14.3%	24.7%	29.4%
When feeling better	28.6%	30.2%	21.3%

[a]Women who were both pregnant and breastfeeding where classified as pregnant.
[b]Only applicable to women who skipped fasting on at least one day during Ramadan.
[c]Multiple answers possible.

TABLE 2 Reported dietary and sleeping behaviours during Ramadan compared to outside Ramadan among Muslim women from rural Sylhet division, Bangladesh (n = 852)

Behaviours	More	Same	Less
Drinking (in general)	97.7%	0.1%	2.2%
Eating (in general)	89.1%	1.5%	9.4%
Eating fruits	94.4%	0.6%	5.0%
Eating vegetables	77.8%	4.1%	18.1%
Eating sweets	89.3%	1.1%	9.6%
Eating fatty foods	97.5%	0.4%	2.1%
Drinking caffeinated drinks[a]	4.2%	4.7%	91.1%
Engaging in physical activity	33.0%	8.9%	58.1%
Eating in evening on non-fasting days[b]	92.5%	4.4%	3.1%
Eating in daytime on non-fasting days[b]	11.3%	8.8%	79.9%
	Yes	**Sometimes**	**No**
Getting up earlier than usual	86.9%	2.8%	10.3%
Going to bed later than usual	79.9%	9.5%	10.6%
Sleeping during the day more than usual	65.8%	25.0%	9.2%

[a]Only applicable to women who generally consume caffeinated drinks (n = 549).
[b]Only applicable to women who skipped fasting on at least one day during Ramadan (n = 478).

of these during Ramadan. On non-fasting days, most women still reported changes in their dietary habits, eating more in the evening and less during the day. More than half of women reported engaging less in physical activity, while around one third reported being more active during Ramadan. Women reported changes in their sleep schedule as well: More than three quarters get up earlier and go to bed later than usual and two thirds sleep during the day more than usual.

3.2 | Beliefs about Ramadan fasting during pregnancy

More than 80% of Muslim women said they believe pregnant women and breastfeeding women should fast during Ramadan and 80% reported that their partner believes women should fast during pregnancy (Table 3). More than half of women expect positive effects of fasting during pregnancy, while around one quarter expect negative effects on the mother and on the unborn child.

3.3 | Food group consumption and dietary diversity during Ramadan

Muslim women consumed an adequately diverse diet on 49% of observed days outside Ramadan and on 83% of observed days during Ramadan (Fig. 1, numeric results and regression results in Tables S5 and S6). In Hindus, the difference between days outside and during Ramadan was small with 58% and 65% of women achieving MDD-W, respectively (Table S5). The odds of achieving MDD-W were five times higher during Ramadan in Muslims, over and above the general seasonal effects coinciding with Ramadan measured in non-Muslims (Odds Ratio (interaction term Ramadan*Muslim): 5.0, 95% CI: 3.62–6.92; Table S6).

Starchy staples, condiments and oil were universally consumed (Table S5). Small fish, other vegetables and sugar were consumed on more than half of the observed days. There is strong evidence for an increased consumption of large fish, pulses, dairy and other fruit, and a decreased consumption of tea and coffee during Ramadan by Muslims over and above general seasonal effects: For these food groups, odds ratios for the interaction Ramadan*Muslim were substantially different from 1.0 with P-values below 0.001 (Table S6).

3.4 | Food group consumption and dietary diversity on fasting and non-fasting days

Muslim women consumed an adequately diverse diet on 75% of non-fasting Ramadan days, 84% of fasting Ramadan days and 60% of days outside Ramadan in the subsample from 2019 (Fig. 2, numeric results and full regression results in Tables S7 and S8). In regression analysis, there is no evidence for a difference in MDD-W between fasting and non-fasting days during Ramadan (p = 0.25) with an odds ratio [95% CI] of 1.62 [0.71,3.68] (Table S8). There is only weak evidence (p = 0.04) for a difference between days outside Ramadan and non-fasting days during Ramadan with an odds ratio [95% CI] for achieving MDD-W of 0.42 [0.18,0.96] (Table S8). Looking at this comparison the other way around, this means that women might be more likely to consume an adequately diverse diet on days during Ramadan when they are not fasting than on days outside Ramadan.

Consumption of large fish, pulses, dairy, other fruit and other drinks was highest on fasting days during Ramadan, lower on non-fasting days during Ramadan and lowest on days outside Ramadan. For caffeinated drinks, which is mainly tea in this setting, the pattern was inverse. Consumption of nuts was generally low, with the lowest consumption on non-fasting days during Ramadan and the highest consumption outside Ramadan (Table S7). In regression analysis,

TABLE 3 Beliefs about Ramadan fasting during pregnancy among Muslim women from rural Sylhet division, Bangladesh (n = 852)

	Fasting Pregnant *n* = 186	Fasting Breastfeeding *n* = 350	Fasting Non-pregnant-non-breastfeeding *n* = 301	Non-fasting *n* = 15
Should pregnant women fast?				
Yes	93.0%	89.1%	88.0%	93.3%
No	7.0%	10.9%	12.0%	6.7%
Should women fast while breastfeeding?				
Yes	86.0%	86.6%	85.4%	60.0%
No	13.4%	13.1%	14.6%	40.0%
Don't know	0.5%	0.0%	0.0%	0.0%
Other	0.0%	0.3%	0.0%	0.0%
Expected effect of fasting on pregnant woman				
Positive effect	63.4%	62.3%	57.1%	60.0%
No effect	12.9%	14.9%	15.6%	13.3%
Negative effect	23.7%	22.9%	27.2%	26.7%
Expected effect of fasting during pregnancy on unborn child				
Positive effect	59.7%	58.0%	52.5%	60.0%
No effect	14.0%	14.6%	15.9%	13.3%
Negative effect	26.3%	27.4%	31.2%	26.7%
Don't know	0.0%	0.0%	0.3%	0.0%
Partner's attitude towards fasting during pregnancy				
Pregnant women should fast	80.1%	81.1%	80.1%	80.0%
Pregnant women should not fast	12.9%	11.1%	9.3%	20.0%
No opinion	7.0%	6.9%	8.0%	0.0%
Don't know	0.0%	0.9%	0.7%	0.0%
No partner	0.0%	0.0%	2.0%	0.0%

however, there is no strong evidence for a difference in consumption of any food group between fasting and non-fasting days during Ramadan (all *P*-values > 0.01). There is strong evidence for higher consumption of other fruit and other drinks on non-fasting days during Ramadan compared to days outside Ramadan (*P*-values < 0.001) (Table S8).

4 | DISCUSSION

This study found that the vast majority of Muslim women in this setting in rural Bangladesh adhere to daytime fasting on most days of Ramadan. Pregnant women fast on even more days than breastfeeding and non-pregnant women. Most Muslim women believe that they should fast during Ramadan even when pregnant or breastfeeding, and most expect positive effects of fasting on the mother and the child. They report changes to when, what and how much they eat during Ramadan, but also in other aspects of lifestyle. We also found that Muslim women are more likely to consume an adequately diverse diet during Ramadan, possibly also on days during Ramadan when they do not adhere to fasting. This is the first study describing dietary changes during Ramadan in Bangladesh and one of few studies assessing dietary adequacy during Ramadan in an undernourished population. Unlike most previous studies, we specifically control for confounding by season.

Higher adherence to fasting among pregnant women than non-pregnant women may seem counter-intuitive, unless one considers the prohibition of fasting during menstruation. As they do not menstruate, pregnant women are not prohibited from fasting on some days during Ramadan as most non-pregnant women are. During the first months of pregnancy, women might also not want to disclose their pregnancy status which would happen when making use of the exemption from fasting for pregnant women. Fasting adherence could thus change over the course of pregnancy. In our setting with overall very high fasting adherence, we found no indication of any major differences by trimester when exploring our data. Having recently given birth was a frequent reason for not fasting, again reflecting the prohibition of fasting during this period.

Pregnant women in the study population also seem to see no reason to skip fasting as they mostly expect positive or no effects of fasting during pregnancy on the mother or the unborn child. Additionally, there is a cost to skipping fasting during Ramadan: Muslims are expected to make up the days they missed during Ramadan by fasting at another time during the year instead. Daytime fasting alone outside Ramadan might be unattractive as traditions such as large *Iftar* meals

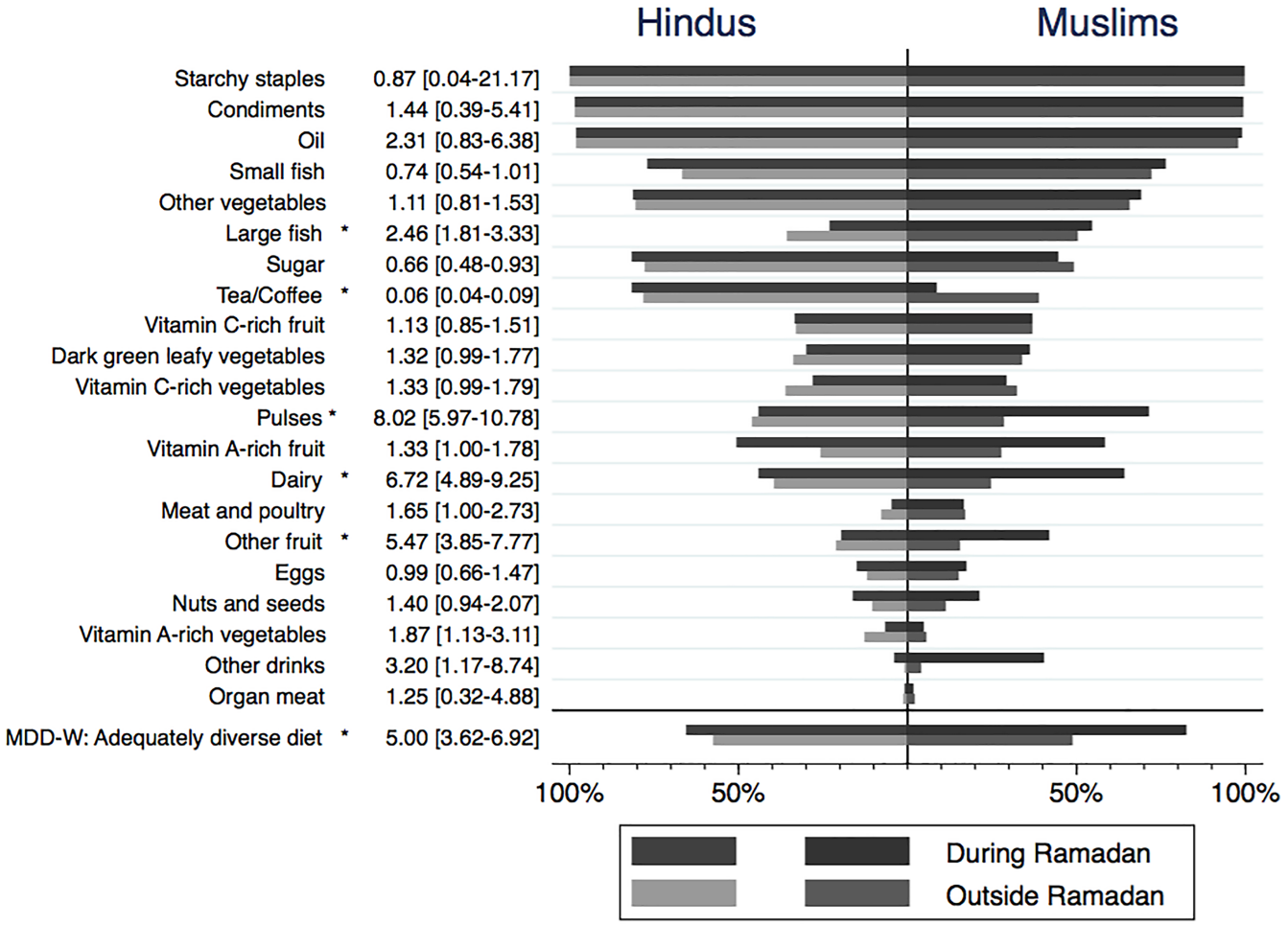

FIGURE 1 Food group consumption and adequately diverse diet during and outside Ramadan in women from rural Sylhet division, Bangladesh (n = 4,157). Bars show the proportion of Muslim and Hindu women consuming 21 food groups and achieving minimum dietary diversity (at least 5 out of 10 standard food groups) during and outside Ramadan. Odds ratios [95% confidence intervals] are estimates for the interaction of Muslim religion and Ramadan in logistic regression controlling for age, wealth, education, repeated measures in the same woman and settlement-level clustering. Asterisks (*) mark outcomes for which consumption during Ramadan differs from outside Ramadan, taking seasonal effects into account (P-value below 0.001 for the interaction of Muslim religion and Ramadan)

in the family are not practised outside Ramadan, and the general comradery and support of fasting family and community members is missing. In settings with salaried jobs, there is also no compensation through reduced working hours for those fasting outside Ramadan. For all these reasons, Muslim women might prefer to fast during Ramadan even when pregnant. Previously reported proportions of pregnant women who fast at least on some days during Ramadan range from around 50% in some high-income countries (Leimer, Pradella, Fruth, Queisser, & van Ewijk, 2018; Savitri et al., 2014) and around 60% in Iran (Ziaee et al., 2010) and Iraq (Safari, Piro, & Ahmad, 2019) to up to 80–90% in the Gambia (Prentice, Prentice, Lamb, Lunn, & Austin, 1983), Indonesia (Savitri et al., 2018), Pakistan (Mubeen, Mansoor, Hussain, & Qadir, 2012) and Yemen (Makki, 2002). Adherence to Ramadan fasting during pregnancy in the present study was comparable to the high levels reported in other low-income countries.

Breastfeeding women also showed high adherence to fasting during Ramadan. Daytime fasting might impair milk production, especially through dehydration, considering that fluids are also not allowed, but there is little literature on the topic. Some women experience problems in breastfeeding when fasting (Bazzano, Potts, & Mulugeta, 2018), but hardly any women in our study reported breastfeeding as a reason to skip fasting during Ramadan. A study of 21 Turkish mothers found reduced micronutrient content in breastmilk during Ramadan (Rakicioglu, Samur, Topcu, & Topcu, 2006). The safety of Ramadan fasting when breastfeeding should be studied in more detail with regards to nutritional needs of the breastfed child.

Changes in diets during Ramadan can be expected to depend on the cultural context and on general dietary patterns outside of Ramadan. What exactly is eaten during Ramadan also depends on local habits and traditions. Populations with, for example, underlying undernutrition or overnutrition might thus experience different impacts of

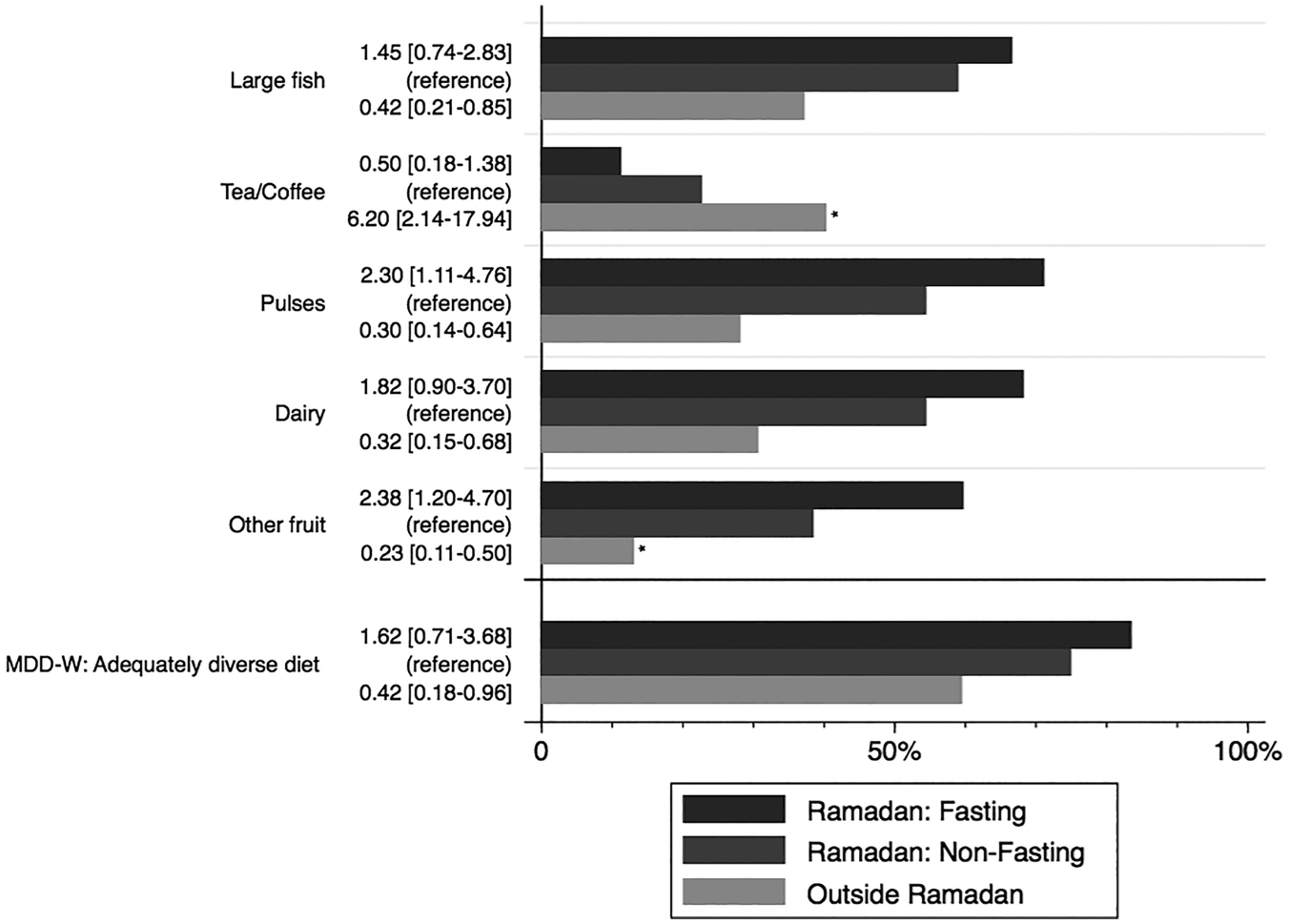

FIGURE 2 Food group consumption and adequately diverse diet during Ramadan on fasting and non-fasting days and on days outside Ramadan in Muslim women from rural Sylhet division, Bangladesh (*n* = 544). Bars show the proportion of Muslim women consuming food groups and achieving minimum dietary diversity (at least 5 out of 10 standard food groups) on days during Ramadan when they did not adhere to fasting, days during Ramadan when they adhered to fasting and days outside Ramadan in the year 2019. The figure shows only food groups for which we find strong evidence for changed consumption during Ramadan in Muslims in the main analysis. Odds ratios (95% confidence intervals) are estimates for fasting days during Ramadan and days outside Ramadan compared to non-fasting days during Ramadan from logistic regression controlling for age, wealth, education, repeated measures in the same woman and settlement-level clustering. Asterisks (*) mark outcomes for which consumption on fasting days during Ramadan or days outside Ramadan was different to non-fasting days during Ramadan (*P*-value below 0.001 in logistic regression controlling for age, wealth, education and settlement-level clustering)

Ramadan with regards to the quality of their diets. A study among pregnant women seeking care in a private hospital in Indonesia's capital city found a lower intake of Vitamin A during Ramadan (Savitri et al., 2018). Another study in adolescents using a population-based sample from Tamale municipality in Northern Ghana found an increase in dietary diversity during Ramadan with increased consumption of several food groups (Ali & Abizari, 2018), similar to our results. Undernutrition is a major problem in Northern Ghana, as it is in our study area in rural Northeastern Bangladesh.

During Ramadan, Muslims may place greater value on the food they consume and deliberately increase their expenses for food, buying foods that are usually not part of their diet or buying more relatively expensive foods. The poor also receive donations of food during Ramadan, as Muslims are expected to give to those in need during the fasting month. Dishes typically consumed during Ramadan may also contribute to increased consumption of certain food groups. In Bangladesh, it is common to eat a main meal instead of breakfast foods for *Suhoor* (the meal before sunrise), often followed by milk, yoghurt or curd, which could explain the increased consumption of dairy. *Iftar* (the meal at sunset) is often celebrated in families and communities with specific dishes. Additionally, *Iftar* markets selling typical Ramadan foods are popular in Bangladesh. The increased consumption of pulses we observed in Muslims during Ramadan could be attributed to dishes and snacks based on lentils and chickpeas, such as *chana-muri*, *piyaju* and *ghugni*. Breaking the fast with a date is a common habit which could explain the increased consumption of other fruits among Muslims during Ramadan. For caffeinated beverages, the decreased consumption in Muslims during Ramadan may be

due to not drinking tea for *Suhoor* although it is popular for breakfast outside Ramadan.

In this study, proportions of women achieving MDD-W were higher than in other studies in Bangladesh (James P Grant School of Public Health and National Nutrition Services, 2016), both during and outside Ramadan. This could be attributable to seasonality. Ramadan observations and selected comparison observations in this study occurred mostly during spring, summer and the early rainy season. Nationally and in Sylhet division, diets are more diverse during summer (Helen Keller International and James P Grant School of Public Health, 2015); however, this is not universally true across Bangladesh (Stevens et al., 2017).

The changes in consumption of Vitamin A-rich fruit illustrate and highlight the necessity of controlling for general seasonal effects coinciding with Ramadan: In non-Muslims, consumption increased from 26% outside Ramadan to 51% during Ramadan (Table S5). This can be explained by the peak of the mango season coinciding with Ramadan in the observed years. In Muslims, consumption increased from 28% outside Ramadan to 59% during Ramadan. In our difference-in-differences model, this translates into an odds ratio of 1.33 with a 95% confidence interval including 1.0 for the interaction term Ramadan*Muslim (Table S6). This means that there was no strong effect of Ramadan in Muslims over and above the general seasonal effect coinciding with Ramadan measured in non-Muslims. Without a Non-Muslim control group, this seasonal effect could have been misinterpreted as an effect of Ramadan.

Changes in food group consumption during Ramadan observed in non-Muslims are likely attributable to seasonal availability, e.g. the increased consumption of Vitamin A-rich fruit observed in both Hindus and Muslims is likely due to the fact that Ramadan coincided with the start of the Bangladeshi mango season (around May/June) in the study period (2016–2019). Ramadan may however also have direct influences on the diets of non-Muslims in Muslim-majority countries, for example through increased food prices and social interaction between religious groups. In Muslims, increased food prices during Ramadan are in part counteracted by donations given to the poor and, in some countries, additional wage payments for employees, while non-Muslims may be subjected to increased prices without compensation (Kunto & Mandemakers, 2019). In our sample, increased food prices could contribute to the slight reduction in the consumption of large fish in Hindus during Ramadan, but this could also be due to seasonal availability. In Muslim majority countries, non-fasting individuals avoid public consumption of foods and drinks during the day out of respect for fasting Muslims. Non-Muslims might similarly adapt their food intake. Although participating in *Iftar* meals is not common among Non-Muslims in rural Bangladesh, diets of non-Muslims could be influenced if they buy typical Ramadan foods in *Iftar* markets.

The study provided some weak evidence for an increased dietary diversity on days during Ramadan when women abstained from fasting. Fasting adherence information was only available for a subset of interviews and the high fasting adherence in our sample lead to a low number of observations from non-fasting days, resulting in low power for this analysis. The suggested effect is however plausible. As households in our study setting usually eat together and consume the same meals, the diet of a woman on a day during Ramadan when she is not fasting would still resemble the diet of other days during Ramadan given that other household members are fasting. To put it differently, the decision to fast or not to fast will influence when a woman eats, but what she eats might be more influenced by the fasting month of Ramadan and its associated traditions than by her individual fasting decision.

4.1 | Limitations and strengths

This study benefits from data collected over several years from a large community-based cohort of women. The rural setting in a lower-middle-income country with high levels of undernutrition targets a vulnerable population in which effects of Ramadan may be different from what is seen in urban settings and countries with higher incomes. This is also the first study on dietary habits during Ramadan in Bangladesh. In addition to describing fasting adherence in pregnant and breastfeeding women, we also explore their beliefs about Ramadan fasting to help understand their decisions around Ramadan fasting. We collected dietary diversity information following international standards for high-quality measures. A major methodological strength of the study is the inclusion of a non-Muslim control group living in the same area to adjust for confounding by season. An additional asset is the comparison of fasting days and non-fasting days during Ramadan as a proof of concept for the influence of Ramadan on the diets of Muslims even when they are not adhering to fasting on a given day.

One limitation is that we did not quantify nutrient intake in this analysis. For example, we found that more women ate any (>15g) dairy during Ramadan, but we did not study how much more dairy they ate and how this translates to specific nutrients. MDD-W is however a widely used proxy for adequate nutrient intake on the population level. Another limitation in the non-fasting day analysis is incomplete seasonal control. We attempt to control for seasonal effects on dietary patterns by comparing observation days during Ramadan to observation days from the months before and after, i.e. a similar season. However, seasonality effects are apparent in the increased consumption of Vitamin A-rich fruits in both Muslims and Hindus during Ramadan, in line with an overlap of Ramadan with the peak of mango season in the study period. The main analysis uses non-Muslims in a difference-in-differences design to control for these residual seasonal effects. The analysis for effects of fasting/non-fasting days during Ramadan cannot include non-Muslims in the same way as there is no equivalent to fasting/non-fasting during Ramadan in Hindus. In the fasting/non-fasting analysis, we therefore focus on food groups that are strongly affected by Ramadan in the main analysis.

5 | CONCLUSION

Millions of Muslim women worldwide are pregnant during Ramadan every year. Fasting adherence during pregnancy is very high in our

study population and in many other settings in low- and lower-middle-income countries. To establish whether or not it is safe for Muslim women and their unborn children to adhere to daytime fasting during pregnancy, it is important to first better understand the dietary changes happening during Ramadan.

We find an increase in dietary diversity in Muslims during Ramadan in a population in rural Bangladesh, suggesting improved nutrition quality during the fasting month. Dietary diversity may even be increased on days during Ramadan when women abstain from fasting. Previous studies on changes in diet and nutrition during Ramadan show differing patterns. This lack of homogenous results points to the context-specific nature of Ramadan effects. Differences in Ramadan practices and underlying nutritional status between countries, but also between subnational populations, should be considered when assessing risks and benefits of Ramadan fasting.

In terms of methodology, our results highlight that studies on Ramadan fasting need to address confounding through seasonal effects coinciding with Ramadan. It is also important to note that retrospective studies with unknown fasting adherence at the individual level cannot distinguish effects of daytime fasting from effects of Ramadan that are independent of individual fasting decisions, such as changes in dietary quality.

Long-term consequences of maternal nutrition and lifestyle during pregnancy for child development and health are generally difficult to study. Ramadan as a natural experiment provides a unique opportunity. However, such studies can only be correctly interpreted when we have sufficient knowledge on the exact nature of dietary and lifestyle changes during Ramadan in the settings under study. Studies like ours on dietary habits during Ramadan are thus crucial to help interpret findings from studies using Ramadan during pregnancy to elucidate the *Developmental Origins of Health and Disease*, and eventually to generate insights into gestation as a sensitive and critical phase for a successful start in life.

ACKNOWLEDGMENTS

We thank Fabienne Pradella, Birgit Leimer and Reyn van Ewijk for sharing their questionnaire on dietary habits during Ramadan and Anja Schoeps for initially adapting the questionnaire to our setting, with input from this research team and Simone Jacobs. We thank Abdul Kader for leading enumerator training and managing data collection.

The FAARM trial is primarily supported by the German Ministry for Education and Research (BMBF) (grant number: 01ER1201). Additional funding for the first year of surveillance came from the Nutrition Embedding Evaluation Programme (NEEP) funded by the UK Department for International Development (DFID) (grant number: DFI.1836–705713-PRE), and fellowship funding for ASW from the Alexander von Humboldt Foundation (grant number: 3.1–1163387).

Open Access funding enabled and organized by ProjektDEAL.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

CONTRIBUTIONS

SG and JW conceived the study idea. SG, ASW and JLW prepared the data collection instruments, and JLW prepared datasets for further analysis. AUS designed the analysis of dietary diversity during Ramadan, performed all analyses and wrote the first draft of the manuscript under the supervision of SG. This work built upon an earlier study on dietary habits conducted by HM. SS interpreted results with regards to local dietary habits and cultural practices in the study area. All authors discussed the results, contributed to the manuscript and read and approved the final version of the manuscript.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

How to cite this article: Seiermann AU, Al-Mufti H, Waid JL, Wendt AS, Sobhan S, Gabrysch S. Women's fasting habits and dietary diversity during Ramadan in rural Bangladesh. *Matern Child Nutr*. 2021;17:e13135. https://doi.org/10.1111/mcn.13135