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The role of seasonality on the diet and household food security of pregnant women living in rural Bangladesh: a cross-sectional study

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Abstract

Objective: To investigate the association of seasonality with dietary diversity, household food security and nutritional status of pregnant women in a rural district of northern Bangladesh.

Design: A cross-sectional study was conducted from February 2013 to February 2015. Data were collected on demographics, household food security (using the Household Food Insecurity Access Scale), dietary diversity (using the women's dietary diversity questionnaire) and mid-upper arm circumference. Descriptive statistics were used to explore demographics, dietary diversity, household food security and nutritional status, and inferential statistics were applied to explore the role of seasonality on diversity, household food security and nutritional status.

Setting: Twelve villages of Pirganj sub-district, Rangpur District, northern Bangladesh.

Subjects: Pregnant women (n 288).

Results: Seasonality was found to be associated with dietary diversity ($P=0{\cdot}026$) and household food security ($P=0{\cdot}039$). Dietary diversity was significantly lower in summer ($P=0{\cdot}029$) and spring ($P=0{\cdot}038$). Food security deteriorated significantly in spring ($P=0{\cdot}006$) and late autumn ($P=0{\cdot}009$).

Conclusion: Seasons play a role in women's household food security status and dietary diversity, with food security deteriorating during the lean seasons and dietary diversity deteriorating during the second 'lesser' lean season and the season immediately after. Interventions that aim to improve the diet of pregnant women from low-income, subsistence-farming communities need to recognise the role of seasonality on diet and food security and to incorporate initiatives to prevent seasonal declines.

Keywords
Maternal undernutrition
Bangladesh
Low-income country
Women's dietary diversity scores
Household Food Insecurity Access Scale

Birth weight is an important indicator of early childhood survival and health. Low-birth-weight babies are at an increased risk of stunting, infant mortality and morbidity, poor cognitive development, and chronic diseases such as diabetes and CVD later in life[1]. In low- and middle-income countries, maternal undernutrition contributes to intra-uterine growth restriction, which results in low birth weight[1,2]. Good nutrition during pregnancy is essential for ensuring fetal growth and development and subsequent childhood health and survival. While studies have identified effective supplementation interventions to address maternal undernutrition in low-income countries, the causes of maternal undernutrition in different contexts remain relatively unexplored[3,4]. To design programmes that address maternal undernutrition, organisations often assess food security and dietary diversity using tools that provide a snapshot of the situation at one point in time. Dietary diversity over a reference period acts as a proxy indicator of dietary quality and is associated with nutrient adequacy[5,6]. Household food security status reflects availability, accessibility and utilisation of food at a household level. Both dietary diversity and household food security are associated with access to and availability of foods, and seasonality is recognised as a key element of

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food availability in many low-income countries. While it may appear logical for seasonality to be associated with dietary diversity and household food security, programme decision makers rarely consider seasonality when designing new programmes to address maternal undernutrition.

Bangladesh has among the highest rates of maternal and child undernutrition globally. One in three pregnant women is undernourished (BMI <18·5 kg/m^2), one in five babies is born with low birth weight, and one in three children aged 6–59 months is stunted[7,8]. In Bangladesh, the times of the year when there are seasonal fluctuations in income and employment are referred to as '*monga*'. *Monga* occurs twice annually: the main *monga* occurs from 15 September to 14 November (Bangladeshi months of Ashbin and Kartik), prior to the main rice harvest, and the lesser *monga* occurs from 15 March to 14 April (Bangladeshi month of Choitro)[9]. During *monga* Bangladeshis face seasonal food shortages that often result in household food shortages, particularly among those in rural areas who rely on subsistence farming. The documented consequences of seasonal food shortages on the nutritional status of women in low-income countries include reduced energy expenditure, weight loss, insufficient weight gain and subsequent low birth weight[10–12]. Despite a number of studies exploring the role of seasonality on dietary diversity and household food security status at specific time points (often pre and post the lean or monsoon season), the role of annual seasonal variations on dietary diversity and household food security, especially among pregnant women, remains largely unknown[13,14]. By understanding seasonal fluctuations in dietary diversity and household food security among pregnant women, programme decision makers can better design interventions to address maternal undernutrition.

The aim of the present study was to investigate the role of seasonality on dietary diversity and household food security for pregnant women living in rural Bangladesh. We also explored relationships of seasonality with maternal nutritional status. We anticipate that these findings will highlight the importance of understanding seasonal variations in maternal dietary diversity and household food security and inform the design of future nutrition interventions in Bangladesh and other low-income contexts.

Methods

Study design

A cross-sectional study was conducted. Recruitment occurred over the period February 2013 to February 2015. The sample consisted of individuals from all villages previously selected for a cluster randomised controlled trial which aimed to measure the effect of a locally produced food-based supplement on reducing intra-uterine growth restriction in undernourished pregnant women. While the sample for the cluster randomised controlled trial consisted of undernourished pregnant women only, the current study looked at all pregnant women from these villages, regardless of their nutritional status. Therefore, participants for the current sample were from two purposively selected unions in Pirganj sub-district, one selected as the intervention and the other matched as the control. From the intervention union, eight villages were randomly selected using computer-generated random numbers. From the control union, four villages were purposively matched. The number of villages was determined based on average population number, prevalence and estimated incidence of pregnant women across the study period, and the required sample size. The data used for the current study come from surveys completed by consenting women confirmed to be pregnant within the twelve villages of interest.

Setting

The study was conducted in twelve rural villages of Pirganj sub-district of Rangpur District, located in northern Bangladesh. According to the 2011 Population and Housing Census, Pirganj sub-district covers an area of 411·34 km^2, consists of 332 villages and has 385 499 inhabitants[15]. The majority of the population is Muslim, with a minority of people belonging to the Santal ethnic group who are predominantly Christian. The average household size is 3·78 and the literacy rate* is 45·4 %[15]. The area has a tropical monsoon climate, and experiences high temperatures and humidity and heavy seasonal rainfall from June to November. Rangpur is commonly referred to as '*monga* prone' and reported as more vulnerable to seasonal food insecurity than other areas of Bangladesh[16]. Rangpur's main employment source is agricultural labour, although wages are very low compared with neighbouring districts[9]. The villages are typical of villages in northern Bangladesh and have dirt road access that is often inaccessible during the wet season. The communities are largely dependent on subsistence farming and have limited experience with non-Bangladeshi foods.

Participants and recruitment

In each of the selected villages, all women were invited to participate in the study if they: (i) were suffering no illness requiring medical referral; and (ii) were confirmed to be pregnant by a midwife, skilled community health volunteer or other health professional. Prior to the commencement of the study, eight female community nutrition volunteers and two (one male, one female) supervisors from the selected villages were trained on the basics of nutrition, study purpose and design. The community nutrition volunteers had at least a primary-school

* Defined as the ability to write a letter in any language, assessed among the population 7 years and above[15].

education, spoke the local dialect, and were aged between 21 and 49 years. Community nutrition volunteers compiled lists of all pregnant women in the twelve villages and produced village maps that determined the location of each woman's household. These women were identified through community discussions, door-knocking and snowballing. If the woman was interested, the community nutrition volunteer then verified that she met the inclusion criteria and referred the woman to a skilled health worker if the pregnancy was not yet confirmed. Women were given a brief overview of the project and invited to participate. Written or verbal (with thumbprint) consent to participate was obtained after participants heard the project information sheet read aloud. A copy of the information sheet in the local language was provided to participants for their further reference. Verbal consent was also obtained from the leaders of each village for inclusion of their village in the study.

The current project had human research ethical approval from the James Cook University (Australia) Ethics Committee (H4498) and the Bangladesh Medical Research Council (BMRC/NREC/2010-2013/58). The research was registered with the ISRCTN registry (ISRCTN97447076).

Data collection

The community nutrition volunteers assisted participants to complete a survey comprising: (i) background demographics; (ii) household food security; (iii) dietary diversity; and (iv) anthropometry. We used the validated Food and Nutrition Technical Assistance Project's Household Food Insecurity Access Scale (HFIAS) questionnaire and the validated FAO dietary diversity questionnaire to explore food security and dietary diversity, respectively[17–19]. The HFIAS questionnaire consisted of nine occurrence questions (conditions) and nine frequency-of-occurrence questions. With a recall period of 30 d, each occurrence question reflected a condition that represented an increasing level of severity of food insecurity (access) and the frequency-of-occurrence questions determined how often the condition occurred. The nine questions were grouped to form three domains to provide additional information on anxiety and uncertainty about household food supplies, insufficient quality and insufficient food intake and its physical consequences. The frequency-of-occurrence questions were also used to calculate scores, which were then grouped into two categories: food secure and food insecure[19]. The dietary diversity questionnaire consisted of thirteen questions that were later aggregated to form nine food groups. With a recall period of 24 h, this questionnaire allowed us to calculate the woman's dietary diversity score (WDDS), identify individual food groups consumed and calculate specific indicators of interest for micronutrient-rich food groups[20]. The study lead author adapted the HFIAS and dietary diversity questionnaires through community dialogue[21]. The HFIAS questionnaire was adapted to ensure a common understanding of certain words (e.g. a locally appropriate definition of 'household' and 'meal'). The dietary diversity questionnaire was adapted to reflect locally available foods. Questionnaires were translated into local terminology, back-translated and field-tested prior to use. In addition, an interviewer's guide was developed to provide additional information on each question, as well as examples to ensure that questions were understood appropriately.

Mid-upper arm circumference (MUAC) measurements were performed using the standardised procedures recommended by the WHO[22]. The community nutrition volunteer took duplicate measurements of the left arm measured to the nearest millimetre with adult MUAC tapes. Triplicate measurements were taken if a variation occurred between the two measurements. Maternal undernutrition was defined as MUAC $\leq$22·1 cm. MUAC was the preferred indicator to identify maternal undernutrition based on its association with low birth weight[23,24]. The cut-off was determined after a review of the evidence and a discussion with organisations conducting nutrition programmes and research in Bangladesh[24].

Statistical methods

The STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) Checklist for cross-sectional studies was used to ensure comprehensive reporting of the present study. Data management was performed using the statistical software package IBM SPSS Statistics, Version 23.0©. Data quality was ensured by quality checks associated with the data-entry process, double entry and data cleaning.

Food insecurity

Household food insecurity was determined using the HFIAS for Measurement of Food Access: Indicator Guide, Version 3. Dichotomous occurrence and ordinal frequency categorical variables were created for each condition; frequencies for each food insecurity access domain (anxiety, food quality and food quantity) and HFIAS scores were used to identify the prevalence of different levels of household food insecurity[19].

Dietary diversity

Women's dietary diversity was determined using the FAO guidelines to measure household and individual dietary diversity[18]. Dietary diversity was summarised to create dichotomous occurrence variables for each food group and indicators of specific interest, and aggregated to create the WDDS[18]. The nine food groups were: (i) starchy staples; (ii) dark green leafy vegetables; (iii) vitamin A-rich fruits/vegetables; (iv) other fruits/vegetables; (v) organ meats; (vi) meat/poultry/fish; (vii) eggs; (viii) legumes/nuts/seeds; and (ix) milk/milk products. The WDDS were used as discrete quantitative variables and divided into tertiles to distinguish diets of high, medium and low diversity. As there are no universally agreed cut-offs to define WDDS tertiles, we created tertiles based on recommendations in current literature[6]. After aggregating household food security and dietary diversity according to the respective guidelines, we analysed the means of the variables, with a higher HFIAS indicating more food insecure and a lower WDDS indicating lower dietary diversity. To explore consumption of vitamin A- and Fe-rich foods, indicators from specific related food groups were created[18].

Household food security, dietary diversity and nutritional status were used as dependent variables and differences in these variables were examined based on the season variable. Grouping questionnaires by the six Bangladeshi seasons (summer = 15 April–14 June; monsoon = 15 June–14 August; autumn = 15 August–14 October; late autumn = 15 October–14 December; winter = 15 December–14 February; spring = 15 February–14 April) created the season variable. We used inferential statistics to test for relationships and differences between the variables of interest.

Data were not normally distributed, so non-parametric tests were used. Questions related to food security, dietary diversity and anthropometry based on season were analysed using the Kruskal–Wallis one-way ANOVA by ranks test followed by the *post hoc* Mann–Whitney *U* test. Comparisons between frequencies of participants' responses on the dietary diversity and food security variables were analysed using the χ^2 test. Statistical significance was accepted at $P < 0.05$.

Table 1 Background characteristics of participating pregnant women (*n* 288) from twelve villages in rural northern Bangladesh, February 2013–February 2015

Background characteristic	*n*	%	Mean	SD
Maternal age (years)			25·3	5·7
Trimester				
First	87	32·5		
Second	147	54·9		
Third	34	12·7		
Lived at village since birth	287	99·7		
Married	288	100·0		
Average household size			3·6	1·4
Male head of household	288	100·0		
School attendance				
Never attended	27	9·4		
Primary	121	42·0		
Lower secondary*	122	42·4		
Higher secondary†	16	5·6		
Tertiary	2	0·7		
Religion				
Islam	246	85·4		
Hindu	32	11·1		
Christianity	10	3·5		
Gravidity				
0	106	37·1		
1	121	42·3		
2	44	15·4		
≥3	15	5·1		
First pregnancy	105	36·5		
Still birth	11	3·8		
Miscarriage	19	6·6		
Woman works outside home, excluding housework	36	12·5		
Anthropometrics				
Maternal height (cm)			148·5	7·7
Maternal height <148 cm	136	47·4		
Maternal MUAC (cm)			23·7	2·3
Maternal MUAC <22·1 cm	85	29·7		

MUAC, mid-upper arm circumference.
*Grade 7–10.
†Grade 11–12.

Results

Participants

From February 2013 to February 2015, 289 pregnant women were identified as potentially eligible. One woman refused participation for unknown reasons. Thus, a total of 288 women were enrolled in the study.

Descriptive data

Background characteristics of the 288 women surveyed are presented in Table 1. The mean age of women was 25·3 (SD 5·7) years. Most women had attended school, with the majority reaching either primary or lower secondary education (42·0 and 42·4 %, respectively). The mean height of women was 148·5 (SD 7·7) cm, with almost half of women below 148 cm (47·4 %). The mean MUAC of women was 23·73 (SD 2·27) cm, with 29·7 % of women below 22·1 cm. Most women were in their second trimester (54·9 %) of their pregnancy. Of women in the first trimester (*n* 85), the mean BMI was 20·4 (SD 3·4) kg/m^2. One in three women reported that she was experiencing pregnancy for the first time (36·5 %).

Main results

Food security

Food security characteristics are presented in Table 2. The mean HFIAS score was 4·06 (SD 2·86; range 0–13 of a possible 27). Of the women, most were identified as food insecure (87·6 %), with 7·7 % identified as severely food insecure.

Dietary diversity

Over nine possible food groups, women's dietary diversity ranged from two to eight food groups. The mean number of food groups consumed was at 4·8 (SD 1·1), indicating low probability of adequate dietary intake[25]. Figures 1 and 2 illustrate the food groups consumed by pregnant women. To further explore the frequency of food groups consumed, Table 3 illustrates the food groups consumed by more than 50 % of women by WDDS tertile.

Seasonal variations in dietary diversity and household food security status

Table 4 presents the percentage of participants reporting consuming each food group (dietary diversity) and their agreement with various statements in relation to household food security, based on season. The relevant medians and interquartile ranges for these analyses can be seen in Table 5. No significant differences in MUAC based on season were found ($P=0{\cdot}130$). The median WDDS varied as a function of season ($H(5)=12{\cdot}97$, $P=0{\cdot}026$). Mann–Whitney U tests revealed that the median value for dietary diversity was significantly lower in summer than in late autumn ($U=2202$, $r=2{\cdot}19$, $P=0{\cdot}029$) and winter ($U=802{\cdot}5$, $r=2{\cdot}21$, $P=0{\cdot}027$) and significantly lower in spring than in late autumn ($U=1286{\cdot}5$, $r=2{\cdot}08$, $P=0{\cdot}038$) and winter ($U=463{\cdot}5$, $r=2{\cdot}23$, $P=0{\cdot}026$). Chi-square analyses revealed that the consumption of meat/poultry/fish varied as a function of season ($\chi^2=11{\cdot}74$, $P=0{\cdot}039$). Based on the percentages presented in Table 4, it appears as though a greater proportion of women consumed meat/poultry/fish in late autumn and winter compared with other seasons. This may have contributed to the significantly higher number of women eating food groups rich in haem Fe during late autumn and winter compared with other months (see Table 4; $\chi^2=12{\cdot}9$, $P=0{\cdot}034$).

A Kruskal–Wallis test determined that the median HFIAS score varied as a function of season ($H(5)=11{\cdot}68$, $P=0{\cdot}039$). Mann–Whitney U tests revealed that the median HFIAS score was significantly higher in spring than in the monsoon season ($U=649{\cdot}5$, $r=-2{\cdot}73$, $P=0{\cdot}006$) and late autumn ($U=1181$, $r=-2{\cdot}61$, $P=0{\cdot}009$). Further analyses of the HFIAS conditions based on season revealed a significant difference in the proportion of participants who reported having to eat a limited variety of foods due to a lack of resources ($\chi^2=12{\cdot}72$, $P=0{\cdot}026$). The percentages reported in Table 4 suggest that more participants reported having to eat a limited variety of foods due to a lack of

Table 2 Food security characteristics of pregnant women (*n* 288) from twelve villages in rural northern Bangladesh, February 2013–February 2015

Food security characteristic	*n*	%
HFIAS category		
Food secure	35	12·2
Mild household food insecurity	59	20·6
Moderate household food insecurity	171	59·6
Severe household food insecurity	22	7·7
HFIAS conditions		
Worry about food intake	111	38·5
Not able to eat preferred foods	195	67·7
Limited variety of foods	133	46·2
Eat unwanted foods	195	67·7
Eat small meals	147	51·0
Eat fewer meals	40	13·9
No food in house	11	3·8
Sleep hungry	9	3·1
Whole day without food	6	2·1
HFIAS domains		
Insufficient food quality	248	86·1
Insufficient food intake	162	56·4

HFIAS, Household Food Insecurity Access Scale.

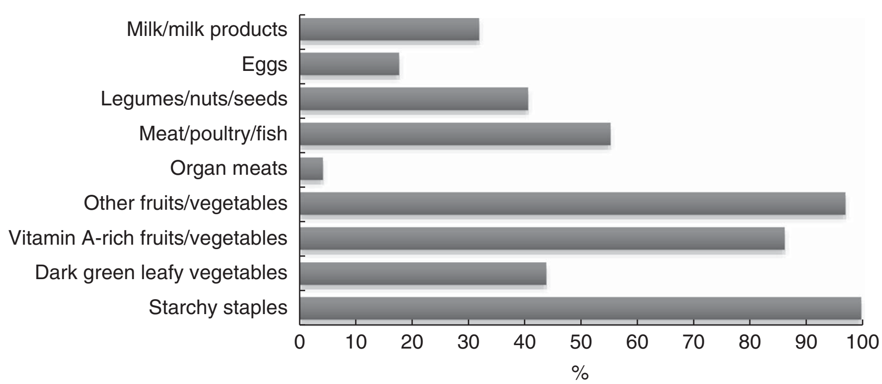

Fig. 1 Food groups consumed over a 24 h period by pregnant women (*n* 288) from twelve villages in rural northern Bangladesh, February 2013–February 2015

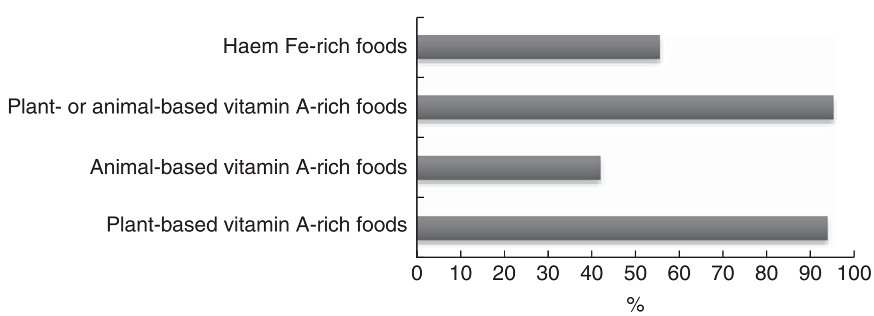

Fig. 2 Micronutrient-rich food groups consumed over a 24 h period by pregnant women (*n* 288) from twelve villages in rural northern Bangladesh, February 2013–February 2015

Table 3 Food groups, according to tertile of dietary diversity, consumed by ≥50 % of pregnant women (*n* 288) from twelve villages in rural northern Bangladesh, February 2013–February 2015

Lowest dietary diversity (≤4 food groups)	Medium dietary diversity (5 food groups)	High dietary diversity (≥6 food groups)
Starchy staples	Starchy staples	Starchy staples
Dark green leafy vegetables	Dark green leafy vegetables	Dark green leafy vegetables
Other vitamin-A rich fruits/vegetables	Other vitamin A-rich fruits/vegetables	Other vitamin A-rich fruits/vegetables
Other fruits/vegetables	Other fruits/vegetables	Other fruits/vegetables
	Meat/poultry/fish	Meat/poultry/fish
		Legumes/nuts/seeds
		Milk/milk products

Table 4 Percentage response to dietary diversity, food security and nutritional status questions as a function of season among pregnant women (*n* 288) from twelve villages in rural northern Bangladesh, February 2013–February 2015

	Season						
	Summer (*n* 89)	Monsoon (*n* 38)	Autumn (*n* 21)	Late autumn (*n* 62)	Winter (*n* 25)	Spring (*n* 53)	*P* value
Dietary diversity: food groups (%)							
Starchy staples	100·0	100·0	100·0	98·4	100·0	100·0	0·691
Dark green leafy vegetables	40·4	44·7	57·1	45·2	48·0	39·6	0·770
Vitamin A-rich fruits/vegetables	77·5	92·1	90·5	90·3	88·0	88·7	0·205
Other fruits/vegetables	98·9	97·4	95·2	93·5	100·0	96·2	0·426
Organ meats	2·2	5·3	9·5	3·2	8·0	3·8	0·457
Meat/poultry/fish	42·7	57·9	57·1	66·1	72·0	52·8	0·039
Legumes/nuts/seeds	42·7	15·4	8·5	25·2	10·2	21·5	0·638
Eggs	16·9	21·1	19·0	21·0	16·0	13·2	0·893
Milk/milk products	33·7	44·7	23·8	27·4	40·0	24·5	0·278
Plant-based vitamin A-rich foods	92·1	94·7	90·5	91·9	100·0	96·2	0·662
Animal-based vitamin A-rich foods	44·9	44·7	42·9	43·5	44·0	32·1	0·753
Haem Fe-rich foods	42·7	57·9	61·9	66·1	72·0	52·8	0·034
HFIAS conditions (%)							
Not able to eat preferred foods	65·2	63·2	76·2	61·3	68·0	79·2	0·336
Limited variety of foods	58·4	39·5	28·6	37·1	36·0	52·8	0·026
Eat unwanted foods	58·4	68·4	85·7	71·0	68·0	71·7	0·198
Eat small meals	66·3	36·8	52·4	37·1	60·0	47·2	0·040
Eat fewer meals	12·4	10·8	0·0	16·1	12·0	22·6	0·176
No food in house	5·6	2·6	0·0	1·6	8·0	3·8	0·628
Sleep hungry	1·1	0·0	0·0	4·8	8·0	5·7	0·197
Whole day without food	2·2	0·0	0·0	3·2	0·0	3·8	0·899
HFIAS domains (%)							
Worry about food intake	37·1	21·1	42·9	33·9	52·0	50·9	0·062
Insufficient food quality	87·6	84·2	90·5	80·6	84·0	90·6	0·692
Insufficient food intake	70·8	40·5	52·4	41·9	64·0	58·5	0·004
HFIAS category: food insecure (%)	89·9	83·8	90·5	93·9	84·0	92·5	0·619

HFIAS, Household Food Insecurity Access Scale.

Table 5 Median (and interquartile range (IQR)) dietary diversity score, food security score and mid-upper arm circumference (MUAC) as a function of season among pregnant women (*n* 288) from twelve villages in rural northern Bangladesh, February 2013–February 2015

	Season											
	Summer		Monsoon		Autumn		Late autumn		Winter		Spring	
	Median	IQR	Median	IQR	Median	IQR	Median	IQR	Median	IQR	Median	IQR
WDDS	5	1	5	2	5	2	5	2	5	2	4	1
HFIAS	4	4	3	4	4	4	3	5·5	4	5	4	4·5
MUAC	24·00	3·80	22·85	3·00	24·50	3·20	23·25	2·50	24·00	3·00	22·15	2·60

WDDS, woman's dietary diversity score; HFIAS, Household Food Insecurity Access Scale.

resources in the summer and spring seasons than all other seasons. The proportion of participants who reported having to eat a smaller meal than they felt they needed to because there was not enough food also differed significantly based on season ($\chi^2 = 17{\cdot}312$, $P = 0{\cdot}04$). Based on the percentages in Table 4, it appears as though participants reported having to eat a smaller meal less often in the monsoon and late autumn seasons than in all other seasons.

Further analysis of the HFIAS domains revealed a significant difference in the proportion of participants who reported having insufficient food intake across the seasons ($\chi^2 = 46{\cdot}57$, $P = 0{\cdot}004$). From the percentages presented in Table 4, it appears as though participants are most concerned about not getting sufficient food intake in the summer and winter seasons.

Seasonal variations in anthropometry

A Kruskal–Wallis test revealed no significant differences in MUAC based on season ($H(5) = 8{\cdot}53$, $P > 0{\cdot}05$; see Table 5 for more detail).

Discussion

In northern Bangladesh, we found that dietary diversity and household food security were sensitive to seasonal variations, a finding which has been observed in similar studies[13,14]. Seasonality was significantly associated with dietary diversity and food security status of pregnant women. A common limitation in the use of the HFIAS and women's dietary diversity tools is that they capture a 'snapshot' of the situation and do not reflect seasonal variances. While a few studies have attempted to address this limitation, studies have traditionally been cross-sectional at two points in time[13,14]. Our study is unique as it recruited women over a 24-month period, taking into consideration seasonal variances across the year. A 2-year period was necessary to reach the required sample size to maximise the chance of finding a significant result. Contrary to findings reported elsewhere, we did not identify significant differences in maternal nutritional status based on season[14].

Women had higher dietary diversity in autumn and winter, corresponding with the first month of *monga* and the month between the main *monga* and lesser *monga*, respectively. The higher dietary diversity in autumn corresponded with a higher consumption of dark green leafy vegetables, vitamin A-rich fruits/vegetables and organ meats; while the higher dietary diversity in winter corresponded with a higher consumption of other fruits/vegetables, organ meats, meat/poultry/fish and milk/milk products. Late autumn and winter corresponded with a higher consumption of Fe-rich foods. Interestingly, these two seasons had the lowest consumption of legumes/nuts/seeds. This may be due to the higher consumption of fresh produce such as fruits, vegetables and meat. During these months, legumes, nuts and seeds may be stored for periods when fresh produce is no longer available or accessible. Women had lower dietary diversity in summer and spring, corresponding with the first month of the lesser *monga* and the month directly after the lesser *monga*. This may be due to households depleting food supplies during the main *monga* and having no reserves for the lesser *monga*. While the first *monga* may be considered the 'main' *monga* due to its longer duration, the effects of the lesser *monga* may be more detrimental on the nutritional status of pregnant women in the household.

We identified that household food insecurity peaked during *monga* (autumn) and lesser *monga* (spring). A similar study conducted in northern Bangladesh, but with a different target group, identified that the prevalence of both food insecurity and undernutrition was higher during the monsoon season compared with the dry season (winter)[14]. While our findings may differ, this is likely due to the study methodology; the other study conducted a survey at two points in time only (monsoon and winter) and therefore did not analyse the differences between other seasons. Our findings clearly illustrate fluctuations in dietary diversity and household food security across the seasons. Spring, which corresponds with the lesser *monga*, had high proportions of participants reporting both low variety of foods and food insecurity. By summer, we continued to see a high proportion of participants reporting low variety of foods, coupled with insufficient food intake, and consumption of smaller sized meals. By autumn, while dietary diversity was higher than in the previous season, household food insecurity remained high. Late autumn, which corresponds to the end of the main *monga*, appeared to be the most food-secure season where dietary diversity was at its highest and where food insecurity affected the lowest proportion of households for the year.

We did not identify a relationship between seasonality and maternal nutritional status (as measured by MUAC). Recent evidence from a similar study in a neighbouring district of Bangladesh contradicts this[14]. In that study, seasonality was associated with nutritional status. However, the target group in Hillbruner and Egan's study was children aged 6–72 months[14] and the target group in the present study was pregnant women. Hence, the conflicting findings may be due to differences in target group. The reason for seasonality not being associated with maternal nutritional status in the present study may be that the negative outcomes of seasonality on dietary diversity and household food security do not last long enough to be associated with maternal nutritional status in the Bangladeshi context. Alternatively, it may be that women are able to mitigate potential associations between seasonal variation and maternal nutritional status by adapting their diet accordingly. The WDDS and HFIAS tools are limited to identifying food groups consumed and classification of household food security status. By using a 24 h dietary recall tool, further analyses may have explored whether seasonal declines in maternal nutritional status were prevented through changes in the quantity of food consumed.

Study limitations

Our study had a number of limitations. First, the month of Ramadan resulted in difficulties finding an 'average' day for the dietary diversity and household food insecurity questionnaires. To address Ramadan, participants observing Ramadan were rescheduled to complete the interview process on a 'normal' day, even if this meant waiting until after Ramadan. Second, we were unable to control for potential differences in seasonal impacts and differences in women across the 2-year enrolment period due to the small sample size. It is important to note, however, that while Bangladesh is disaster-prone, no natural disasters occurred in the study areas across the study period. Third, both the dietary diversity and household food insecurity questionnaires have a recall period (24 h and 30 d, respectively) which may have resulted in a recall bias. Participants may forget items, and particularly for the dietary diversity questionnaire, the time period may be insufficient to capture the typical food groups consumed by the participant and may capture episodic foods that are not typically consumed. Fourth, respondent bias may also be an issue. In population groups where food assistance or developmental aid assistance is frequent, participants may over-report food insecurity and under-report dietary diversity with the expectation of receiving assistance. Conversely, participants may modify their responses based on social desirability. Lastly, despite our active home visits by the community nutrition volunteers, the proportion of women included early in pregnancy was lower than desired, a limitation experienced by others[26].

Conclusion

In conclusion, the present study identified that seasonality was significantly associated with dietary diversity and household food security of pregnant women in Pirganj, Bangladesh. Women's household food security status was significantly worse during the two *mongas* and dietary diversity was significantly lower during the lesser *monga* and the month immediately after the lesser *monga*. While the highest annual levels of food security and dietary diversity occurred during the season after the main *monga*, indicating a quick recovery from the main *monga*, we identified a high proportion of food insecurity during the lesser *monga* and an even higher proportion of food insecurity in the season immediately after the lesser *monga*, potentially indicating that households struggled to recover from the lesser *monga*. While economic and nutritional support is required during *monga*, continued support is also required for the period between the lesser *monga* and the main *monga*. This support could be through behavioural change strategies, food banks and diversification of household food production. Support during this time may lessen the shocks of the two *mongas* on household food security and maternal dietary diversity.

Our study highlights the importance of measuring WDDS and HFIAS across the year in order to identify seasonal variations. By recognising these seasonal variations, policy makers and programme decision makers can design context-specific interventions to improve the diet of pregnant women while incorporating initiatives to prevent negative seasonal declines in food security and dietary diversity, thus contributing to better development outcomes for the mother and child.

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